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GCE A LEVEL

A480U20-1

TUESDAY, 14 JUNE 2022 - MORNING

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:

- **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 4.

(Turn over)

Answer ALL questions in the spaces provided.

1 FIGURE 1a opposite is a simplified diagram of the rock cycle.

(a) Using your knowledge, state the external and internal energy sources that drive Earth's rock cycle processes. [2 marks]

External energy source

Internal energy source

(b) Refer to FIGURE 1a.

(i) Identify the position of the rock cycle processes listed in TABLE 1 by inserting each letter once into an appropriate blank box on FIGURE 1a. [3 marks]

TABLE 1

Rock cycle process	Letter
uplift	U
lithification	L
partial melting	P

1 (b) (ii) Describe and explain the most likely differences in maturity of the sediments deposited at locations A and B on FIGURE 1a. [4 marks]

1 (c) **FIGURE 1b opposite is a photograph of a metamorphic rock formed at one of the two locations where metamorphic rocks can form as shown on FIGURE 1a.**

Refer to FIGURE 1a and FIGURE 1b.

(i) **Describe the evidence from FIGURE 1b that supports the interpretation that this rock is metamorphic in origin. [2 marks]**

1 (c) (ii) **A student stated that 'the rock in FIGURE 1b was formed at METAMORPHIC ROCK LOCATION 2 rather than METAMORPHIC ROCK LOCATION 1 on FIGURE 1a'. Evaluate the student's statement.**

[2 marks]

1 (d) **FIGURE 1c opposite shows how the geotherm and the temperature at which rocks begin to melt vary with depth in the Earth.**

Refer to FIGURE 1c.

(i) **State the depths between which the rate of temperature change in the Earth is the greatest. State the evidence for your answer. [2 marks]**

Depths: _____

_____

Evidence: _____

_____

_____

_____

1 (d) (ii) Mark in BOX Y on FIGURE 1c with labelled arrows:

- **the top of the outer core (← T)**
- **the base of the outer core (← B).**

Explain your answer with reference to the information on FIGURE 1c. [3 marks]

18

2 FIGURE 2a opposite is a graph (the Hjulström graph) showing the water velocity required to erode, transport and deposit quartz grains of various sizes.

(a) Refer to FIGURE 2a.

(i) Complete TABLE 2 to state the minimum velocity required to erode and transport a quartz grain with a diameter of 0.1 mm. [2 marks]

TABLE 2

minimum velocity required to erode a quartz grain with a diameter of 0.1 mm	• _____ $cm\,s^{-1}$
minimum velocity required to transport a quartz grain with a diameter of 0.1 mm	• _____ $cm\,s^{-1}$

(ii) Explain why there is a difference between the two values in TABLE 2. [2 marks]

2 (a) (iii) Draw and label lines on FIGURE 2a to show: **[2 marks]**

- **an erosion velocity curve for grains with a density greater than quartz. Label the line with an arrow (←E)**
- **a settling velocity curve for grains with a density greater than quartz. Label the line with an arrow (←S)**

(b) FIGURE 2b opposite shows how the mean settling velocity for clays (diameter<0.004 mm) varies with water salinity in a modern-day estuary in Portugal.

(i) Use FIGURE 2b to describe the relationship between the mean settling velocity for clays and water salinity in the estuary. [2 marks]

2 (b) (ii) Refer to FIGURE 2b. Explain the relationship between the mean settling velocity for clays and water salinity. [4 marks]

12	

3 FIGURE 3a opposite is a photograph of the trilobite *Olenellus* from the early Cambrian. FIGURE 3b opposite is a photograph of the fossil *Spriggina* from the Ediacaran fauna of late Precambrian age.

(a) Refer to FIGURE 3a.

(i) State the name of the hard parts labelled A and B on the trilobite *Olenellus*. [2 marks]

A _____

_____

B _____

_____

3 (a) (ii) A student stated that '*Olenellus* had a pelagic mode of life'. Evaluate this statement. [3 marks]

3 (b) Refer to FIGURE 3a and FIGURE 3b.

Describe the morphological similarities between *Olenellus* and *Spriggina* that may indicate that these fossil groups are related. [3 marks]

3 (c) **FIGURE 3c opposite shows changes in faunal diversity during the late Precambrian and Cambrian and some possible causes of these changes in faunal diversity.**

Refer to FIGURE 3c. Explain what is meant by the term 'Cambrian Explosion'. [2 marks]

3 (d) Refer to FIGURE 3c. Describe and explain how

- **changes in atmospheric oxygen content**
- **changes in the rate of chemical weathering**
- **major glaciations and meteorite impacts**

since 630 Ma may have led to the 'Cambrian Explosion'. [6 QER]

16

4 FIGURE 4 opposite is a geological map.

Refer to FIGURE 4.

(a) State the type of igneous body (pluton, dyke, sill, lava flow) represented by igneous body K. Give TWO pieces of evidence to support your answer.

[3 marks]

Type of igneous body

1. _____

_____

_____

_____

2. _____

_____

_____

_____

_____

4 (b) **Describe the geological history of the area represented on FIGURE 4. Write your answer in full sentences in age order. [6 QER]**

4 (c) **Igneous body K can be radiometrically dated at LOCATION 2 using the ^{147}Sm-^{143}Nd method, using the equation opposite:**

(i) **The value of $\frac{N_d}{N_p}$ in an augite crystal sampled at LOCATION 2 is 3.56×10^{-3}.**

Calculate the age in Ma of igneous body K at LOCATION 2 to show that this radiometric age is younger than the radiometric age shown for LOCATION 1 on FIGURE 4. Show your working and give your answer to the correct number of significant figures. [3 marks]

_____ **Ma**

4 (c) (ii) Refer to FIGURE 4. Explain the most likely reason why the radiometric age of igneous body K is younger at LOCATION 2 than at LOCATION 1. [3 marks]

15

5 FIGURE 5a opposite shows details of the plate tectonic setting of the Aleutian Islands in the Pacific Ocean.

Refer to FIGURE 5a.

(a) State TWO pieces of evidence, from FIGURE 5a only, for a convergent plate boundary in the area of the Aleutian Islands. [2 marks]

1. _____

_____

_____

_____

2. _____

_____

_____

_____

5 (b) (i) Describe the variation in the speed of the Pacific Plate. [2 marks]

(ii) With reference to the age of the Pacific Plate, suggest a possible reason for the variation in the speed of the Pacific Plate. [2 marks]

FIGURE 5b opposite is a cross-section along the line X–Y on FIGURE 5a. It shows the distribution of earthquake foci of magnitude 2.5 or greater recorded over a three-month period across the plate boundary.

Refer to FIGURE 5a and FIGURE 5b.

(c) (i) Draw and label on FIGURE 5b a line to show the probable position of the top of the subducted Pacific oceanic plate. [2 marks]

(ii) In this area, magma is believed to start to form at depths of 70 km by the partial melting of the mantle in the overriding North American plate.

- **Label on FIGURE 5b with an arrow (M→) the location where magma starts to form.**

- **Label on FIGURE 5b with an arrow (V→) the location where a volcano formed from this magma may be found. [2 marks]**

5 (c) (iii) **Refer to FIGURE 5a. Explain how and why the composition of lavas erupted in the eastern and western part of the Aleutian Islands may be expected to differ. [3 marks]**

5 (d) **Suggest why there is a lack of earthquake foci with a depth greater than 33 km in the area around Z on FIGURE 5a. [2 marks]**

15

6 FIGURE 6a opposite shows the present-day distribution of coral reefs.

(a) Refer to FIGURE 6a.

(i) Describe the present-day distribution of coral reefs.

[3 marks]

6 (a) (ii) **Coral reef limestones are found in rocks of Silurian age in the UK.**

A student stated that 'these Silurian rocks were deposited in the same conditions as present-day coral reefs'. Evaluate the student's statement. [2 marks]

6 (b) **FIGURE 6b opposite shows the oxygen isotope ratios (^{18}O:^{16}O) obtained from analysing the calcium carbonate ($CaCO_3$) skeletons of recent coral reefs at location A on FIGURE 6a.**

(i) Explain how corals can preserve the oxygen isotope record of ancient seawater. [2 marks]

6 (b) (ii) Use FIGURE 6b to complete TABLE 3 to show the oxygen isotope ratio values (^{18}O:^{16}O) preserved in the corals in the years 1800 and 1990. [2 marks]

TABLE 3

Year	oxygen isotope ratio ^{18}O: ^{16}O
1800	•
1990	•

6 (b) (iii) **A decrease of 0.18 in the oxygen isotope ratio values (^{18}O:^{16}O) preserved in corals is equivalent to a 1 ^{o}C increase in seawater temperature. Use your values in TABLE 3 to calculate the increase in seawater temperature at location A between the years 1800 and 1990. Show your working. [2 marks]**

_____ ^{o}C

6 (c) **FIGURE 6c opposite is a model to explain why oxygen isotope ratios (^{18}O:^{16}O) obtained from coral skeletons vary according to seawater temperature.**

Refer to FIGURE 6c. Explain why oxygen isotope ratios (^{18}O:^{16}O) obtained from coral skeletons vary according to seawater temperature.

[3 marks]

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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 1b http://all-geo.org/metageologist/2012/10/

FIGURE 2b Portela, L.I., Ramos, S. and Trigo-Teixeira, A., 2013. Effect of salinity on the settling velocity of fine sediments of a harbour basin. In: Conley, D.C., Masselink, G., Russell, P.E. and O'Hare, T.J. (eds.), Proceedings 12th International Coastal Symposium (Plymouth, England), Journal of Coastal Research, Special Issue No. 65, pp. 1188-1193, ISSN 0749-0208.

FIGURE 3a http://www.fossilmuseum.net/Fossil_Galleries/TrilobitesNevada/Olenelluschiefensis/Olenelluschiefensis.htm

FIGURE 3b https://www.adelaidenow.com.au/news/south-australia/spriggina-chosen-as-south-australias-fossil-emblem/news-story/b15c8d115af55cae-f859e16568e37282

FIGURE 3c Environmental upheavals of the Ediacaran period and the Cambrian "explosion" of animal life. Grant Young. Geoscience Frontiers. Volume 6, Issue 4, July 2015, Pages 523-535.

Oxygen concentration information from: https://courses.lumenlearning.com/boundless-biology/chapter/the-evolutionary-history-of-the-animal-kingdom/

FIGURE 6b https://www.terrapub.co.jp/e-library/kawahata/pdf/205.pdf

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1	18	
2	12	
3	16	
4	15	
5	15	
6	14	
Total	90	

FIGURE 1b

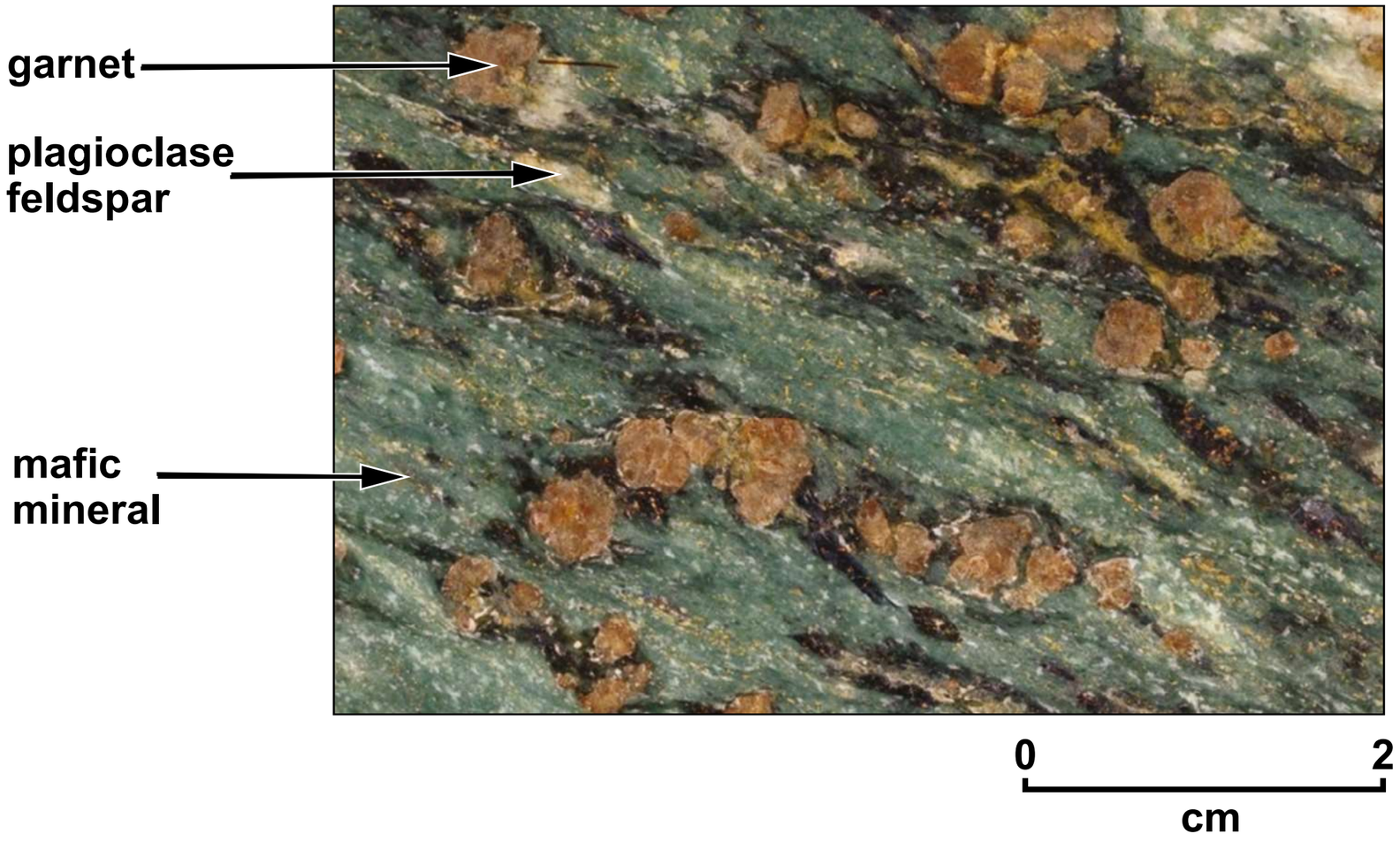


FIGURE 1a

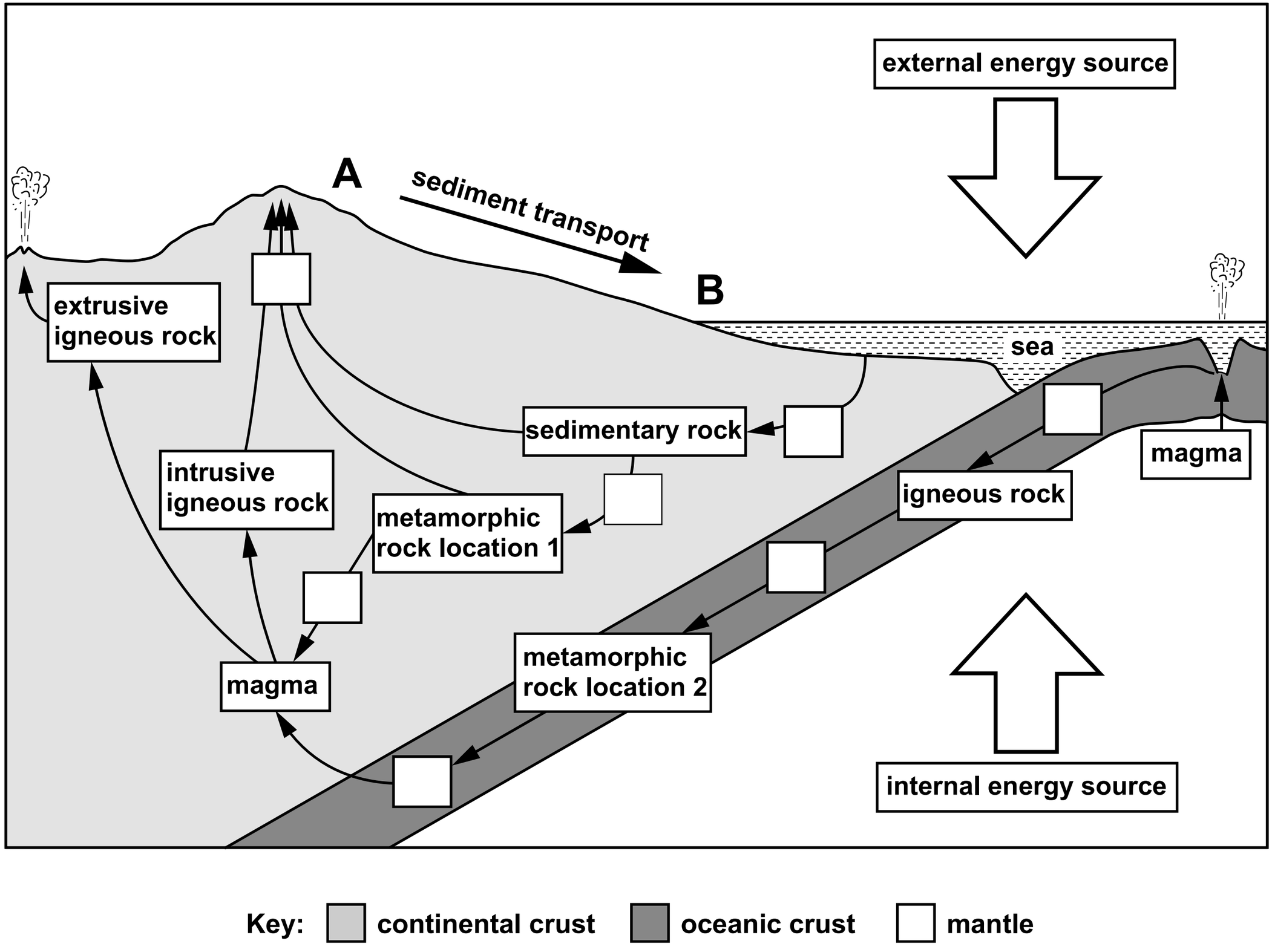

external energy source
A
sediment transport
B
extrusive igneous rock
sea
sedimentary rock
magma
intrusive igneous rock
igneous rock
metamorphic rock location 1
metamorphic rock location 2
magma
internal energy source
Key:
continental crust
oceanic crust
mantle

FIGURE 1c

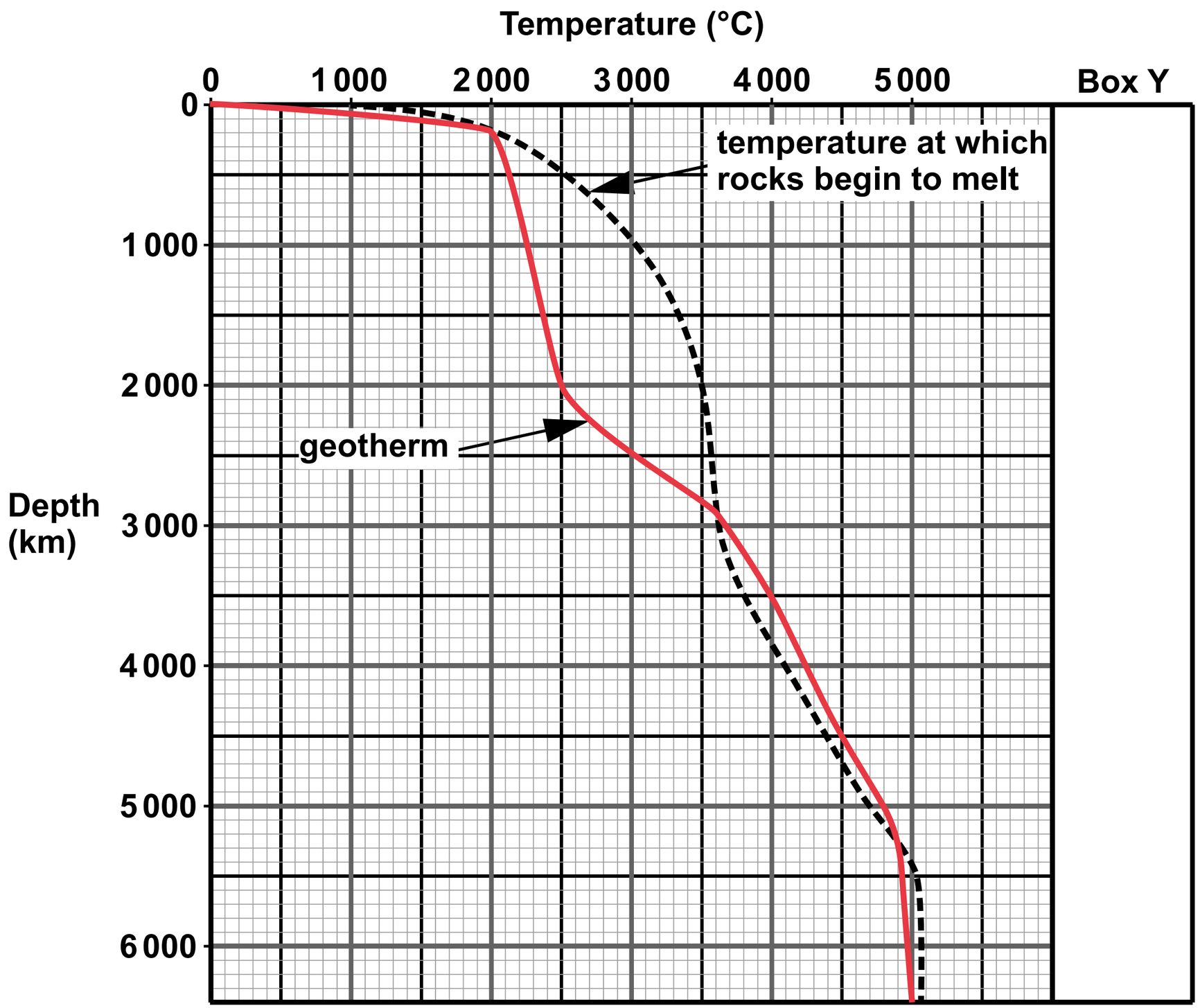

Temperature (°C)
0
1 000
2 000
3 000
4 000
5 000
Box Y
Depth (km)
0
1 000
2 000
3 000
4 000
5 000
6 000
temperature at which rocks begin to melt
geotherm

FIGURE 2a

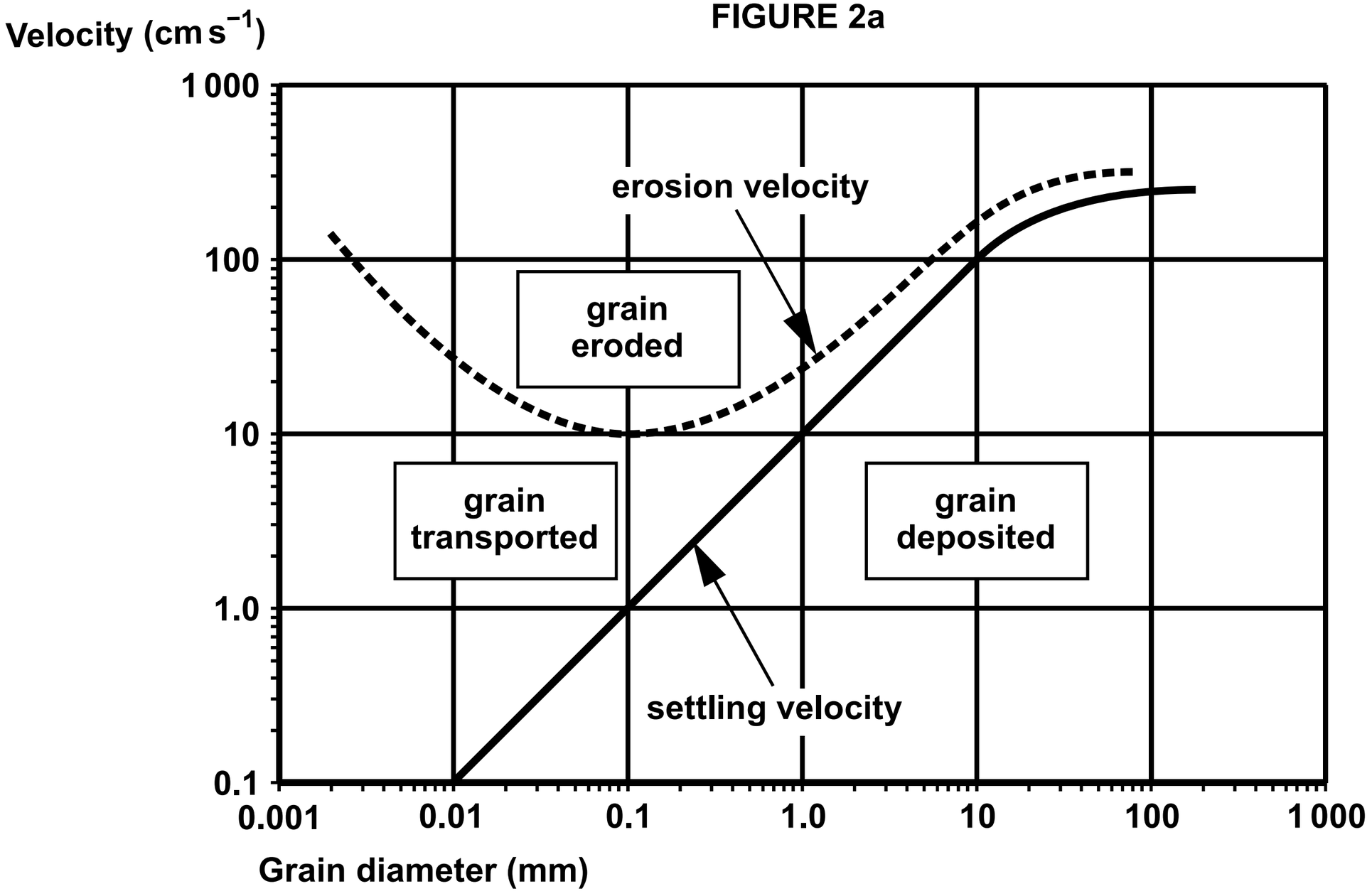
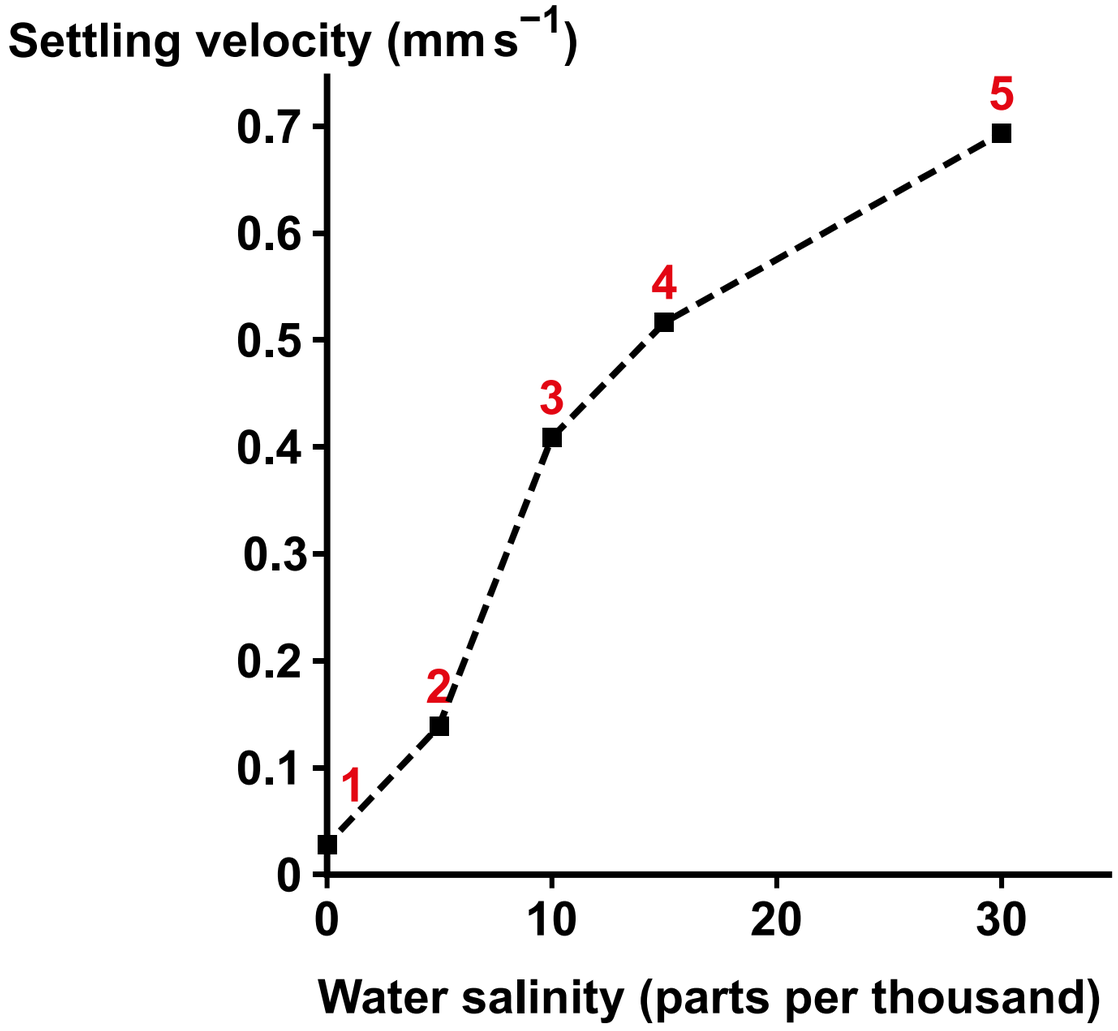
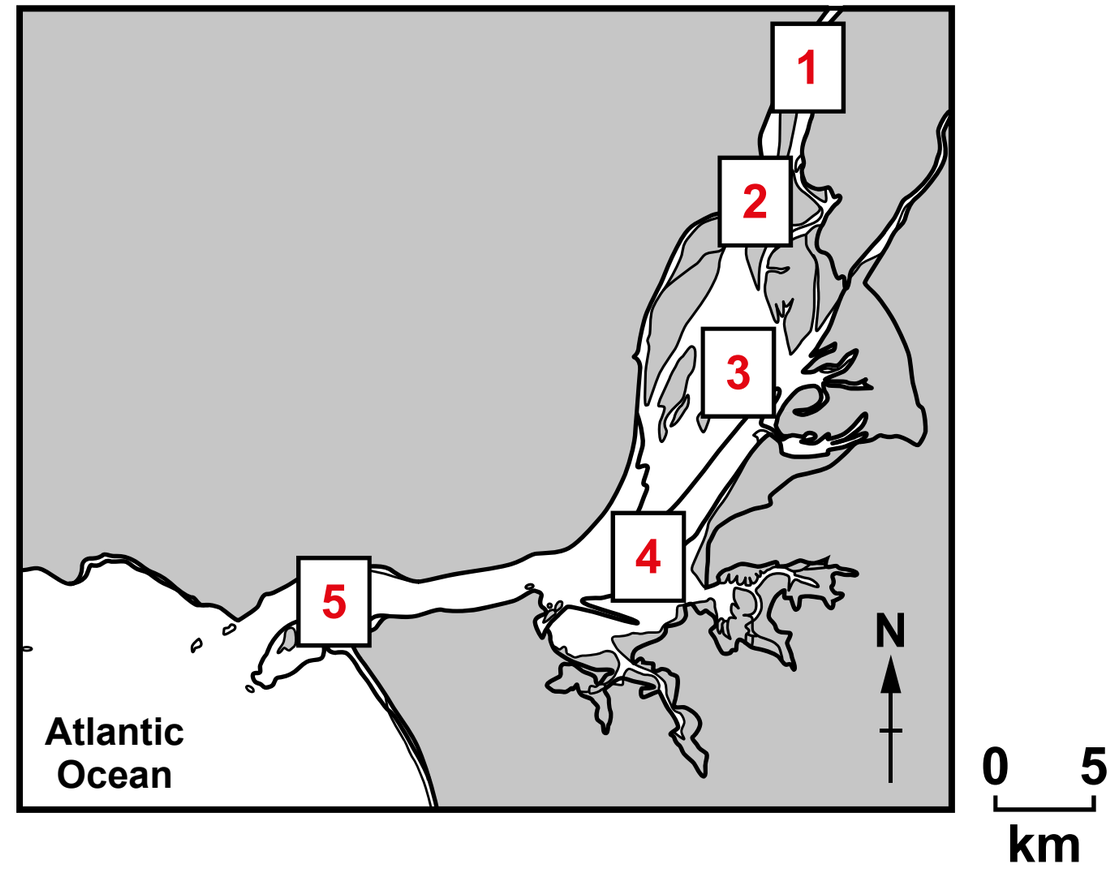

Velocity (cm s^{-1})
1 000
100
10
1.0
0.1
erosion velocity
grain eroded
grain transported
grain deposited
settling velocity
0.001
0.01
0.1
1.0
10
100
1 000
Grain diameter (mm)

FIGURE 2b





Map showing where water samples were obtained

FIGURE 3a

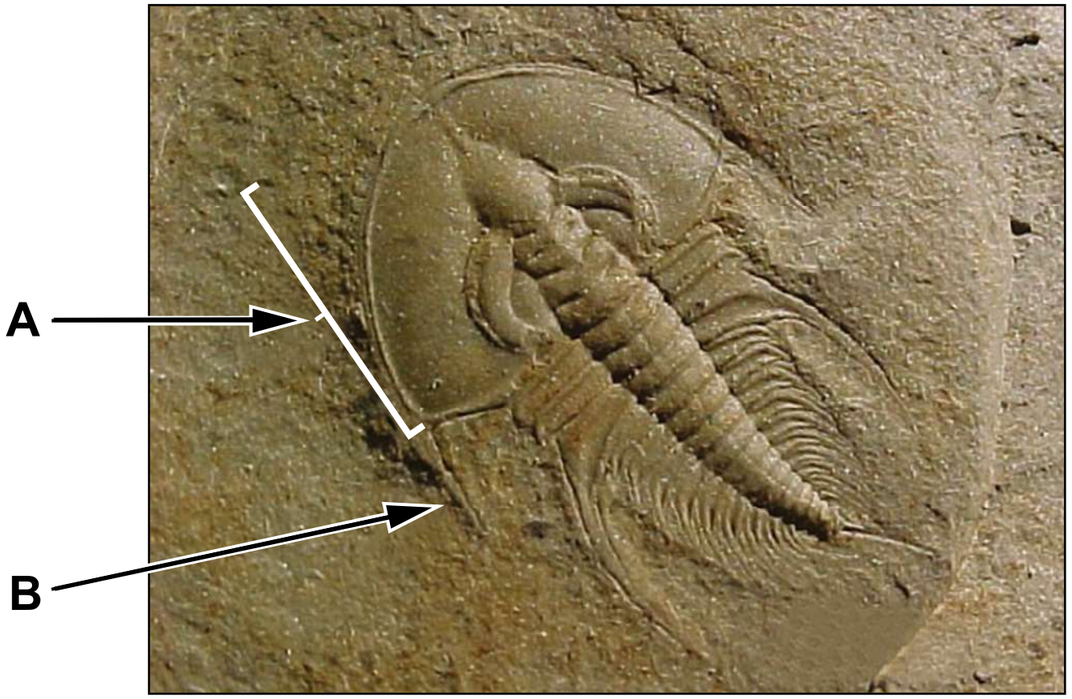


FIGURE 3b

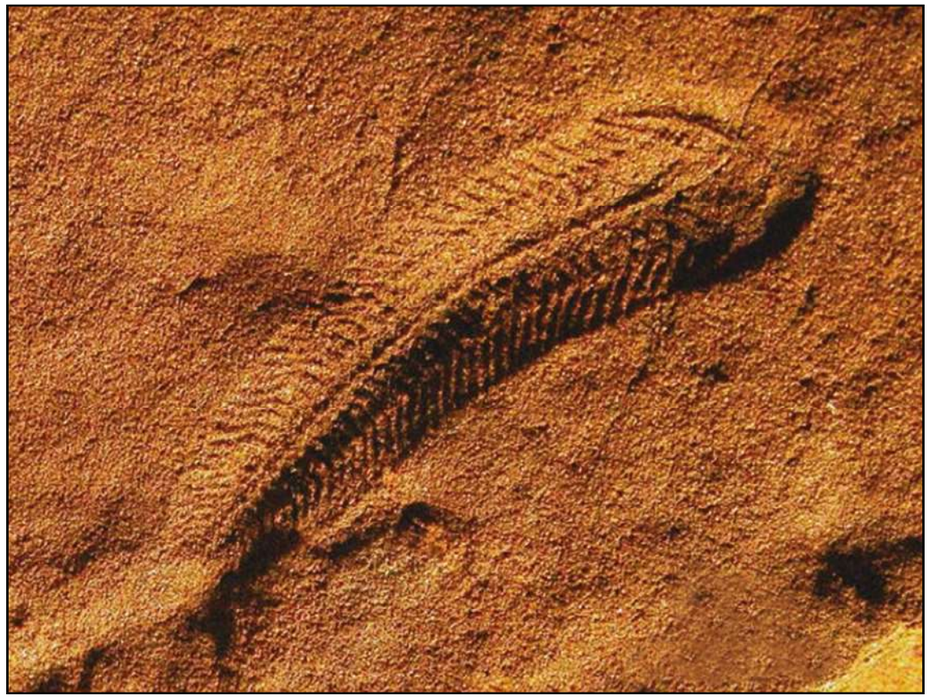


FIGURE 3c

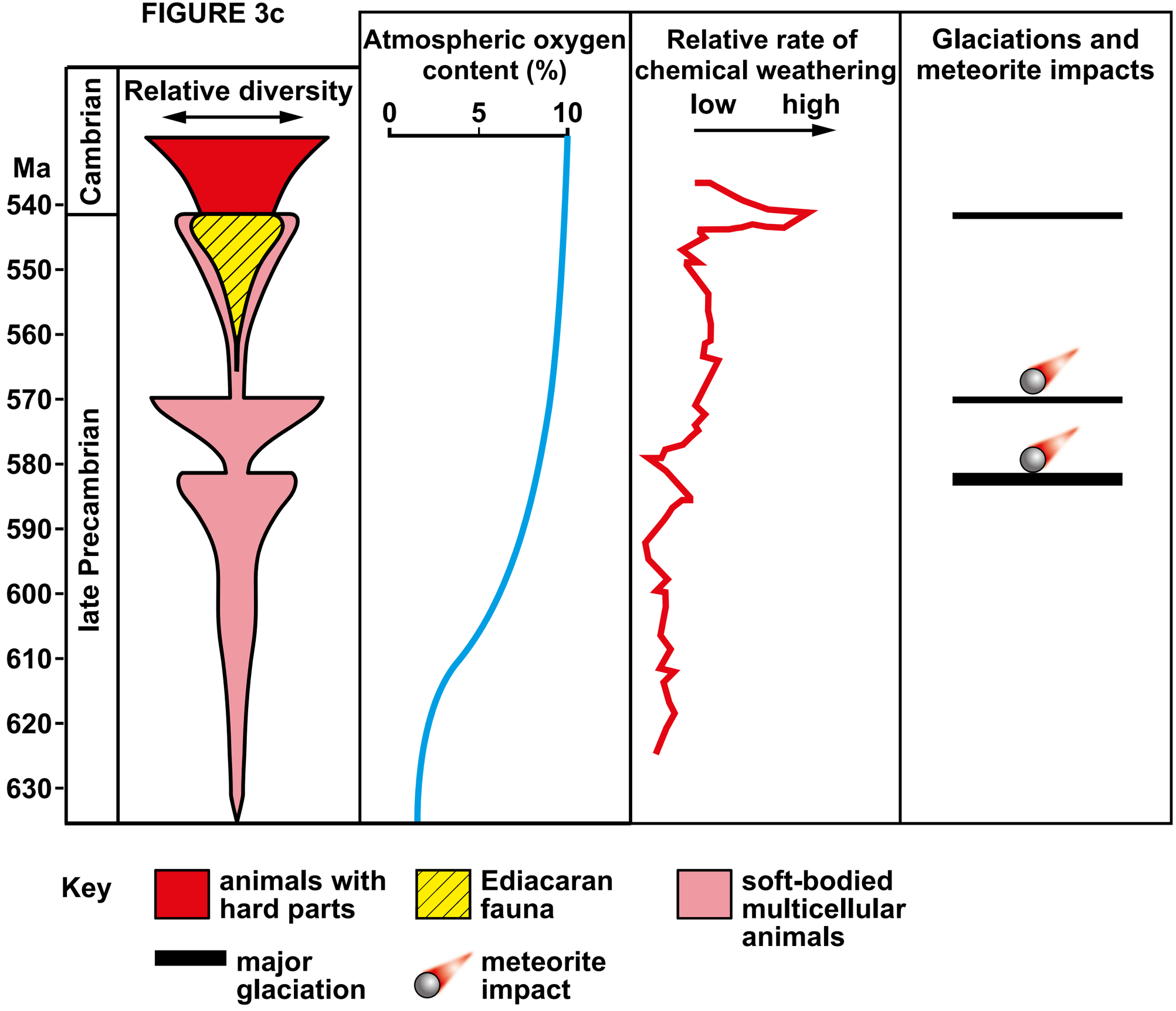
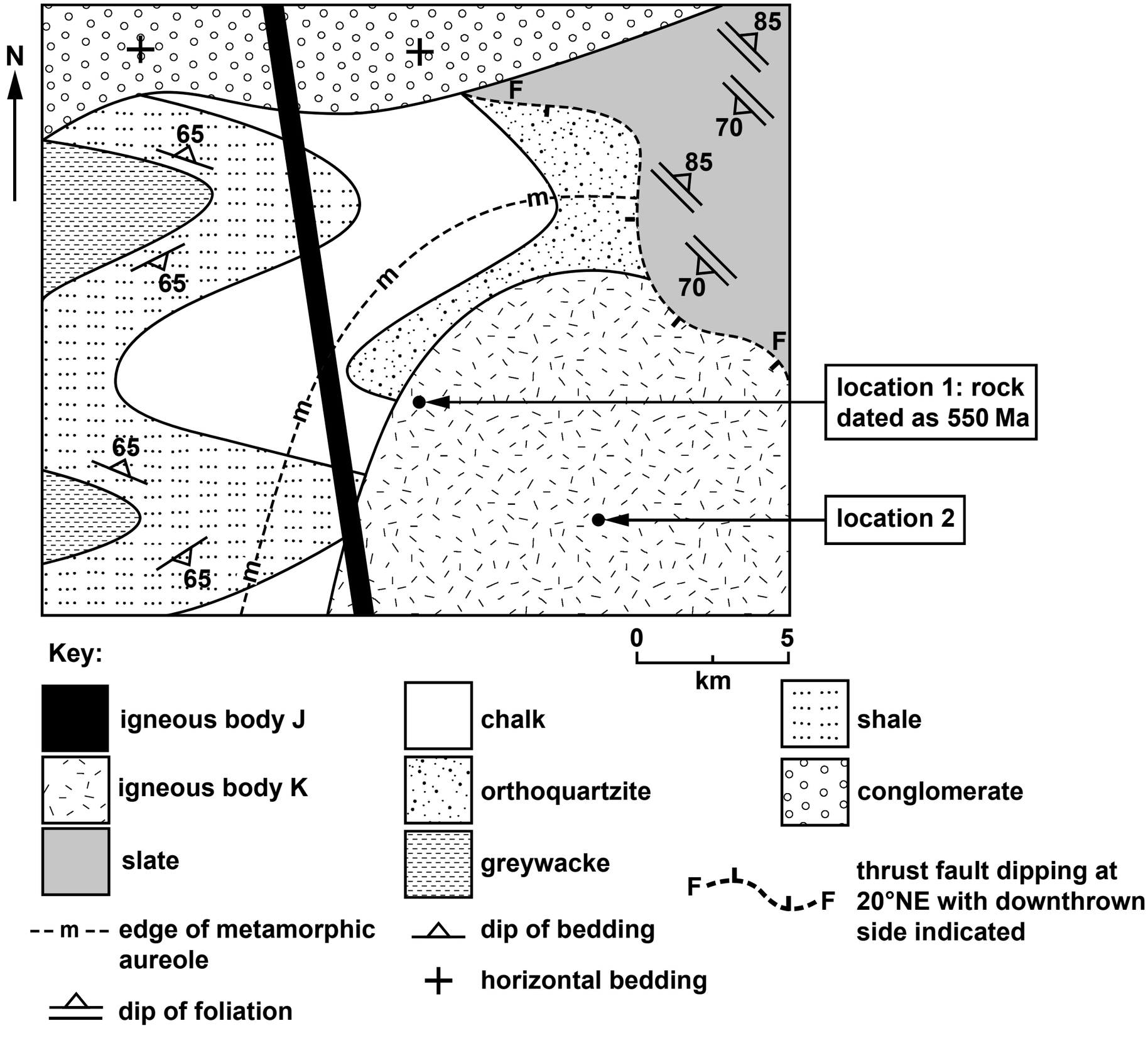

Ma
540
550
560
570
580
590
600
610
620
630
Cambrian
late Precambrian
Relative diversity
Atmospheric oxygen content (%)
0
5
10
Relative rate of chemical weathering
low
high
Glaciations and meteorite impacts
Key
animals with hard parts
Ediacaran fauna
soft-bodied multicellular animals
major glaciation
meteorite impact

FIGURE 4


N
85
70
85
70
F
F
65
65
65
65
m
m
m
m
location 1: rock dated as 550 Ma
location 2
0
5
km
Key:
igneous body J
igneous body K
slate
chalk
orthoquartzite
greywacke
shale
conglomerate
-- m -- edge of metamorphic aureole
dip of foliation
dip of bedding
horizontal bedding
F F
thrust fault dipping at 20°NE with downthrown side indicated

$$t = \left(\frac{T}{0.693}\right) \ln\left(\frac{N_d}{N_p} + 1\right)$$

where

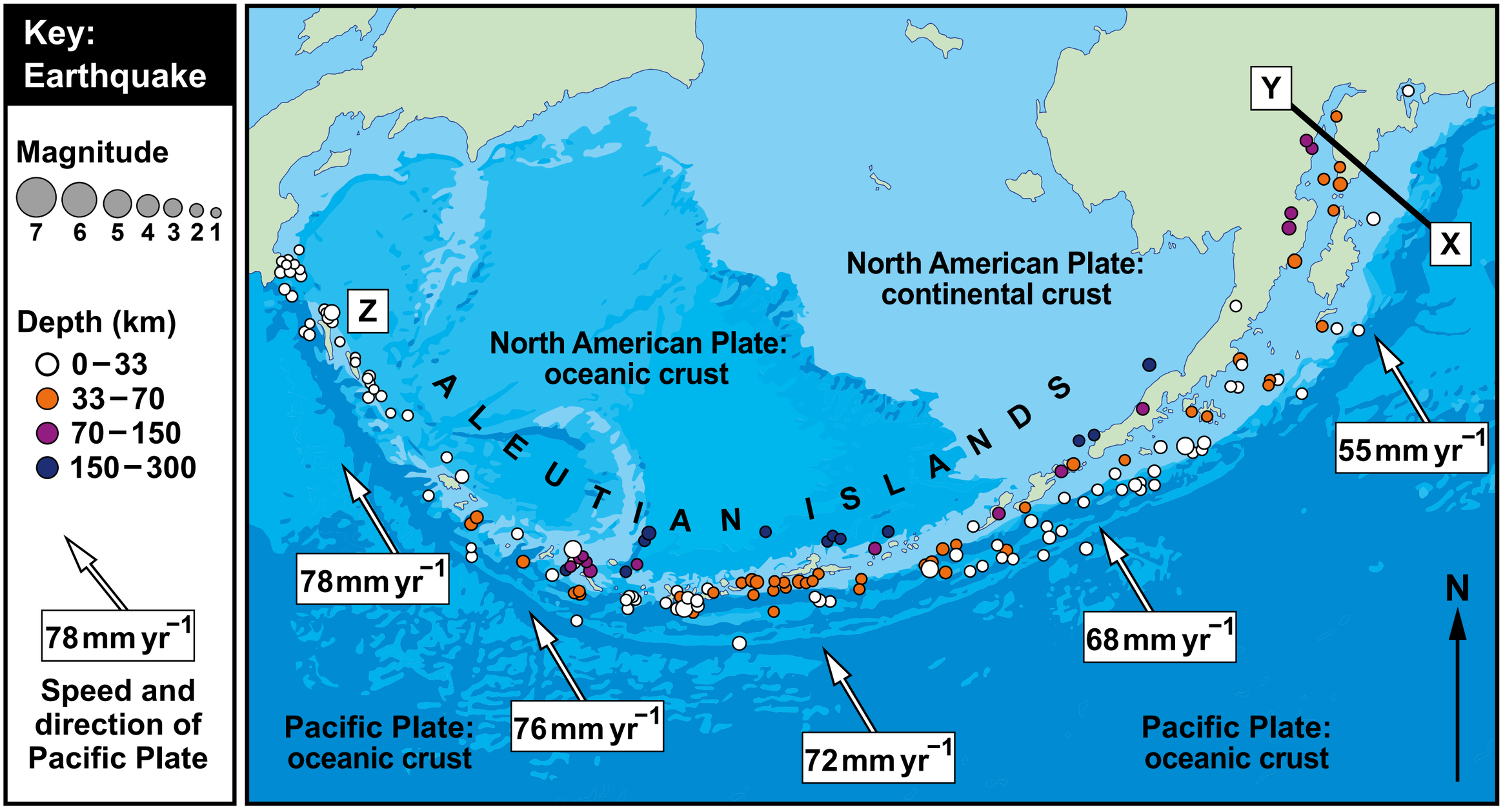
t is the age of the specimen in millions of years,

N_d is the number of daughter atoms,

N_p is the number of parent atoms

and T is the half-life of $^{147}Sm = 1.06 \times 10^5$ Ma.

FIGURE 5a



Increasing age of Pacific Plate oceanic crust

FIGURE 5b

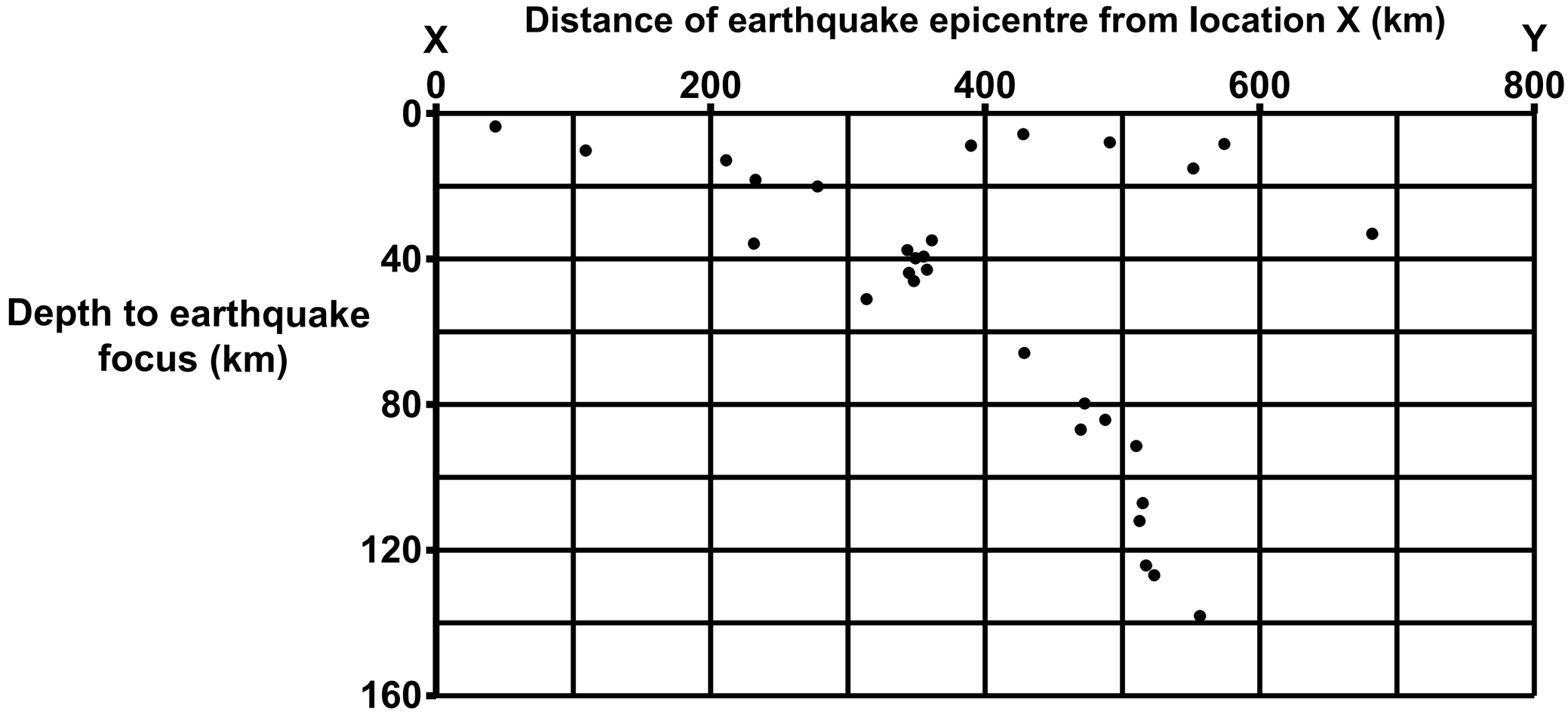

Distance of earthquake epicentre from location X (km)
X
Y
0
200
400
600
800
0
40
80
120
160
Depth to earthquake focus (km)

FIGURE 6a

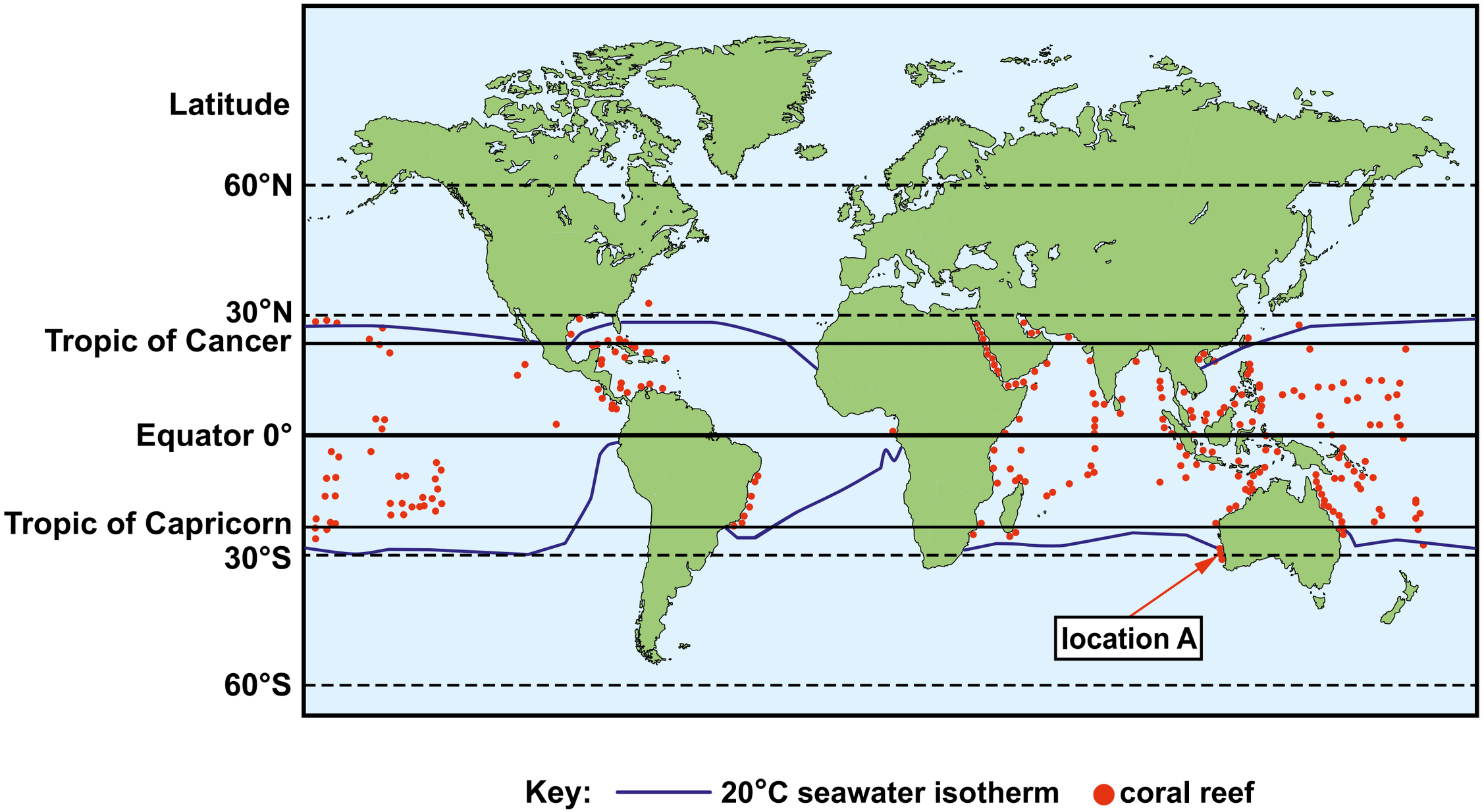

Latitude
60°N
30°N
Tropic of Cancer
Equator 0°
Tropic of Capricorn
30°S
60°S
location A
Key:
20°C seawater isotherm
coral reef

FIGURE 6b

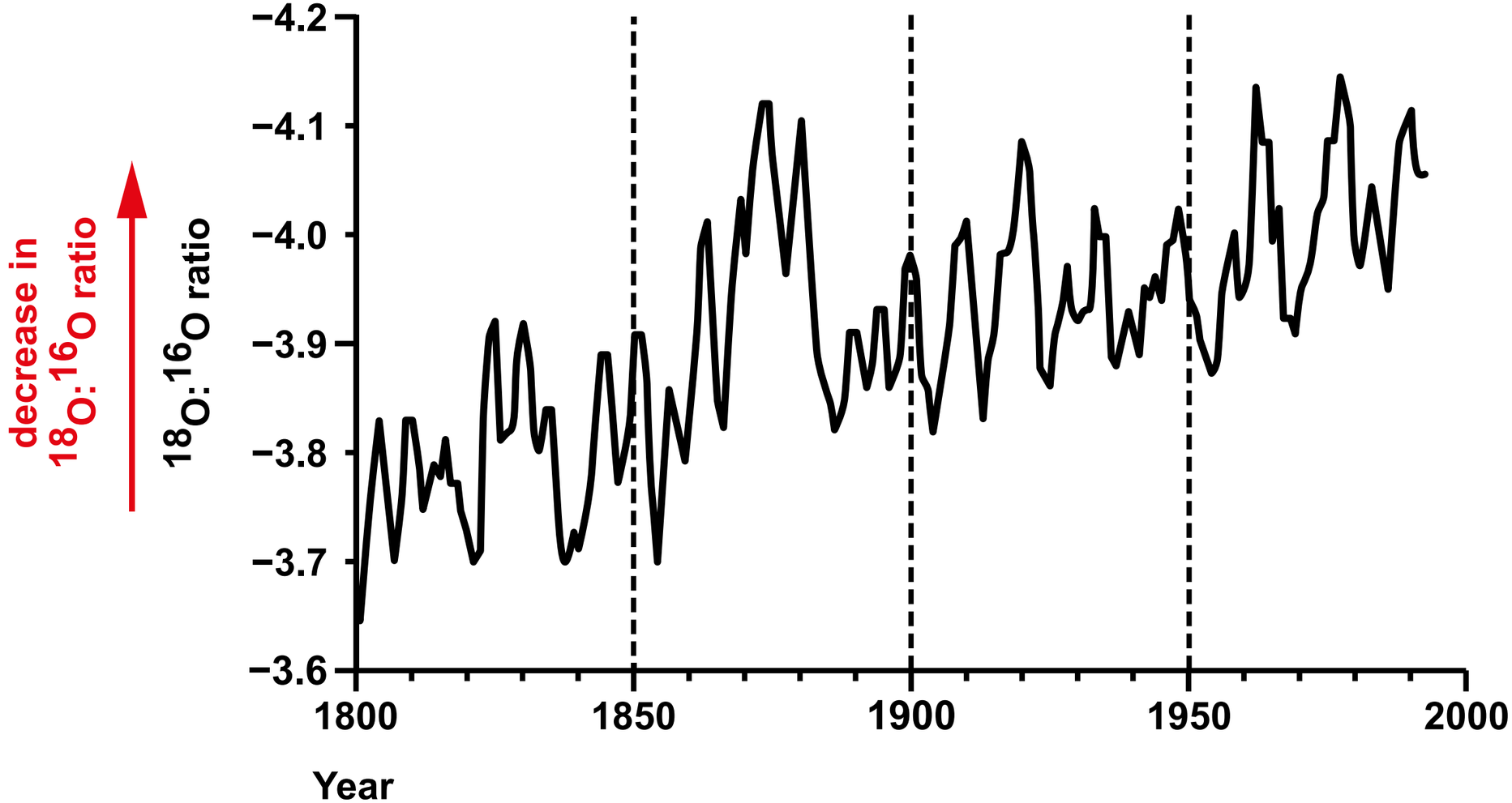
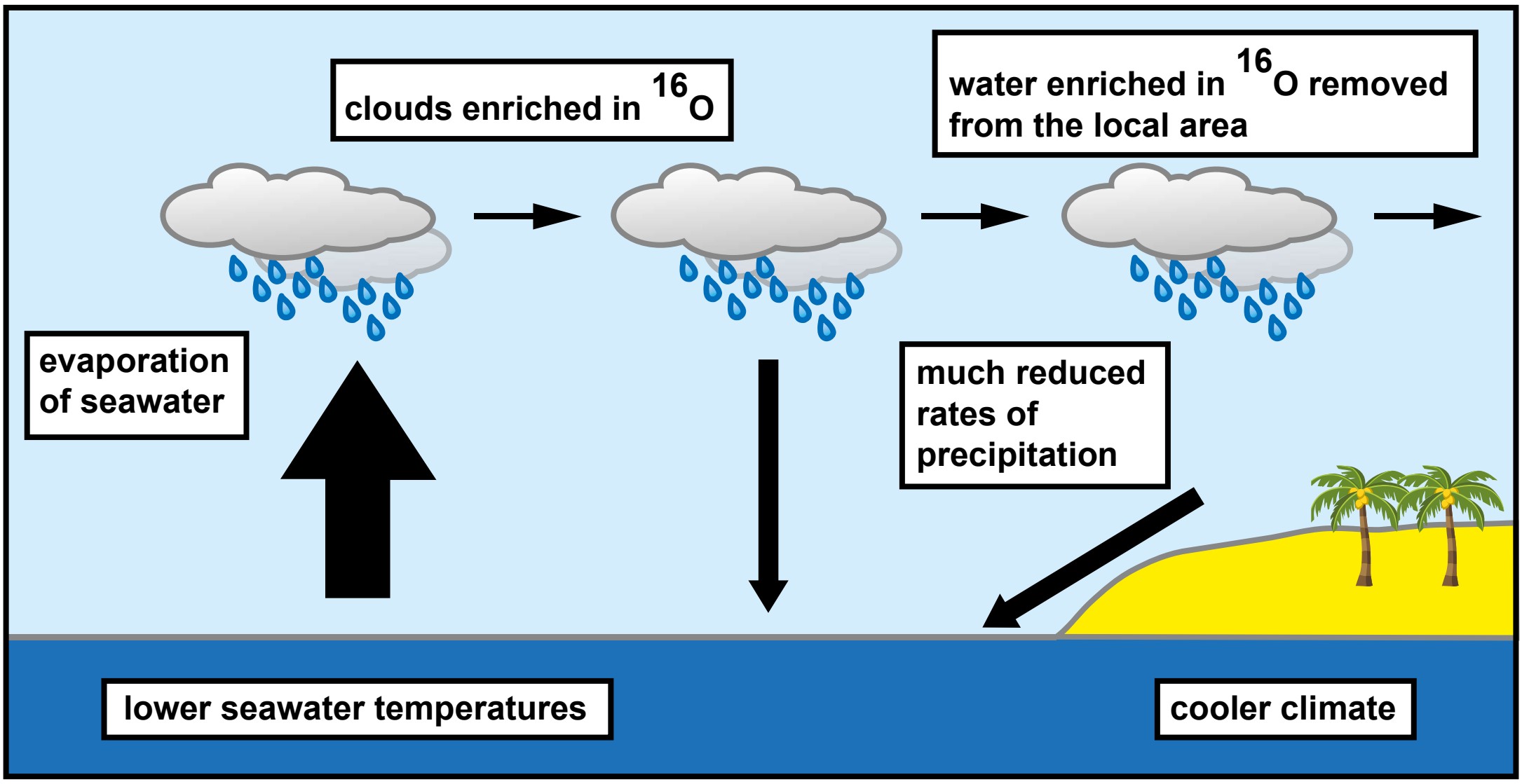
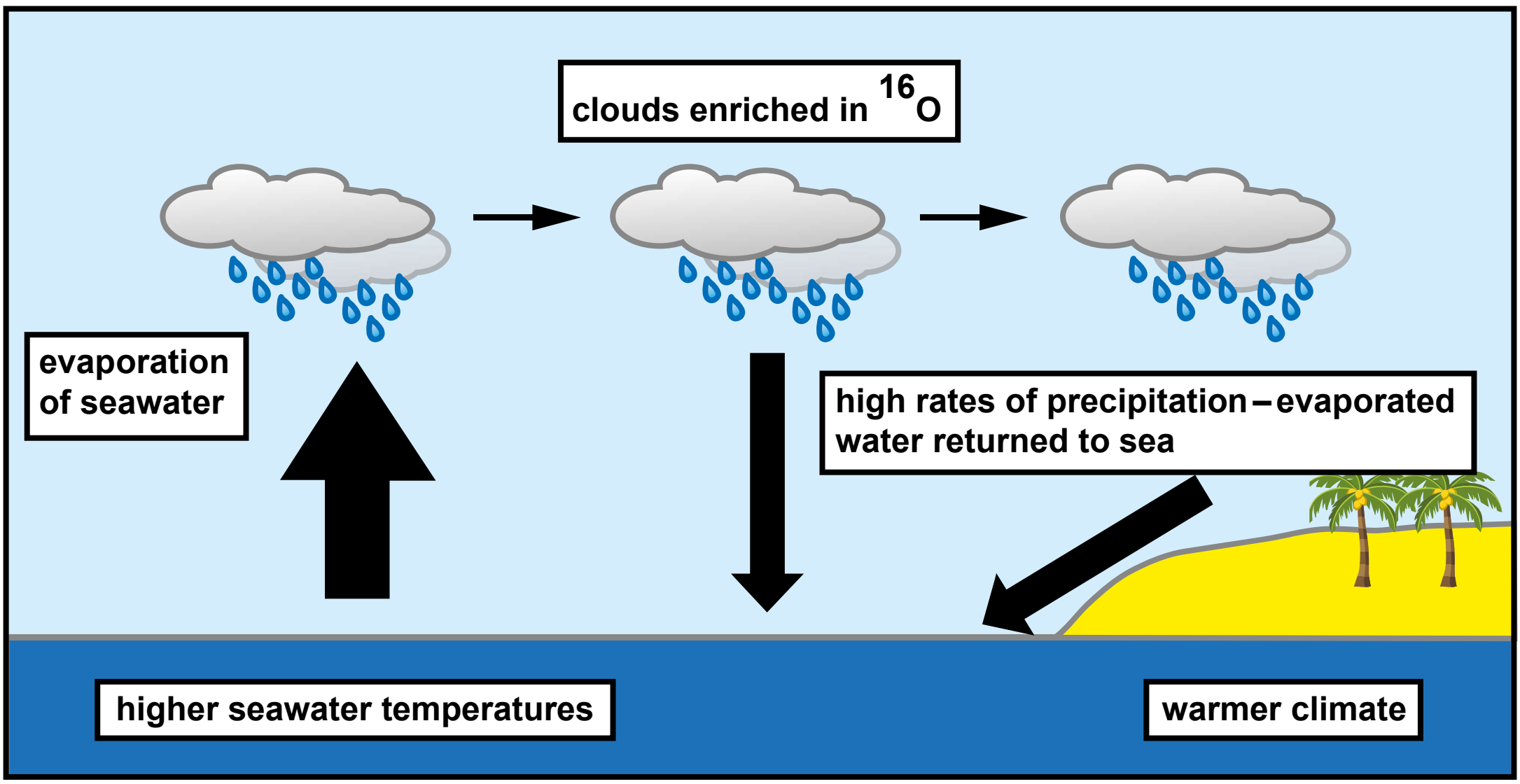

decrease in
18O:16O ratio
18O:16O ratio
−4.2
−4.1
−4.0
−3.9
−3.8
−3.7
−3.6
1800
1850
1900
1950
2000
Year

FIGURE 6c


clouds enriched in ^{16}O
water enriched in ^{16}O removed from the local area
evaporation of seawater
much reduced rates of precipitation
lower seawater temperatures
cooler climate


clouds enriched in ^{16}O
evaporation of seawater
high rates of precipitation – evaporated water returned to sea
higher seawater temperatures
warmer climate