GCE A level

1214/01

GEOLOGY – GL4

Interpreting The Geological Record

A.M. MONDAY, 2 June 2014

2 hours plus your additional time allowance

Surname ______________________

Other Names ______________________

Centre Number ______________________

Candidate Number 2 ______________________

	For Examiner's use only		
	Question	Maximum Mark	Mark Awarded
Section A	1.	15	
	2.	15	
	3.	15	
	4.	15	
Section B	5.	14	
	6.	10	
	7.	4	
	8.	12	
	Total	100	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:
- the Geological Map Extract (Whitehaven);
- a hand-lens or magnifier to study the map (optional);
- a calculator;
- a protractor.

INSTRUCTIONS TO CANDIDATES

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

Write your name, centre number and candidate number in the spaces provided on the front cover.

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.

Candidates are reminded that marking will take into account the quality of communication used in their answers.

FIGURE 1a

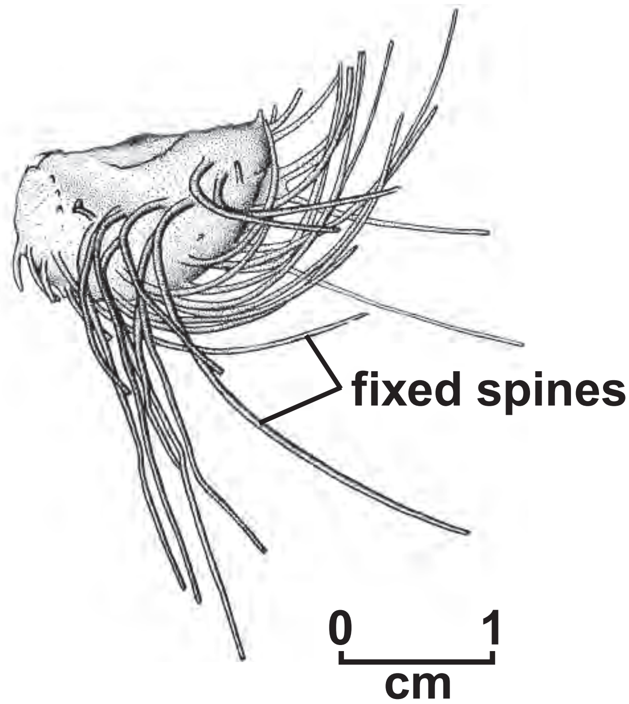
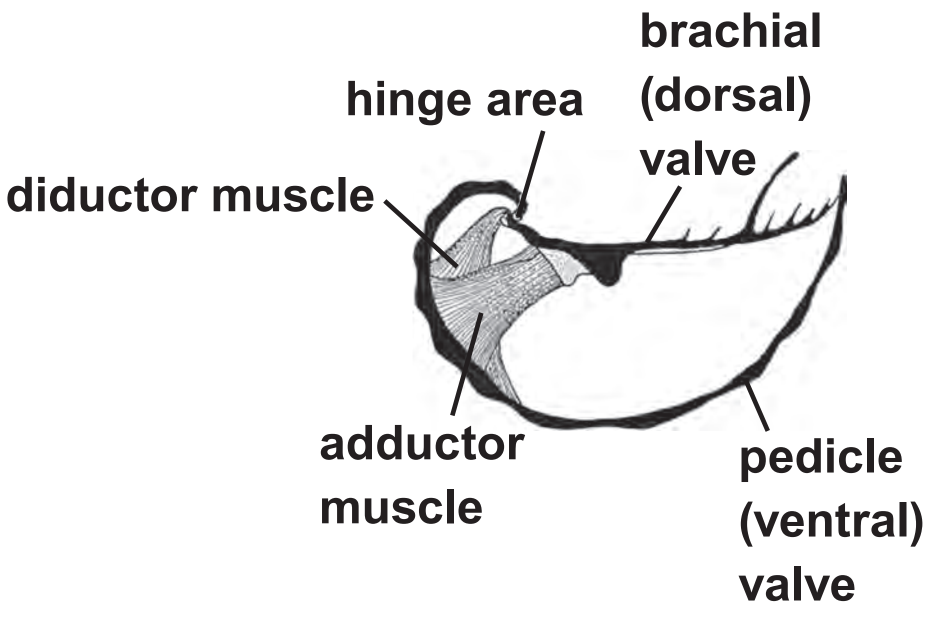


FIGURE 1b



SECTION A

Answer ALL questions in the spaces provided.

This section should take approximately 1 hour to complete.

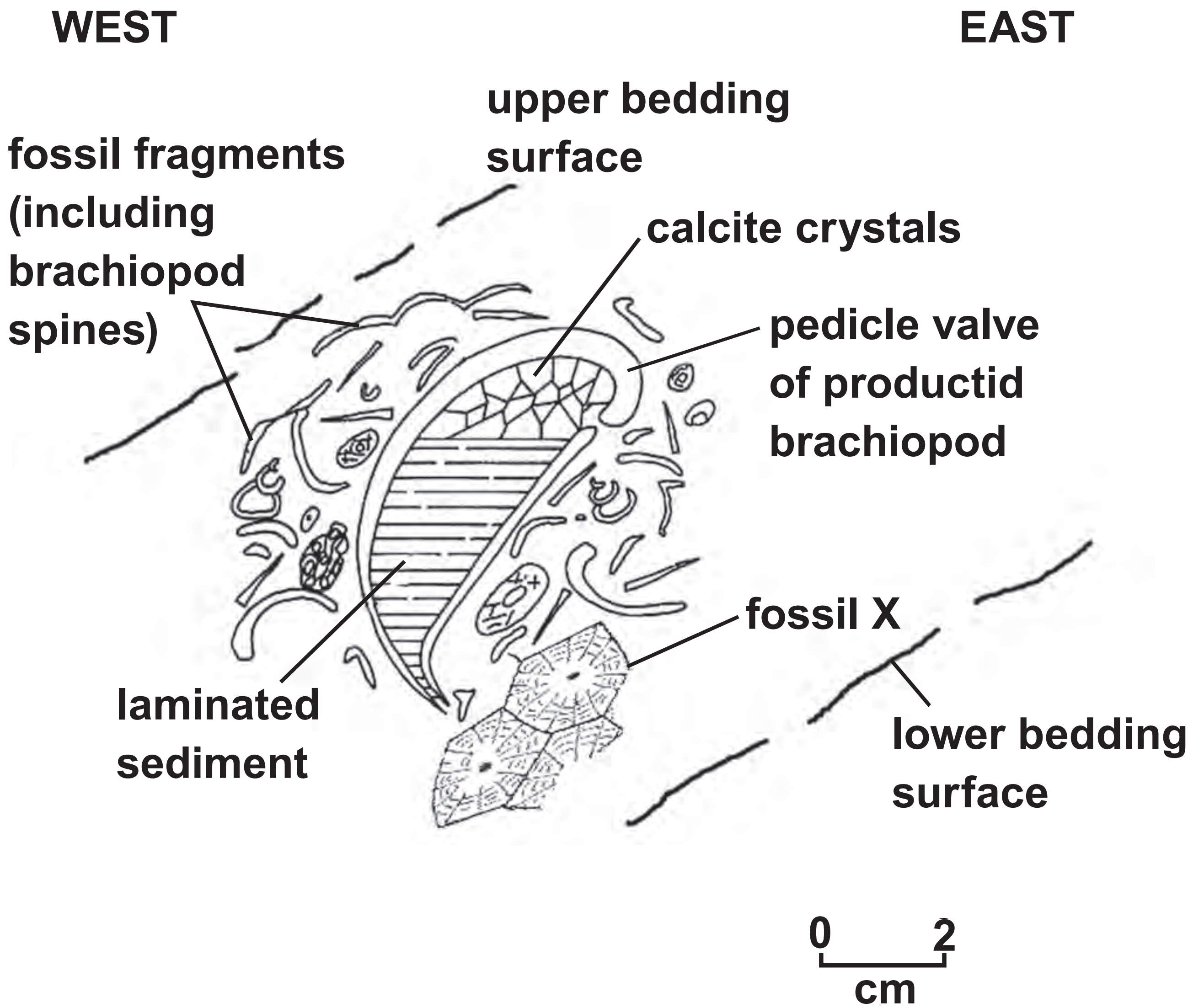
1. FIGURE 1a shows the external morphology of a fossil (productid) brachiopod in life orientation. FIGURE 1b is a reconstruction showing the muscle system of a similar specimen.

(a) Refer to FIGURES 1a and 1b opposite.

(i) Explain how the productid brachiopod opened and closed its valves. [2]

1(a) (ii) With reference to its morphology, describe the probable mode of life of the productid brachiopod. [2]

FIGURE 1c


WEST
EAST
upper bedding surface
fossil fragments (including brachiopod spines)
calcite crystals
pedicle valve of productid brachiopod
fossil X
laminated sediment
lower bedding surface
0
2
cm

1(b) FIGURE 1c opposite is a sketch of a vertical exposure of reef limestone showing true dip.

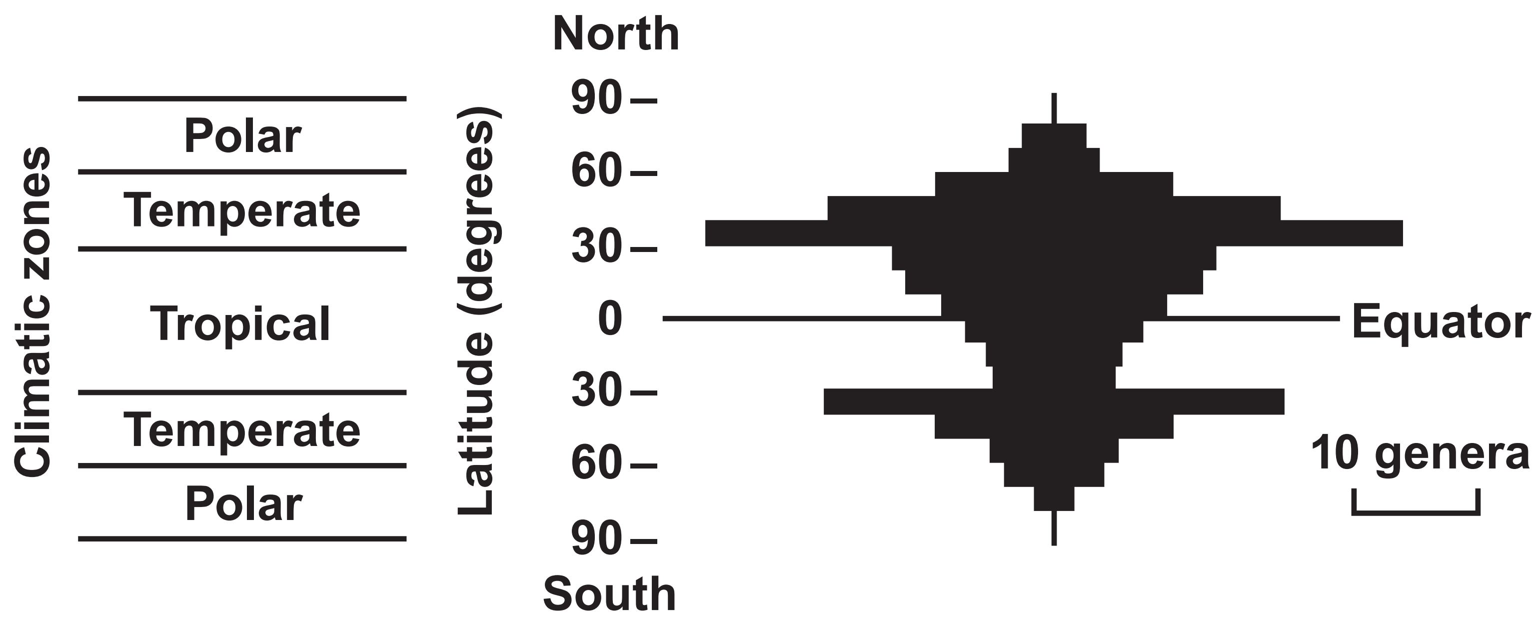
(i) State the fossil group to which FOSSIL X in FIGURE 1c belongs. [1]

(ii) Complete the chart below by measuring the dip of the limestone in FIGURE 1c. [1]

Dip angle of the limestone in FIGURE 1c	•
Dip angle of the sediment infilling the brachiopod shell	Horizontal - zero degrees

1(b) (iii) Explain how the data in FIGURE 1c support the hypothesis that the limestone was laid down on a SLOPE in a high energy, coral reef environment. [3]

FIGURE 1d



The distribution of living brachiopods may be related to

- water depth
- water salinity
- water temperature
- the type of the sea floor (hard rock or mud)

1(c) FIGURE 1d shows the worldwide distribution of living brachiopods.

(i) Describe the distribution of living brachiopods in FIGURE 1d. [2]

(ii) Suggest which ONE of the factors listed in FIGURE 1d is likely to have the most influence on the worldwide distribution of living brachiopods. Explain your answer. [2]

1(d) Suggest in which climatic zone (FIGURE 1d) the limestone in FIGURE 1c was probably deposited. Explain your reasoning. [2]

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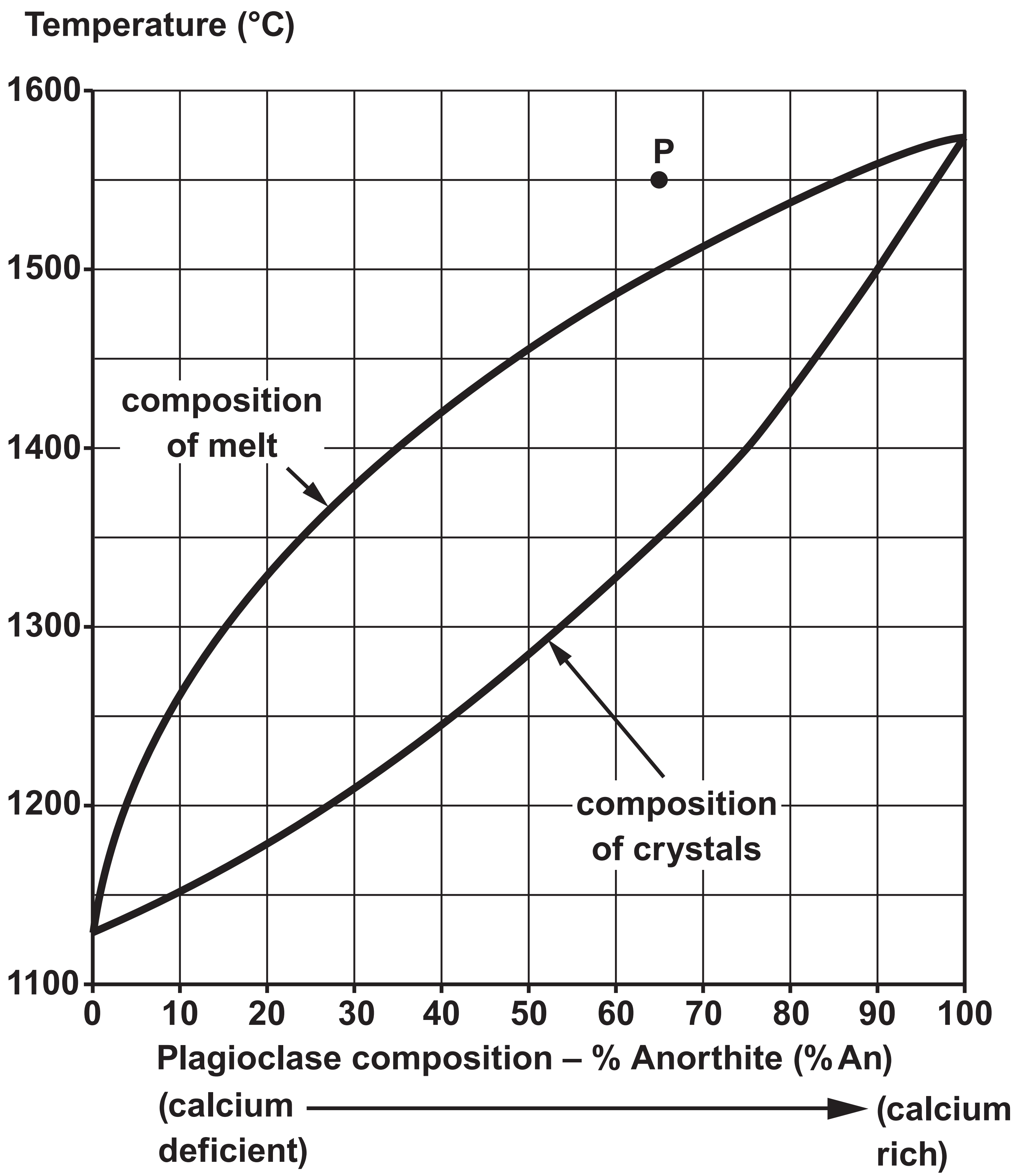
FIGURE 2a


Temperature (°C)
1600
1500
1400
1300
1200
1100
P
composition
of melt
composition
of crystals
0
10
20
30
40
50
60
70
80
90
100
Plagioclase composition – % Anorthite (% An)
(calcium
deficient)
(calcium
rich)

2. FIGURE 2a opposite is a phase diagram showing the experimental crystallisation of plagioclase feldspar over a range of compositions, from Ca-rich plagioclase to Ca-deficient plagioclase, measured in percentage Anorthite (% An).

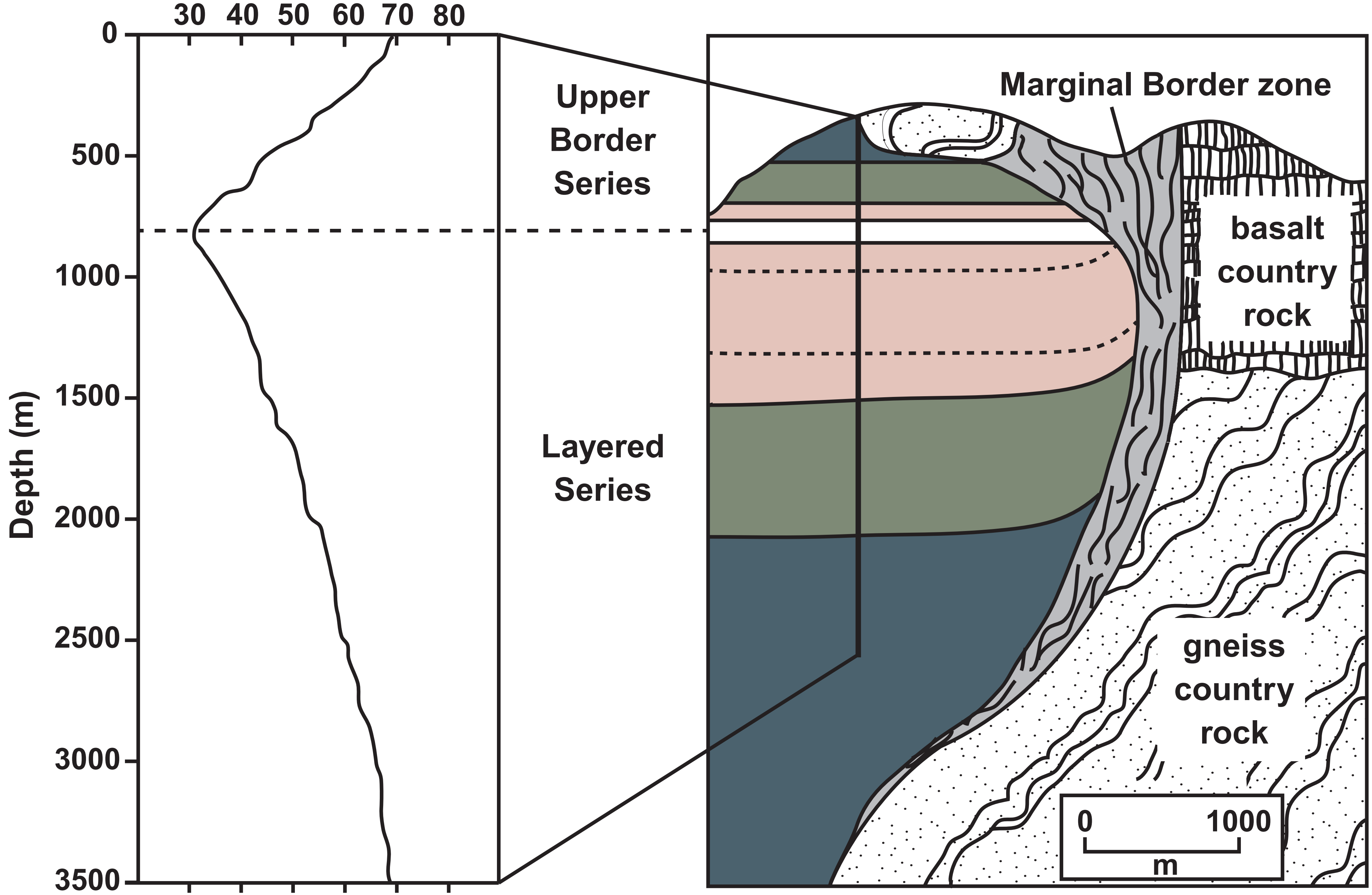
(a) Melt P on FIGURE 2a has the composition of 65% Anorthite (An_{65}).

Complete the box below to show the crystallisation characteristics of melt P as it cools, assuming that the melt remains in EQUILIBRIUM with the crystals that form. [5]

Melt P 65% Anorthite	Temperature of melt (°C)	Composition of melt (% An)	Composition of crystals (% An)
Initial crystallisation	•	65	•
Crystallisation at 1400° C	1400	•	75
Final crystallisation	•		•

FIGURE 2b

FIGURE 2c



The shading represents zones within the intrusion

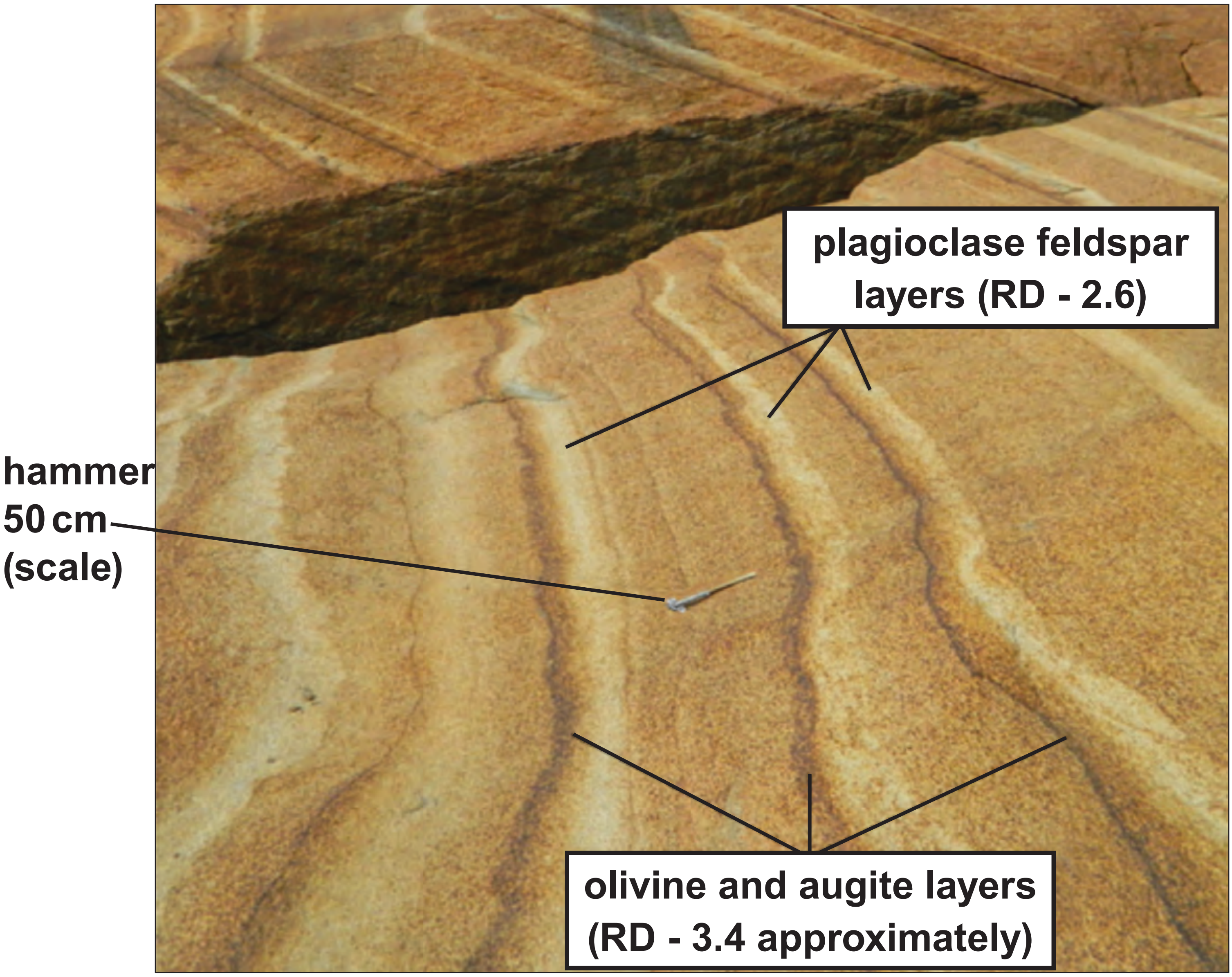
2(b) FIGURE 2b opposite shows changes in the composition of plagioclase feldspar through the Skaergaard Intrusion (Greenland), considered to be a magma chamber which was emplaced by the intrusion of MAFIC magma (FIGURE 2c opposite).

(i) Describe the change in plagioclase feldspar composition through the measured height of the intrusion. [2]

2(b) (ii) With reference to FIGURE 2a, account for the variation in plagioclase feldspar composition through the intrusion. [3]

2(b) (iii) The original composition of the magma in the Marginal Border zone has been contaminated by xenoliths from the adjacent country rock. Suggest which of the country rocks is most likely to have caused the greatest change in the composition of the magma. Explain your answer. [2]

FIGURE 2d


plagioclase feldspar layers (RD - 2.6)
hammer 50 cm (scale)
olivine and augite layers (RD - 3.4 approximately)

2(c) FIGURE 2d opposite is a photograph of part of the Layered Series of the Skaergaard Intrusion showing the relative density (RD) of minerals within the layers.

With reference to FIGURES 2c and 2d, account for the mineral layering. [3]

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3. FIGURE 3 opposite is a partly drawn coastal cliff section, part of which has been obscured by a landslip.

(a) Complete FIGURE 3 by sketching in the geological features described in TABLE 3. Use the appropriate shading provided in the key. [8]

(b) A student concluded that the difference in geology to the east and west of the landslip could best be explained by:

- a fault, dipping west
- showing normal movement
- that had been reactivated

Evaluate these statements explaining the EVIDENCE for your conclusions.

(i) a fault, dipping west [2]

3(b) (ii) showing normal movement [3]

(iii) that had been reactivated [2]

15

4. FIGURE 4a opposite shows two fossil leaves used to indicate changes in climate based on leaf shape. FIGURE 4b opposite shows the correlation between mean annual temperature and leaf shape in modern leaves.

(a) Refer to FIGURE 4a.

Describe TWO differences in the shapes of leaves X and Y. [2]

1. ____

____

2. ____

____

4(b) Refer to FIGURE 4b.

(i) Describe the correlation in FIGURE 4b. [2]

____

____

____

____

____

____

(ii) Identify which of the fossil leaves (X or Y) best represents the most common shape of leaf margin species at point P in FIGURE 4b. Explain your answer. [2]

Leaf (X or Y) ☐

Explanation______________________________

____

____

____

____

____

FIGURE 4c

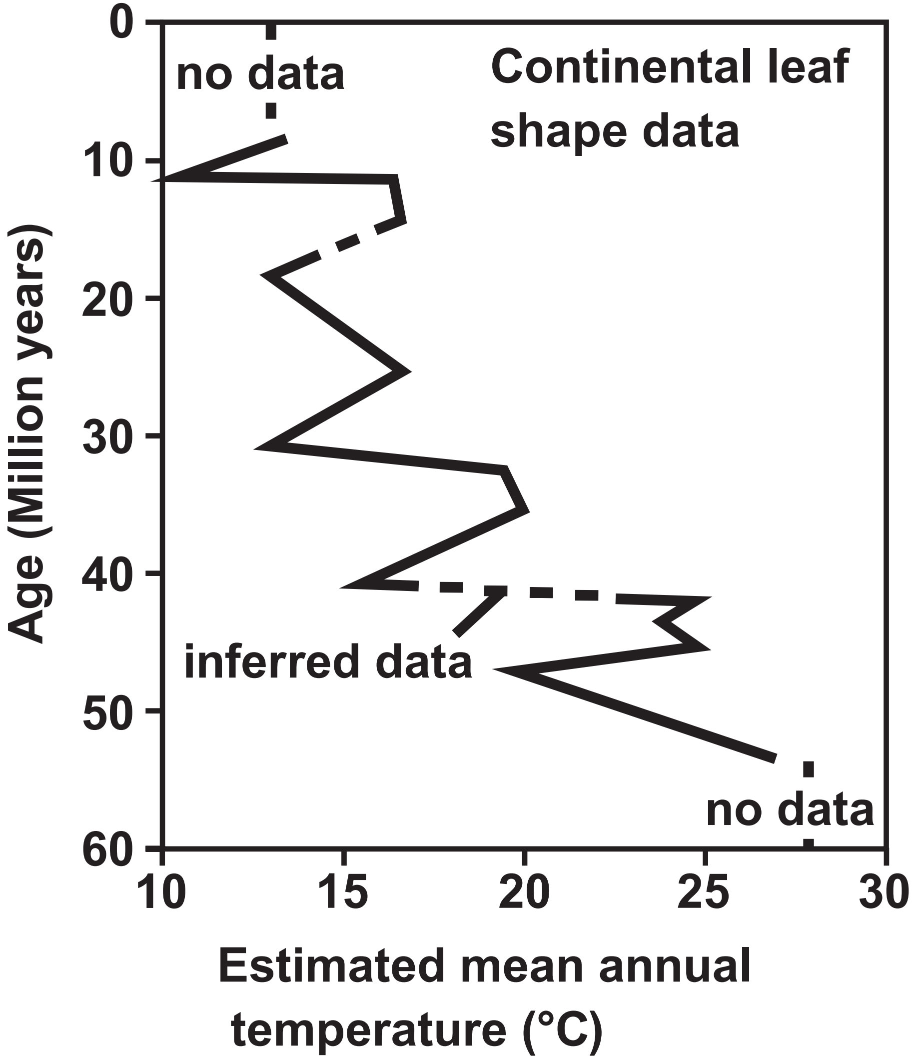
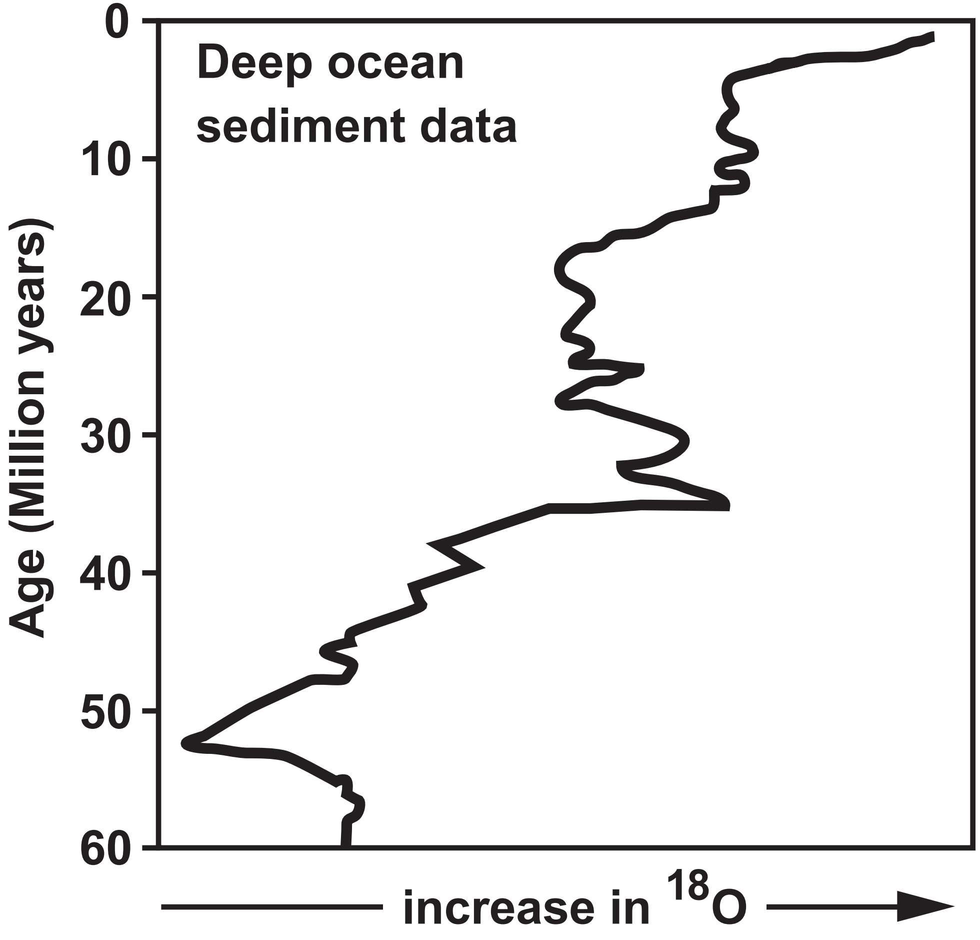


FIGURE 4d



4(c) FIGURE 4c opposite shows the estimated variation in mean annual temperature based on the outline shapes of fossil leaves during the last 60 million years. FIGURE 4d opposite shows the variation in ^{18}O:^{16}O ratios measured in deep ocean sediments over the same period.
(after Ruddiman: Earth's Climate, Past and Present).

(i) On FIGURE 4c, mark in a line of best fit for the data set. [1]

(ii) Describe the changes in the mean annual temperature during the last 60 million years based on leaf shape, in FIGURE 4c. [2]

4(c) (iii) **With reference to FIGURE 4d, explain the overall increase in ^{18}O recorded in deep ocean sediments during the last 60 million years. [3]**

4(d) **With reference to FIGURES 4c and 4d AND YOUR KNOWLEDGE, suggest why the continental temperature record, based on leaf shape, may be less reliable than the record obtained from deep ocean sediments. [3]**

15

SECTION B

Questions 5–8 relate to the BRITISH GEOLOGICAL SURVEY 1:50 000 GEOLOGICAL MAP extract of WHITEHAVEN

**Answer ALL questions in the spaces provided.
This section should take approximately 1 hour to complete.**

5(a) Refer to boxes X and Y on the GEOLOGICAL MAP.

(i) Calculate the MEAN angle of dip of the St Bees Sandstone (SBS) within box X. Show your working. [2]

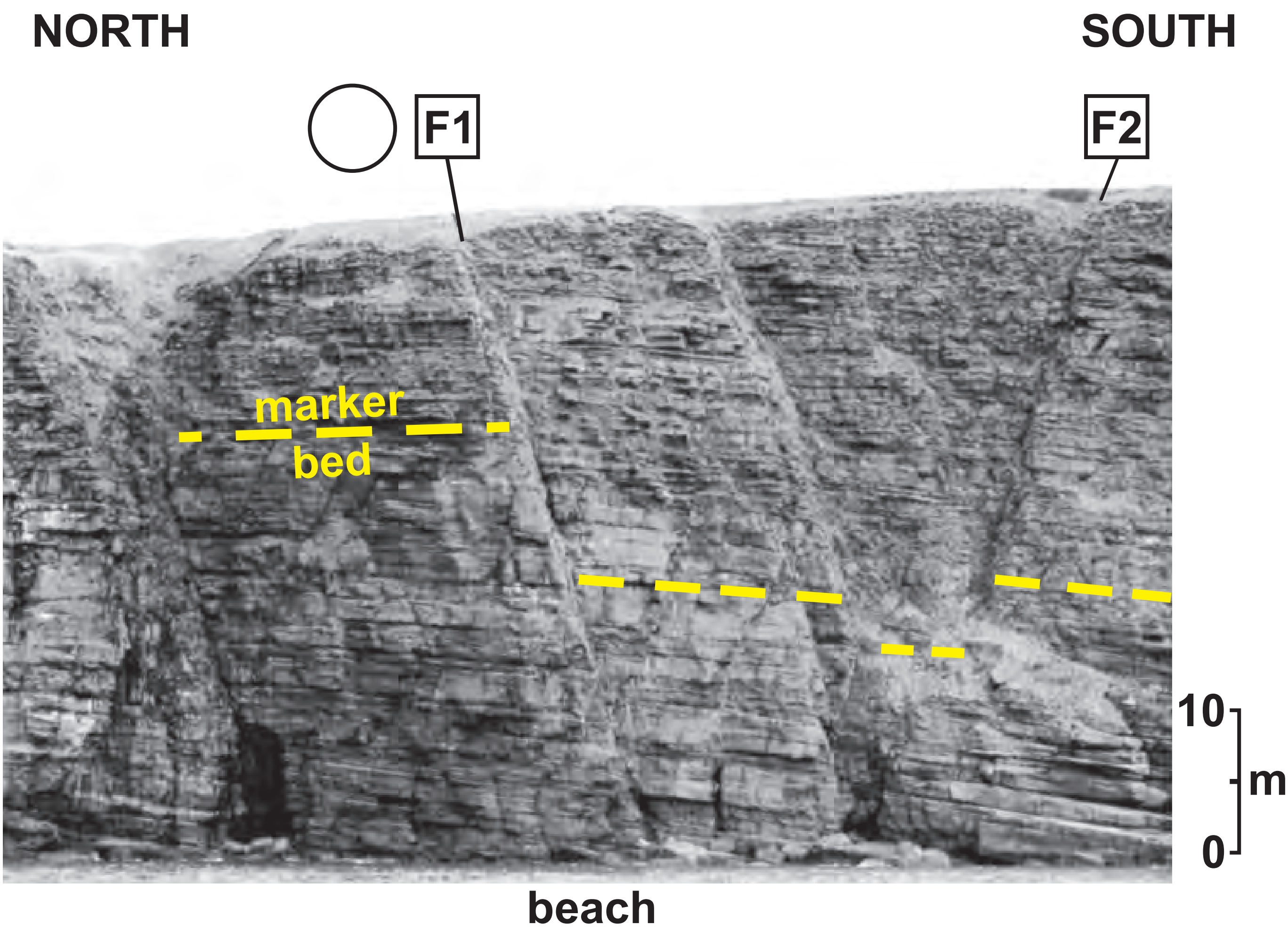
Mean dip = ______________________ degrees

5(a) (ii) Using an annotated diagram(s), describe the field measurements that were made at these localities so that the dip symbols could be plotted. [3]

5(a) (iii) State how the outcrop pattern in box Y on the GEOLOGICAL MAP suggests that the St Bees Sandstone (SBS) is dipping at

- a low angle
- to the SW. [3]

FIGURE 5



5(b) FIGURE 5 opposite is a photograph of the cliff face at South Head (GRID REFERENCE – GR 950120).

(i) Complete TABLE 5 to describe the fault characteristics of the two faults (F1 and F2) shown at South Head on FIGURE 5. [3]

TABLE 5

Fault characteristic	Fault F1	Fault F2
Apparent dip of fault (degrees)	•	
Throw (m)	•	5 m
Fault type	Normal	•

5(b) (ii) Draw an arrow (↖↘) in the blank circle on FIGURE 5 to show the orientation of the principal stress component, σ MAX for fault F1. [1]

(iii) With reference to the GEOLOGICAL MAP, CROSS-SECTION and FIGURE 5, compare the faults at North Head (GRID SQUARE 9414) with South Head (FIGURE 5) by stating ONE similarity and ONE difference in the orientation of the principal stress component, σ MIN. [2]

Similarity ______________________________

____

____

____

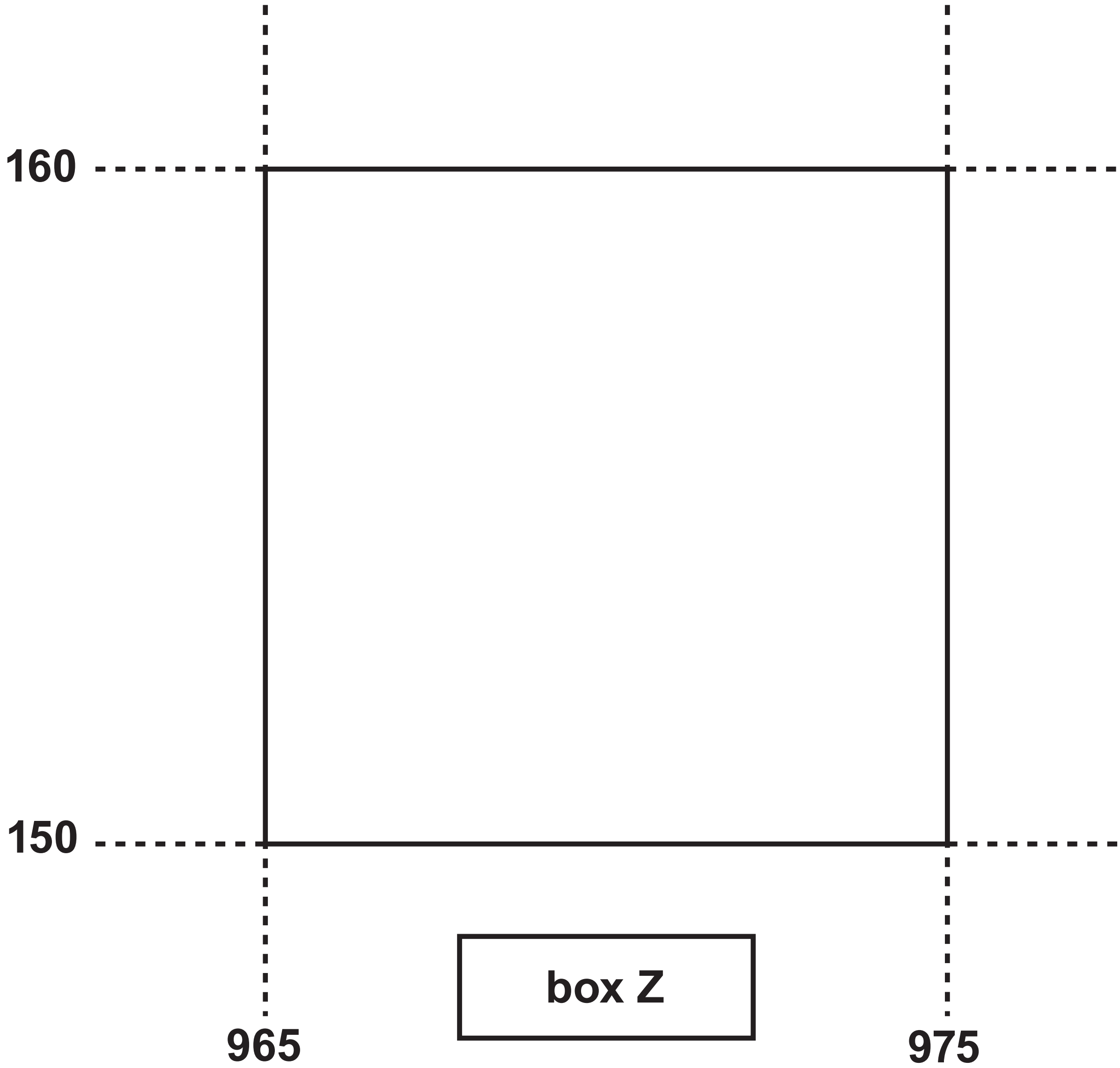
Difference ______________________________

____

____

____

14


160
150
box Z
965
975

6. The GENERALISED GEOLOGICAL column indicates an unconformity at the base of the Permo-Triassic Brockram (BK).

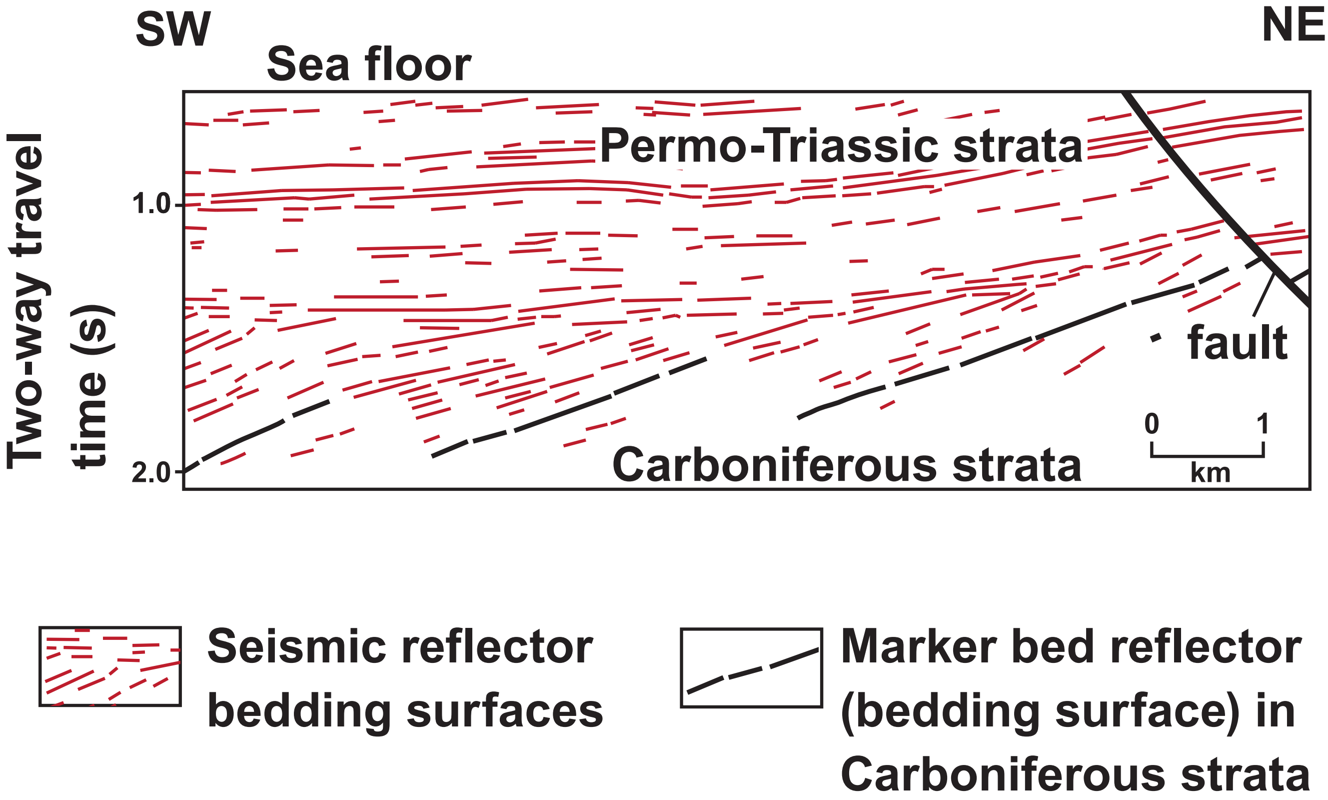
(a) (i) In the blank grid square opposite, draw and label the map evidence for this unconformity from box Z on the GEOLOGICAL MAP.

Carefully label on your map

- the LINE OF UNCONFORMITY
- the RELATIVE AGE of the strata (younger or older) that crop out on either side of the unconformity. [3]

(ii) With reference to the GENERALISED GEOLOGICAL COLUMN suggest the most probable reason for the variation in the width of outcrop of the St Bees Evaporite (SBE) in box Z. [1]

FIGURE 6



Note: Although the horizontal scale is in kilometres, the vertical scale is two-way travel time (in seconds), not depth. Two-way travel time is the time taken for seismic waves to travel from the surface to a sub-surface rock boundary (a bedding plane, fault etc.) and back to the surface.

6(b) FIGURE 6 opposite is an offshore seismic reflection section recorded to the west of the geological map in the Irish Sea.

(i) Mark and label on FIGURE 6 the extent of

1. the unconformity at the base of the Brockram (BK),

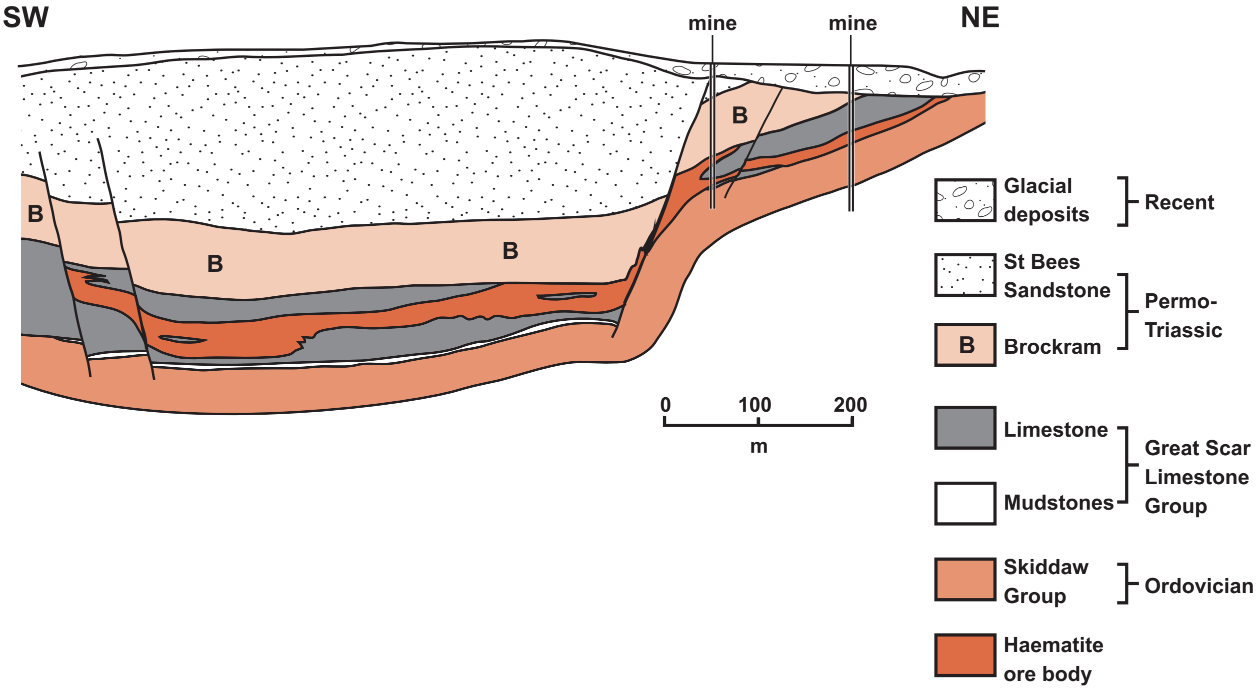
2. TWO INCLINED faults that are older than the unconformity. [4]

(ii) The mean seismic wave velocity through this section is 2.15 $km\,s^{-1}$ (kilometres per second). Calculate the MAXIMUM depth of the marker bed reflector in Carboniferous strata, on the seismic section. Show your working. [2]

Depth = ______________________ km

10

FIGURE 7



HAEMATITE – IRON ORE

The formation of the haematite iron ore bodies is believed to be associated with

1. iron-rich mineralising fluids,

2. fluids percolating through fractures and permeable strata,

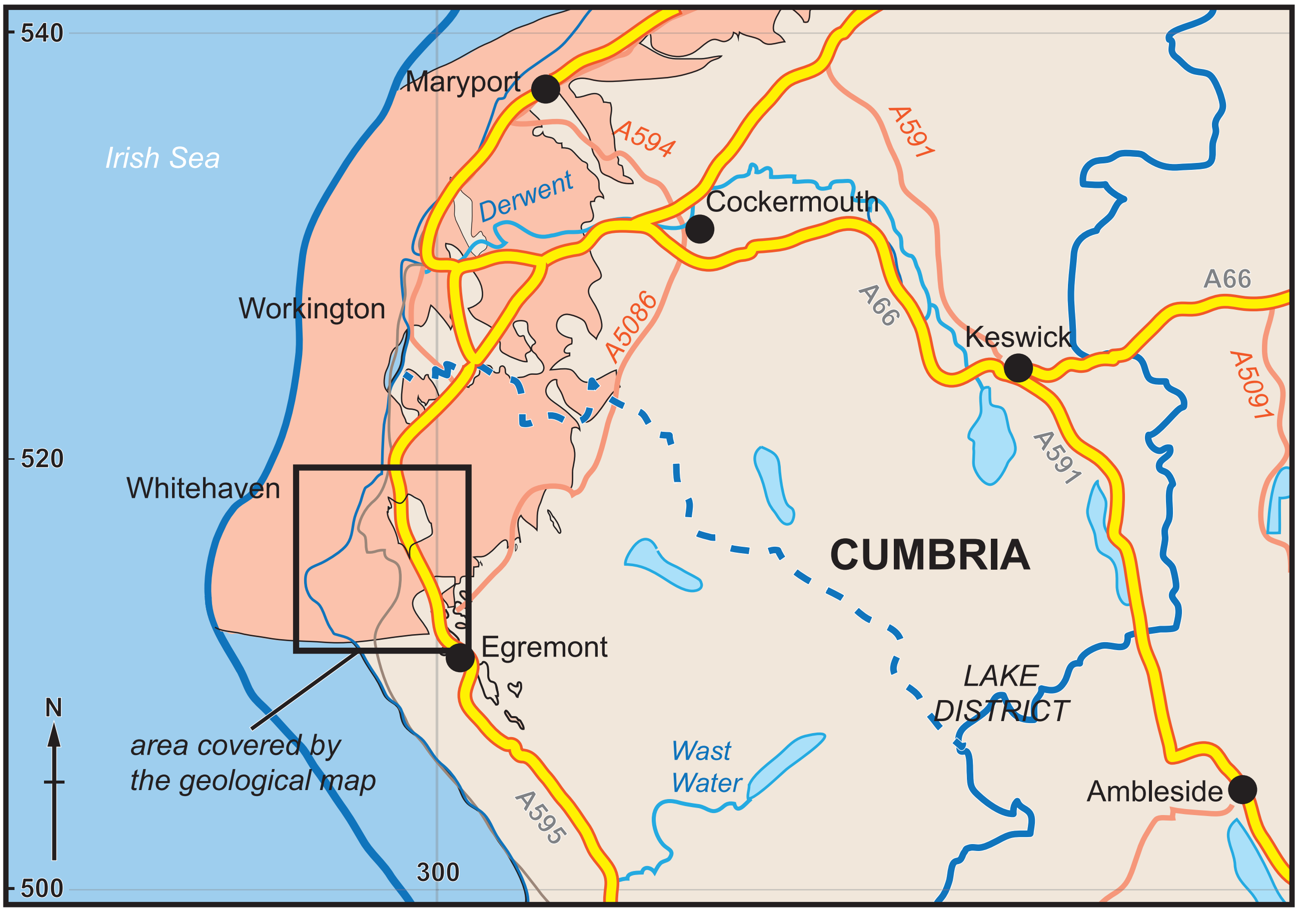
3. the replacement of limestone.

7. **FIGURE 7 opposite shows a section through a typical haematite ore body seen on the geological map, (e.g. grid square 0011).**

Using the GEOLOGICAL MAP and FIGURE 7, evaluate the evidence that suggests the distribution of haematite ore bodies is controlled by rock type and structure. [4]

4

FIGURE 8a



excluded area – area excluded where one or more of the exclusion criteria apply to the whole rock volume between 200 m and 1000 m depth

survey boundaries

8. FIGURE 8a opposite shows the result of a survey to rule out areas of west Cumbria (including up to 5 km offshore) that are geologically unsuitable to host a radioactive waste disposal facility. TABLE 8 shows the exclusion criteria used in the survey.

TABLE 8

EXCLUSION CRITERIA
The survey criteria were based only on the need to EXCLUDE areas: 1. where exploitable freshwater groundwater resources exist BELOW 200 m deep; 2. where one or more natural resources exist BELOW 200 m deep (minerals, fossil fuels and alternative energy resources) that might be exploited by future generations.

FIGURE 8b

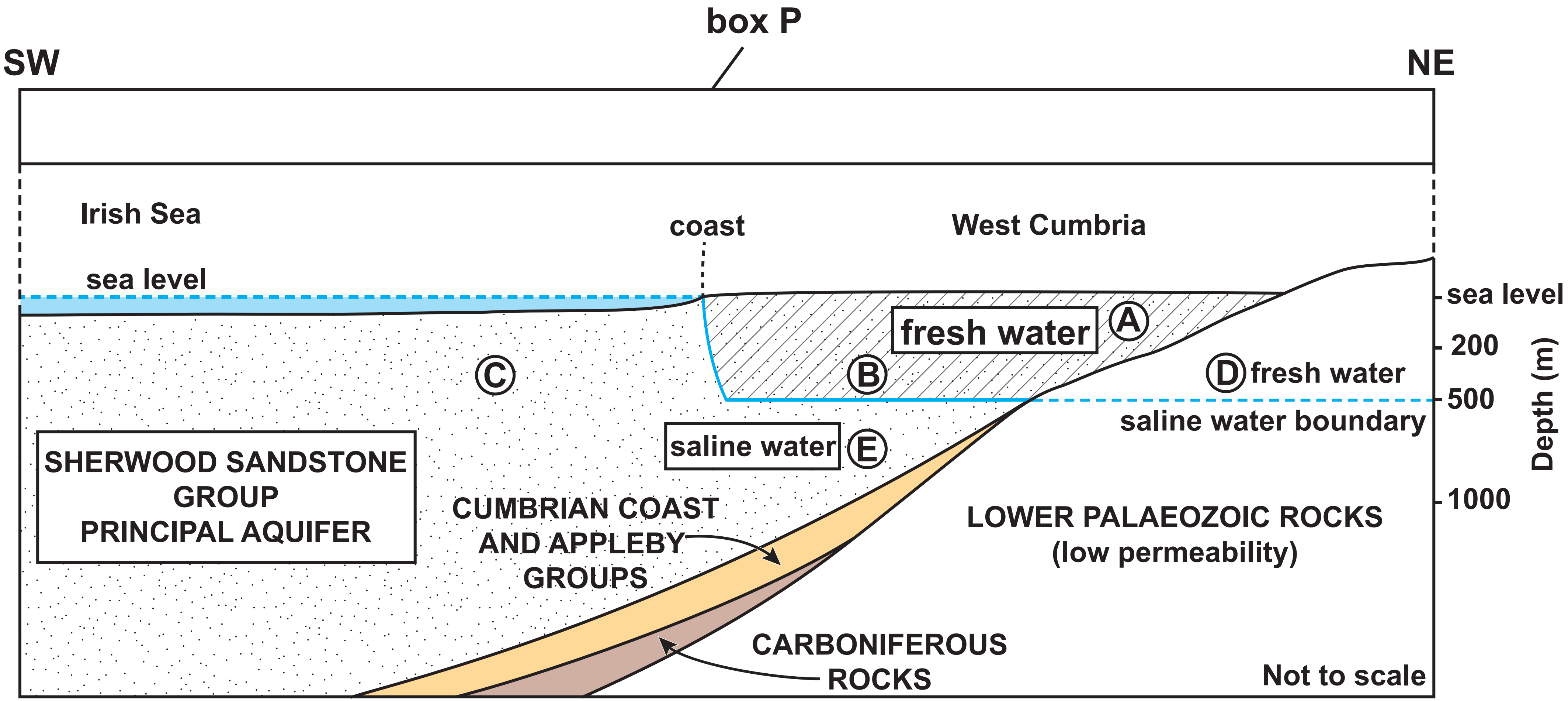

box P
SW
NE
Irish Sea
sea level
coast
West Cumbria
fresh water
A
B
C
D fresh water
saline water boundary
saline water
E
sea level
200
500
1000
Depth (m)
SHERWOOD SANDSTONE GROUP PRINCIPAL AQUIFER
CUMBRIAN COAST AND APPLEBY GROUPS
LOWER PALAEOZOIC ROCKS (low permeability)
CARBONIFEROUS ROCKS
Not to scale

FIGURE 8b opposite is a sketch section across an area of west Cumbria and the Irish Sea to the north of the GEOLOGICAL MAP, showing the principal Sherwood Sandstone Group aquifer (which includes the St Bees Sandstone - SBS).

8(a) Refer to FIGURE 8b and the groundwater resource exclusion criterion (CRITERION 1 in TABLE 8 on page 30).

(i) State which ONE of the five locations (A–E) would qualify as being UNSUITABLE as a host site for a radioactive waste facility, according to the groundwater resource exclusion criterion (1) ALONE. Explain your answer. [2]

(ii) Shade in box P (FIGURE 8b) to show the extent of the area below which it is geologically UNSUITABLE to dispose of radioactive waste according to the groundwater resource exclusion criterion (1) ALONE. [2]

8(b) Using the GEOLOGICAL MAP and cross-section and the PREVIOUS DATA, explain why large parts of the area covered by the GEOLOGICAL MAP were considered to be geologically unsuitable for radioactive waste disposal as defined by the exclusion criteria in TABLE 8. [4]

TABLE 8

EXCLUSION CRITERIA
The survey criteria were based only on the need to exclude areas: 1. where exploitable freshwater groundwater resources exist BELOW 200 m deep; 2. where one or more natural resources exist BELOW 200 m deep (minerals, fossil fuels and alternative energy resources) that might be exploited by future generations.

8(c) Suggest what other GEOLOGICAL factors might also need to be considered when determining the suitability of a potential site for a radioactive waste facility in western Cumbria. [4]

END OF PAPER

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FIGURE 3

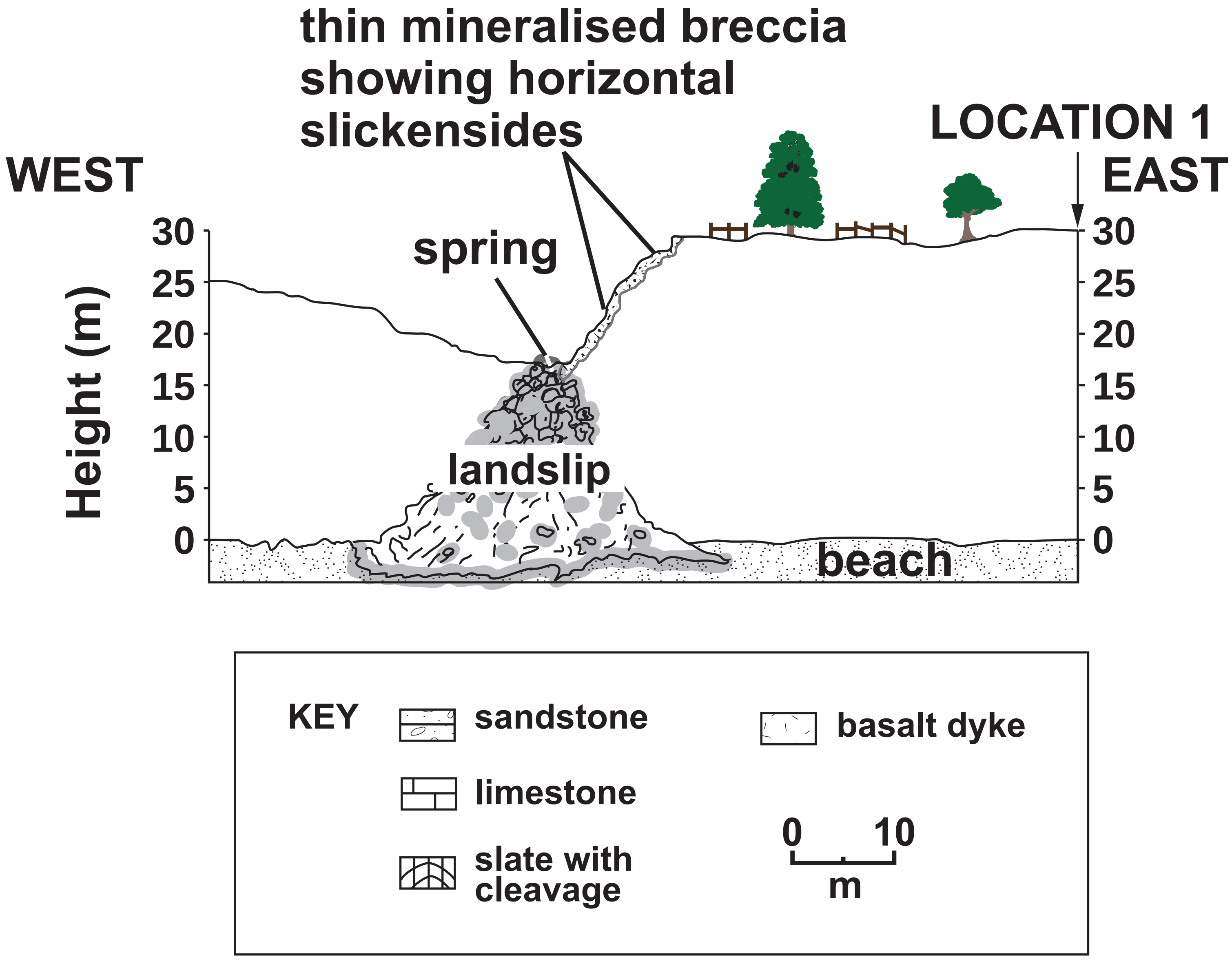

TABLE 3

<table>
<tr><th>Location</th><th>WEST OF LANDSLIP</th><th rowspan="7">LANDSLIP</th><th colspan="2">EAST OF LANDSLIP</th></tr>
<tr><td rowspan="6">Geology</td><td rowspan="3">A series of folded slates with an axial planar cleavage dipping 80°E</td><td colspan="2">A vertical section (showing vertical thicknesses) measured at LOCATION 1 on the eastern edge of the cliff section (in stratigraphic order – OLDEST AT THE BASE)</td></tr>
<tr><td rowspan="5">Youngest
↑
Oldest</td><td>5 m bedded sandstone, dipping 10° N</td></tr>
<tr><td>Irregular unconformity, dipping 10° N</td></tr>
<tr><td rowspan="3">Cut by a 2 metre thick vertical, basaltic dyke (10 m from the western margin)</td><td>10 m well-bedded limestone, dipping 15° W</td></tr>
<tr><td>Unconformable junction, dipping 15° W</td></tr>
<tr><td>15 m folded slates with an axial planar cleavage, dipping 80° E</td></tr>
</table>

FIGURE 4a

Fossil land plants may provide evidence of different climatic zones. The percentage of smooth-margined fossil leaf species can be used to estimate a mean temperature for fossil forests.

In general, forests in warmer climates have a higher percentage of smooth (entire) margined leaf species. Leaves in temperate forests often have jagged (toothed) margins, and tend to dominate in cooler climates.

FIGURE 4b