

**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

- (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]

- (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]

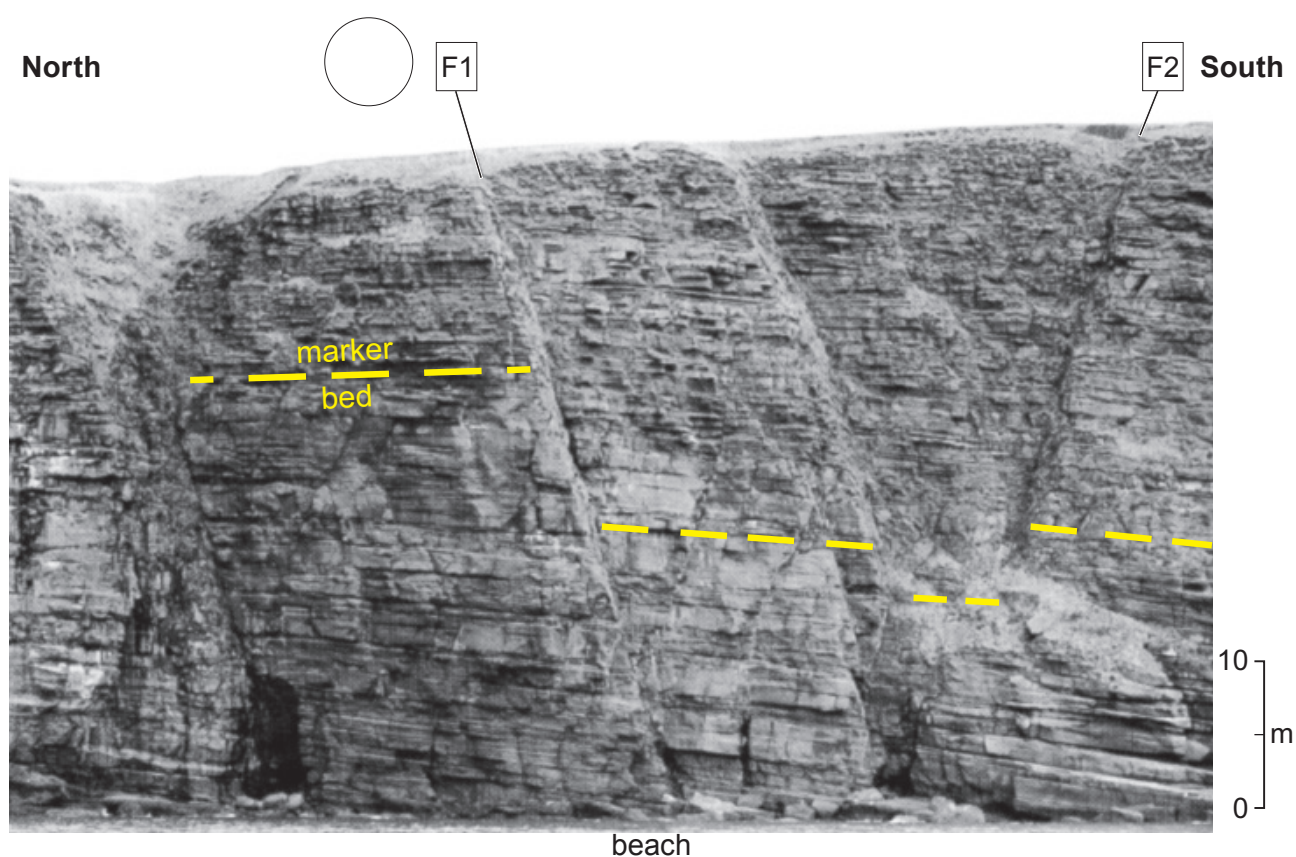
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(b) **Figure 5** is a photograph of the cliff face at South Head (grid reference – GR 950120).



**Figure 5**

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

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

**Table 5**

- (ii) Draw an arrow ( $\nearrow$ ) in the blank circle on **Figure 5** to show the orientation of the principal stress component,  **$\sigma$  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,  **$\sigma$  min**. [2]

*Similarity* .....

.....

*Difference* .....

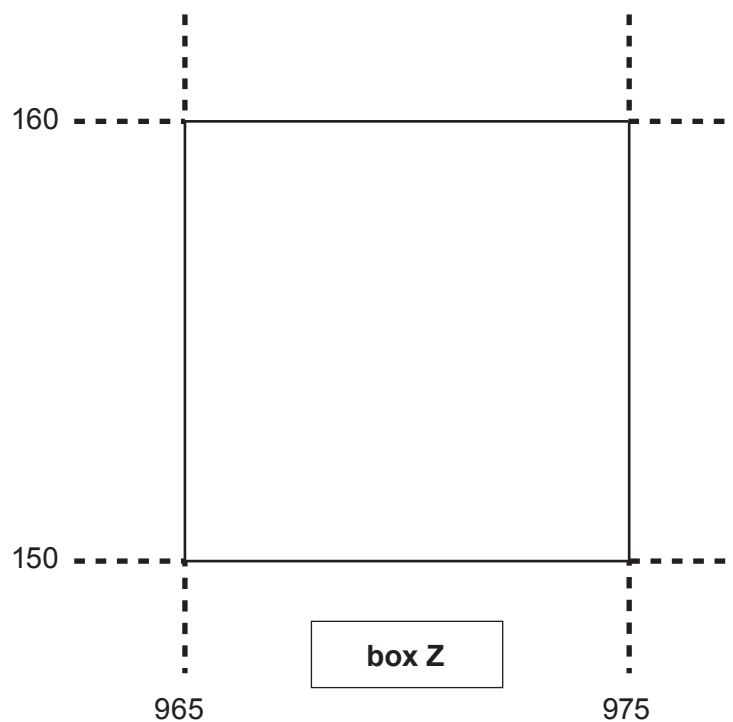
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6. The **generalised geological column** indicates an unconformity at the base of the Permian-Triassic Brockram (**BK**).

- (a) (i) In the blank grid square below, 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]

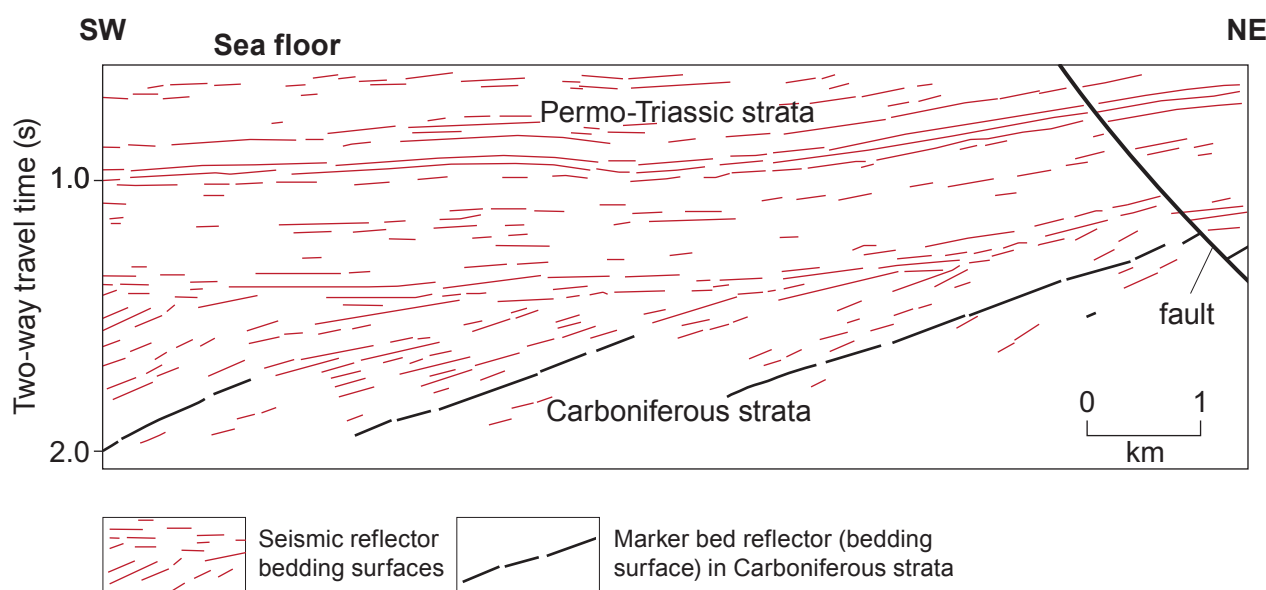


- (ii) With reference to the **generalised geological column** suggest the most probable reason for the variation in the width of outcrop of the St Bees Evaporite (**SBE**) in **box Z**.
- [1]

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



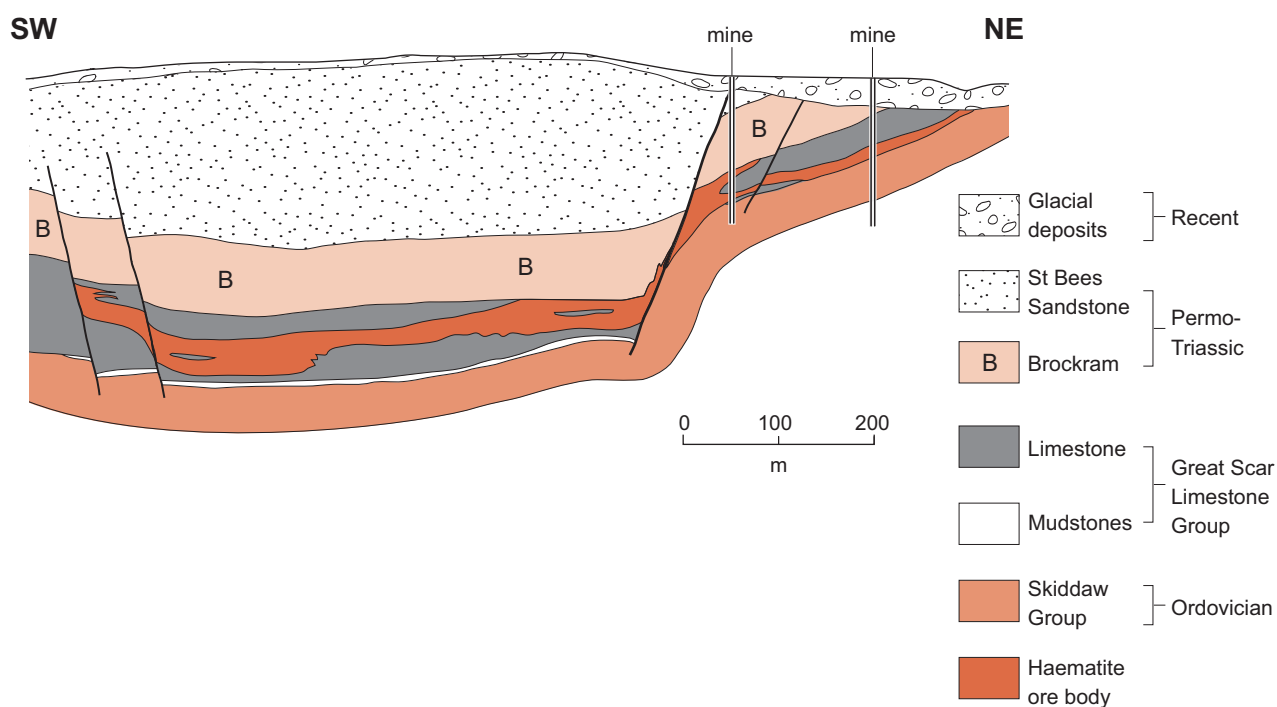
Note: Although the horizontal scale is in kilometres, the vertical scale is two-way travel time (in seconds), not depth. Two-way travel time is the time taken for seismic waves to travel from the surface to a sub-surface rock boundary (a bedding plane, fault etc.) and back to the surface.

**Figure 6**

- (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  $2.15 \text{ km s}^{-1}$  (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

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



### 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.

**Figure 7**

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]

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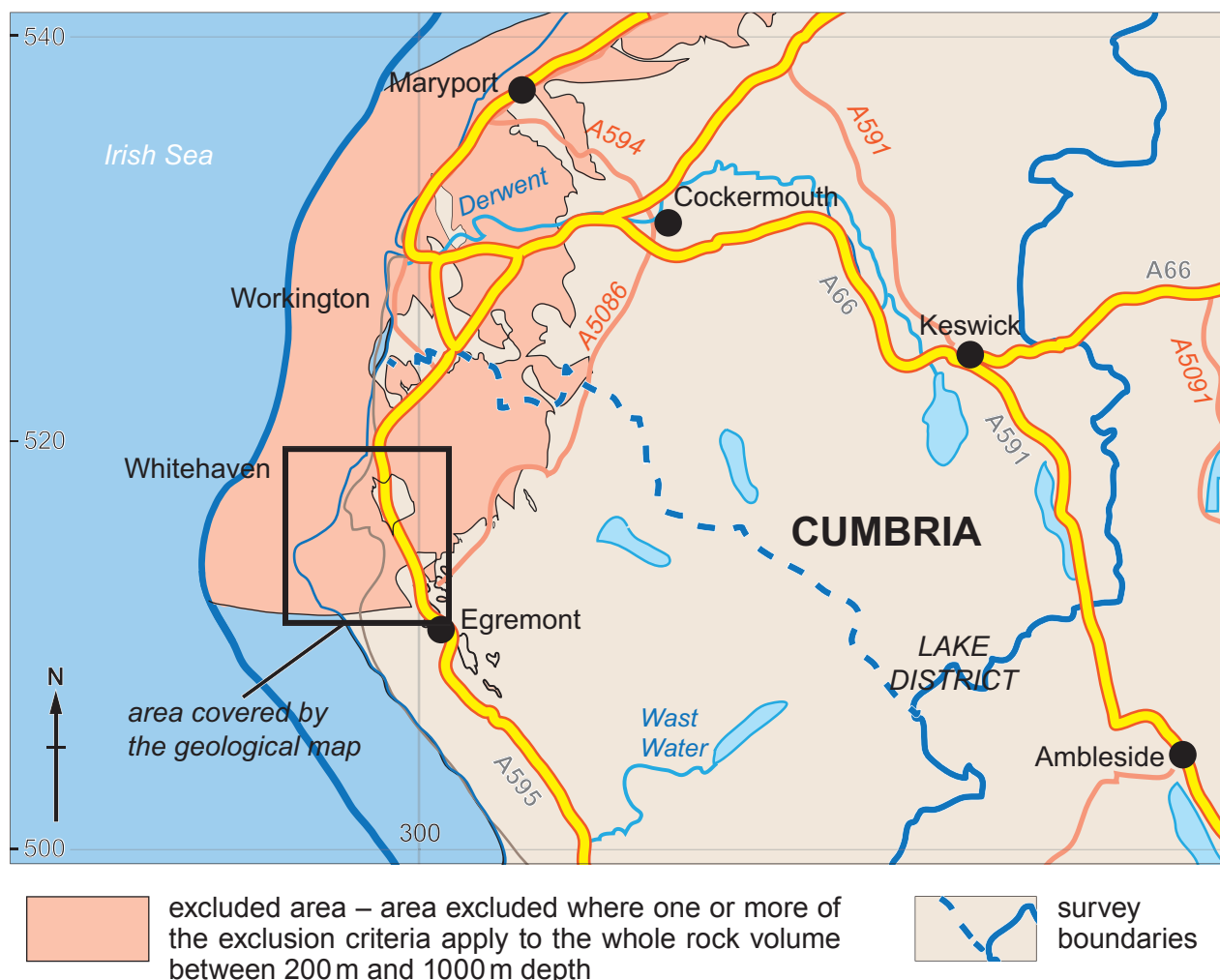
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8. **Figure 8a** shows the result of a survey to rule out areas of west Cumbria (including up to 5 km offshore) that are geologically **unsuitable** to host a radioactive waste disposal facility. **Table 8** shows the exclusion criteria used in the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

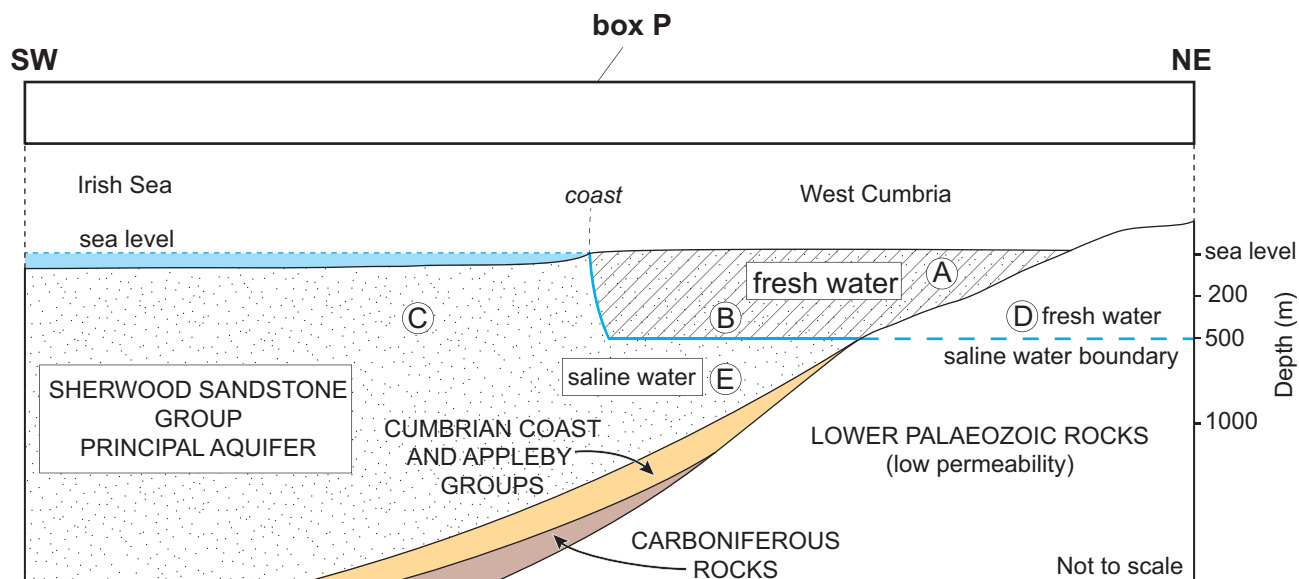


**Figure 8a**

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

**Table 8**

**Figure 8b** 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**).



**Figure 8b**

- (a) Refer to **Figure 8b** and the groundwater resource exclusion criterion (**criterion 1** in **Table 8**).

- (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]

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- (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]



- (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]

### Exclusion Criteria

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**Table 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**

Figures 1a, 1b, 1c and 1d Source: After Rudwick – “Living and Fossil Brachiopods” – Sedgwick Museum

Figures 2b and 2c Source: Adapted from [http://www.geodsz.com/deu/d/images/1859\\_lagenintrusion.png](http://www.geodsz.com/deu/d/images/1859_lagenintrusion.png)

Figure 2d Source: [www.elbrownpetrology.com/photos.html](http://www.elbrownpetrology.com/photos.html)

Figure 4a Source: [http://nature.nps.gov/geology/nationalfossilday/climate\\_change\\_past.cfm](http://nature.nps.gov/geology/nationalfossilday/climate_change_past.cfm),  
<http://geology.com/articles/green-river-fossils/plant-fossils.shtml>

Figure 4b Source: <http://droyer.web.wesleyan.edu/research.htm#margins>

Figure 5 Source: BGS: Geology of the west Cumbria district (Plate 3)

Figures 6 and 7 Source: BGS: Geology of the west Cumbria district

Figures 8a and 8b Source: BGS report. (CR/10/072)-Managing radioactive waste safely: Initial geological unsuitability screening of west Cumbria