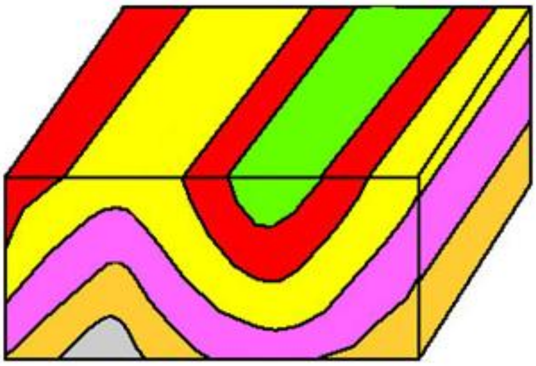
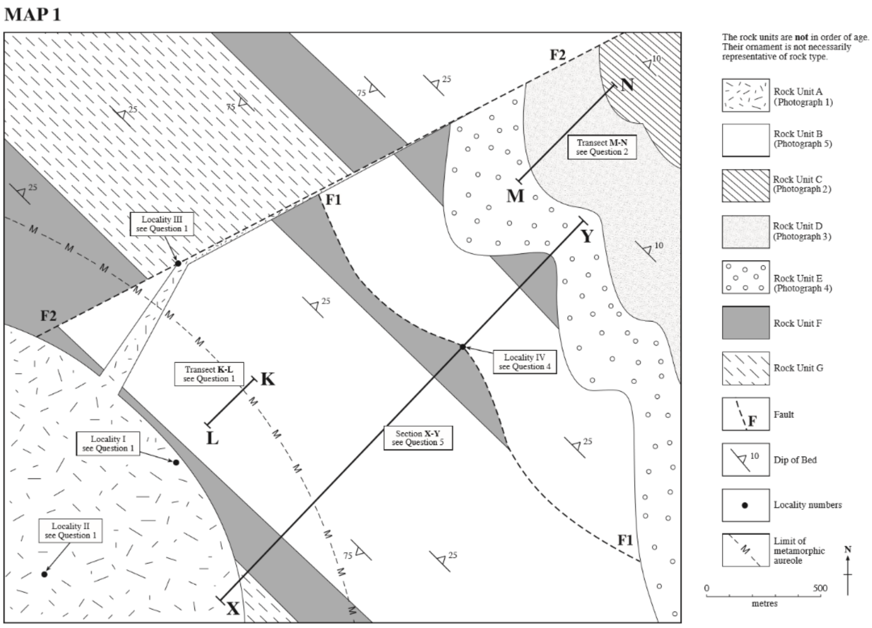
AS Geology

Component 1 – Investigations

Mapwork Booklet





Year 12

An Introduction to Geological Maps

Name: ____

Whitmore High School

INTRODUCTION

A Geological Map is the means by which a Geologist communicates the geology of an area. It shows the **outcrop** patterns of different rock types (i.e. the pattern made by the rocks as they reach the surface if all the vegetation and soil were missing). The outcrop pattern shown on a geological map depends on two factors:

- Topography (the shape of the landscape)
- Geological Structure

We can work out the geological structure by interpreting the outcrop pattern in conjunction with an awareness of the landscape. The most common way of interpreting the structure shown by a geological map is by constructing a cross-section. This is a “slice” cut through the geology of an area which shows the underground structure and can be extended above the present surface to show features that have been eroded.

The maps you will be dealing with at AS level are simplified “problem” maps. This will teach you the skills that you need to deal with real geological maps in Year 13 as the logic behind every geological map is exactly the same. It is important not to be overwhelmed by the amount of data on a geological map, the exam questions will guide you to the locations on the map that are relevant.

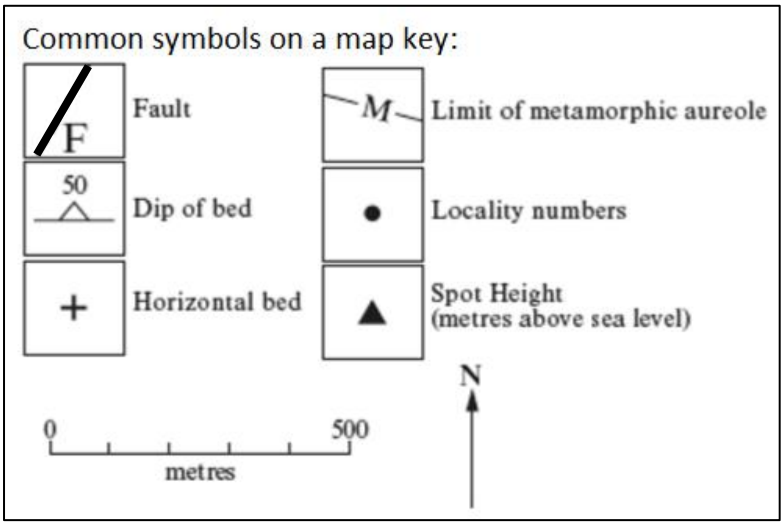
CHECKLIST

Before you start to read the Geology of the map there are some details that you need to check.

- **Scale:** All the maps that you will deal with at AS level will have their own scale. Always check it before you start to work on your map.

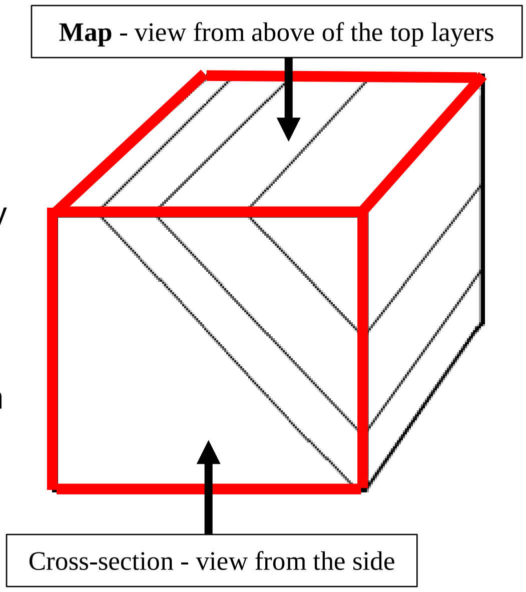
- **Geographical information:** Most geology maps are overlain over the topography of an area as the topography is one of the variables (with geological structure) that controls outcrop pattern. You do need to look carefully for crucial information such as contour patterns or rivers.

- **Geological Symbols:** The symbols used to show the geological structure are standardised at AS level. A key to these symbols is always included with the map. Remember it is a convention on geology maps to show definite boundaries and structures with a continuous line and inferred (estimated) boundaries with a dashed line.



GEOLOGICAL MAPS

A geological map is like any other in that it is a representation of the ground looking straight down on the surface. A geological map shows where different rock units reach the surface (or outcrop) by using colour or, as in the case of AS maps, with different types of shading. The pattern that these rock units make is called the outcrop pattern and there are distinctive outcrop patterns that are indicative of different geological structures. We can use geological maps to determine the nature of the geology **below** the surface.



CROSS-SECTIONS

Cross-sections are an imaginary "slice" cut through the ground. Geologists use cross-sections to show the structure of the rocks. You will be asked to construct a cross-section across the map you are given in your exam.

OUTCROP PATTERNS

Section A: Horizontal Beds

Think of beds as large slabs of rock, with the boundaries between these slabs (bedding planes) drawn on the map where they reach the surface. We assume that all sedimentary rocks started as horizontal layers.

Horizontal beds can form very intricate outcrop patterns. The outcrop pattern is controlled by the shape of the land (topography); therefore, any valley will expose the sequence of beds along its length.

Horizontal Beds can be recognised on a map in two ways:
1. A cross symbol drawn on the map (check the key).
2. Geological boundaries that follow the contours without crossing them. This can result in quite intricate outcrop patterns (see diagram below.)

Figure. 1 is a block diagram (a) and a geological map (b) showing horizontal beds.

(a)

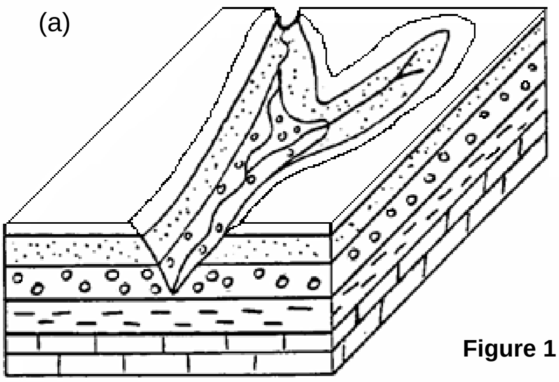
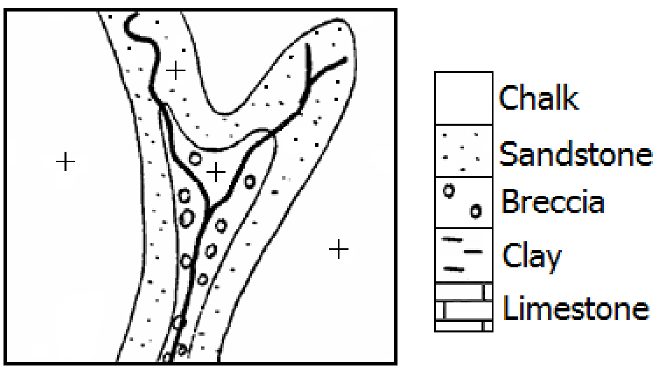


Figure 1

(b)



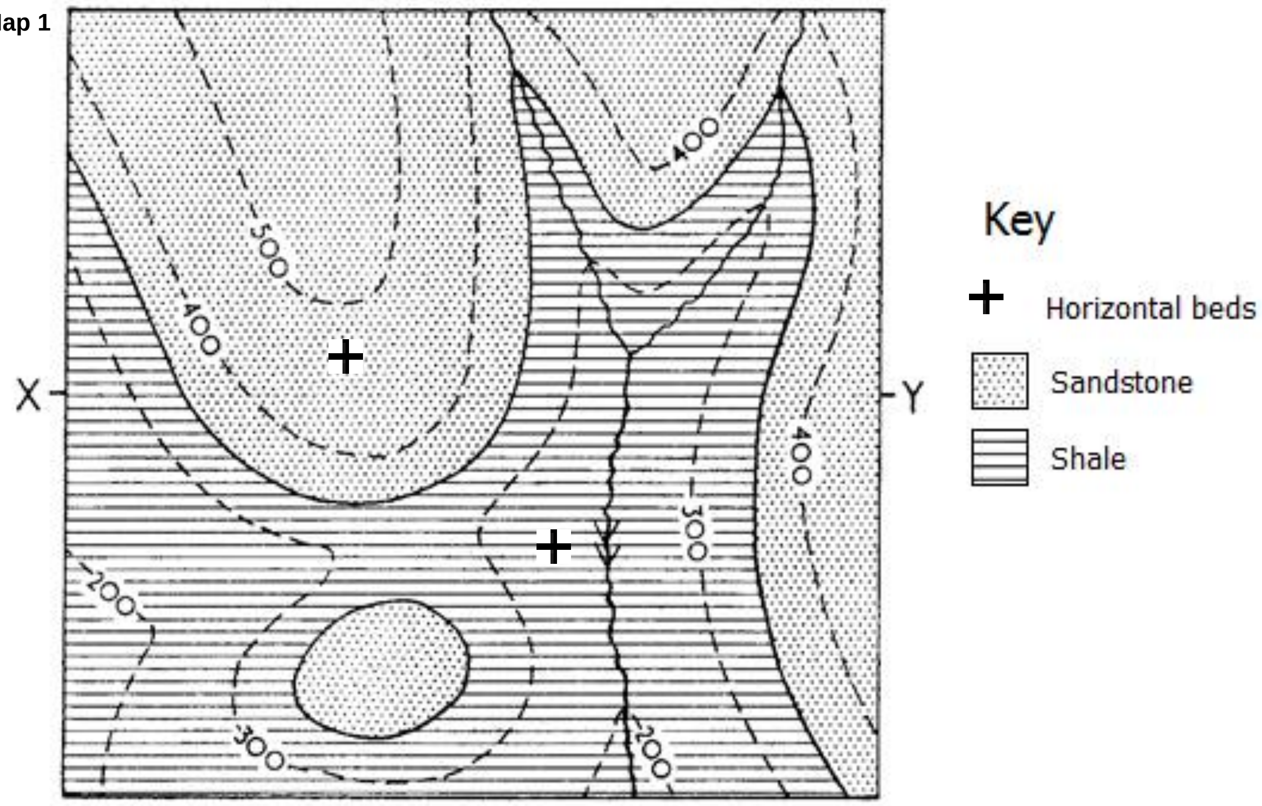
TASK 1: EXAMPLE OF HORIZONTAL BEDS

Map 1 shows a sequence of horizontal beds. A cross section has been drawn from A to B (diagram (c).

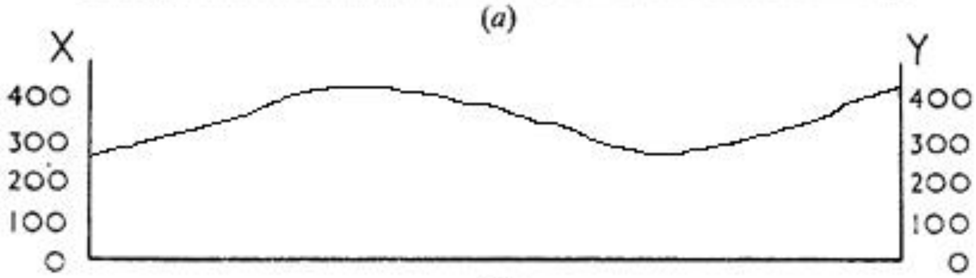
1) What height is the boundary between the sandstone and shale? _____________

2) Construct a cross section to show the geology between X and Y.

Map 1



(*a*)



(*b*)

3) Is the sandstone or the shale likely to be younger? _____________________

4) Which rock appears to be more resistant to erosion, and why?

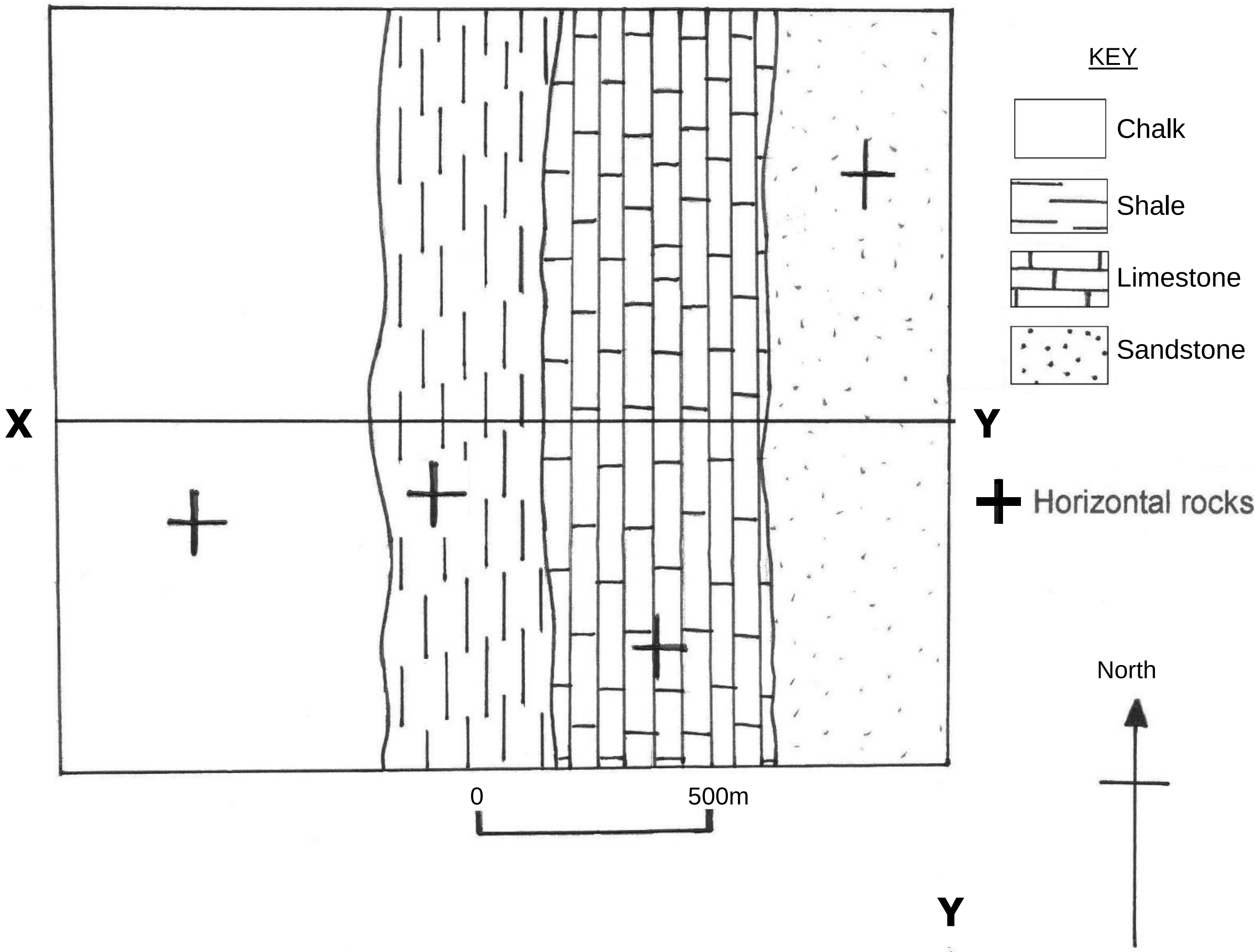
____

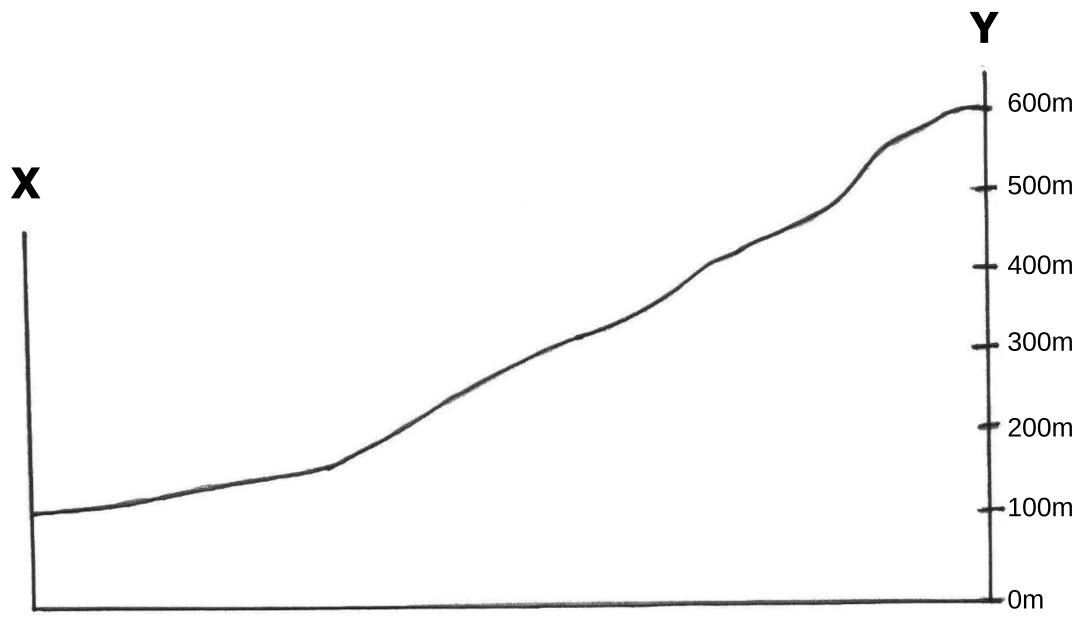
____

____

MAP EXERCISE 1: HORIZONTAL BEDS

1) Complete the cross section X-Y below using the information on the map.





2) How thick is the bed of shale? ________m

3) Which bed of rock is the thickest? __________________

Section B: Dipping Beds

Beds that are inclined from the horizontal are said to “dip”. This is often the result of tectonic activity at plate boundaries.

We measure the inclination of beds by defining the dip and strike of the bed. The strike of a bed is the direction along which there is no inclination. At right angles to this, the bed will be at its maximum inclination. This is called the dip of the bed. This is shown in **Figures 2 and 3** below.

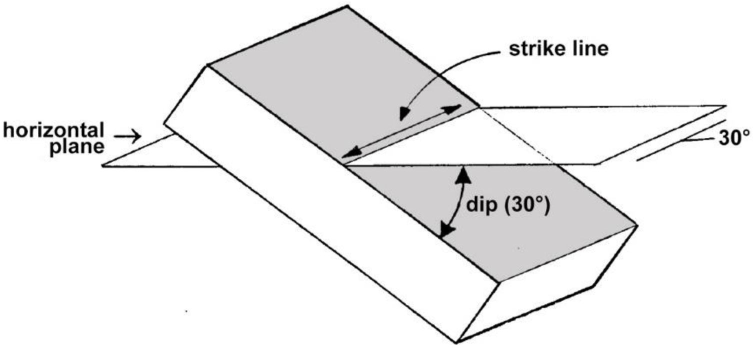


Figure 2

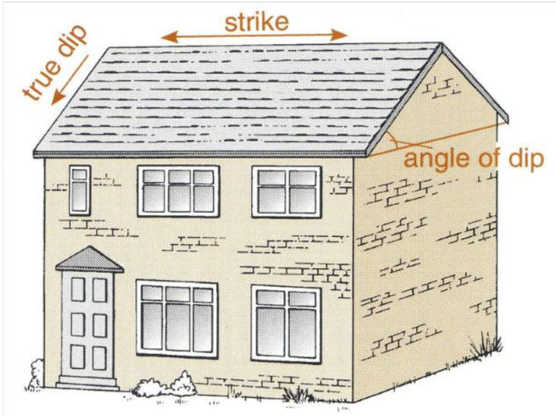


Figure 3

The angle of dip is measured from the horizontal and is shown on AS maps as this symbol.

TASK 2: DIPPING BEDS

Figure 3 is a block diagram showing dipping beds.

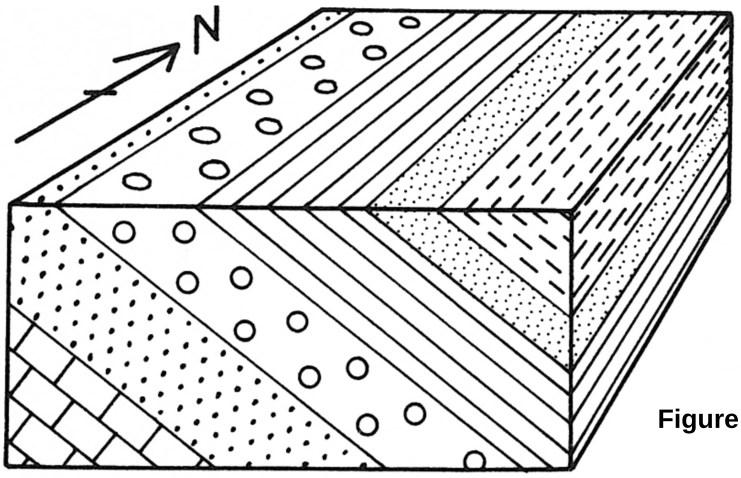


Figure 3

1) Label on Figure 3 (above) the following:
   - geological **map**
   - **dip** cross-section
   - **strike** cross section

2) With a protractor measure and mark a dip arrow to show the dip on the geological map.

TASK 3: OUTCROP WIDTH

The width of the outcrop will vary depending on the angle of dip and the shape of the landscape (topography).

Figure 4 is a cross-section through a hill.

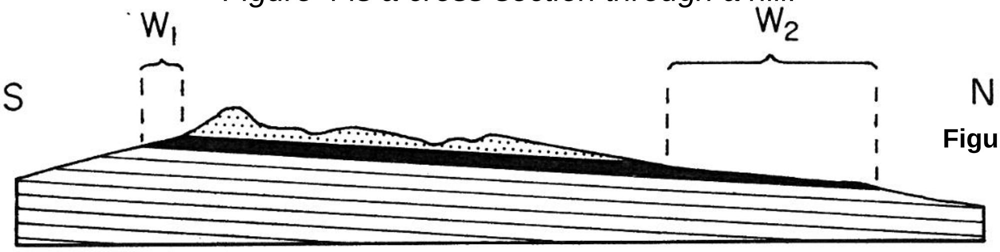


Figure 4

The coal seam (shaded black) in Figure 5 has a much shallower width of outcrop (W1) than in the north (W2).

1) Annotate Figure 5 to show why there are different outcrop widths of the same bed of coal.

Figure 5 is a cross-section showing two edges formed by beds of limestone in a succession of shales.

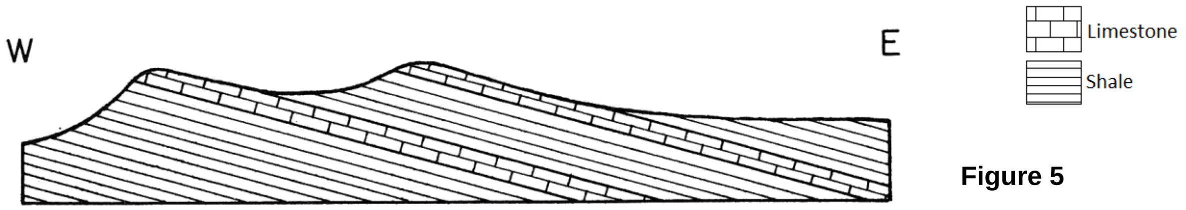


Figure 5

Using Figure 5:

2) Express the true thickness of one of the limestone beds as a fraction of the shales between them.

3) Express the widths of outcrop of the two rock types in the same way.

4) Explain the discrepancy between these two results.

____

____

The angle of dip can also have an effect on the width of outcrop.

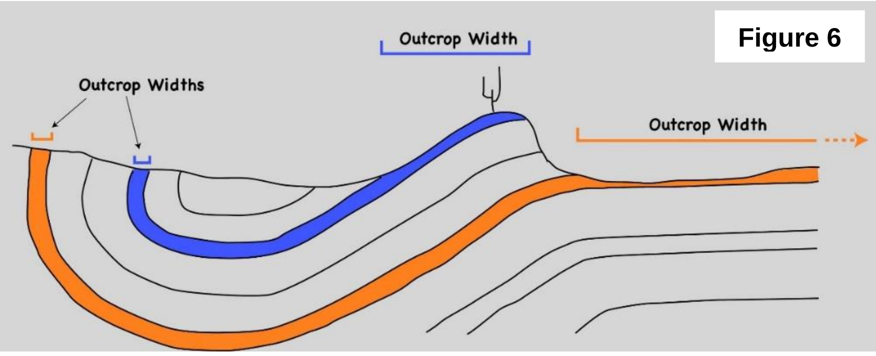


Figure 6

TASK 4: RECOGNISING DIPPING BEDS

Where dip arrows are not shown, dipping beds can also be recognised using distinctive patterns.
*Beds will get **younger** in the direction of dip.*

1) How can the dip of the beds be recognised on the geological map in Figure 7?

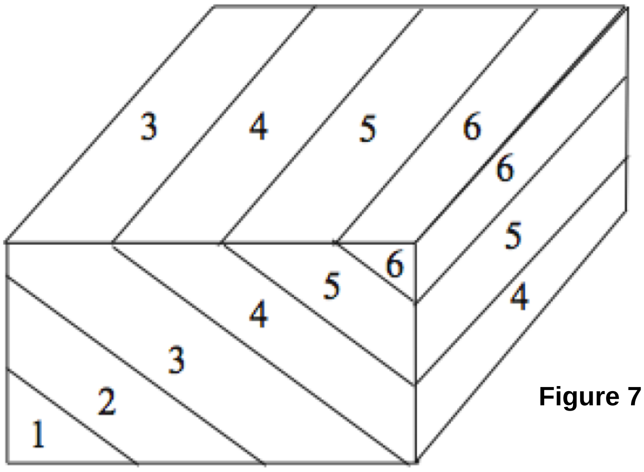


Figure 7

Dipping beds that outcrop across a valley will show a "V" shaped outcrop pattern with the point of the "V" pointing in the direction of dip. It is important to recognise where the outcrop crosses a valley; contour patterns, rivers or alluvium drift deposits all provide good clues.

2) Annotate the block diagrams and geological maps in Figures 8 & 9 to show how the outcrop patterns show the structure of the geology.

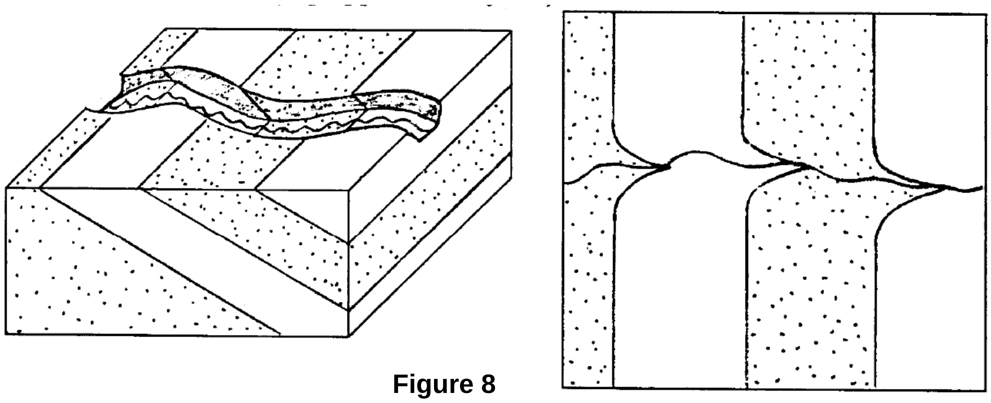


Figure 8

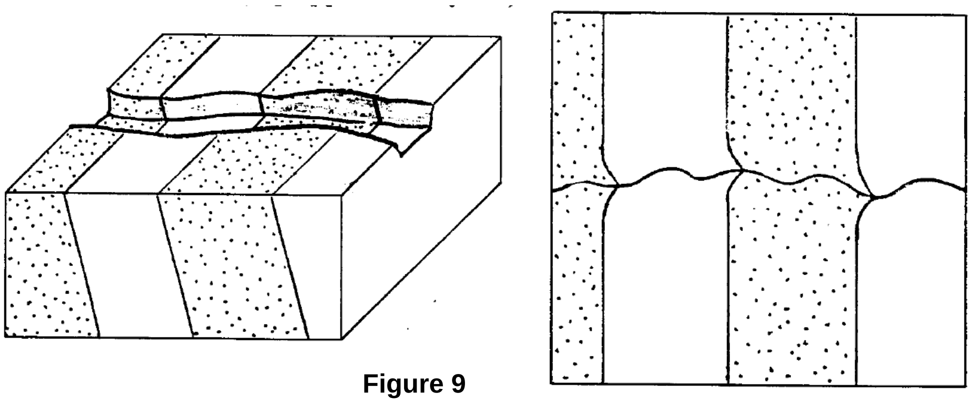
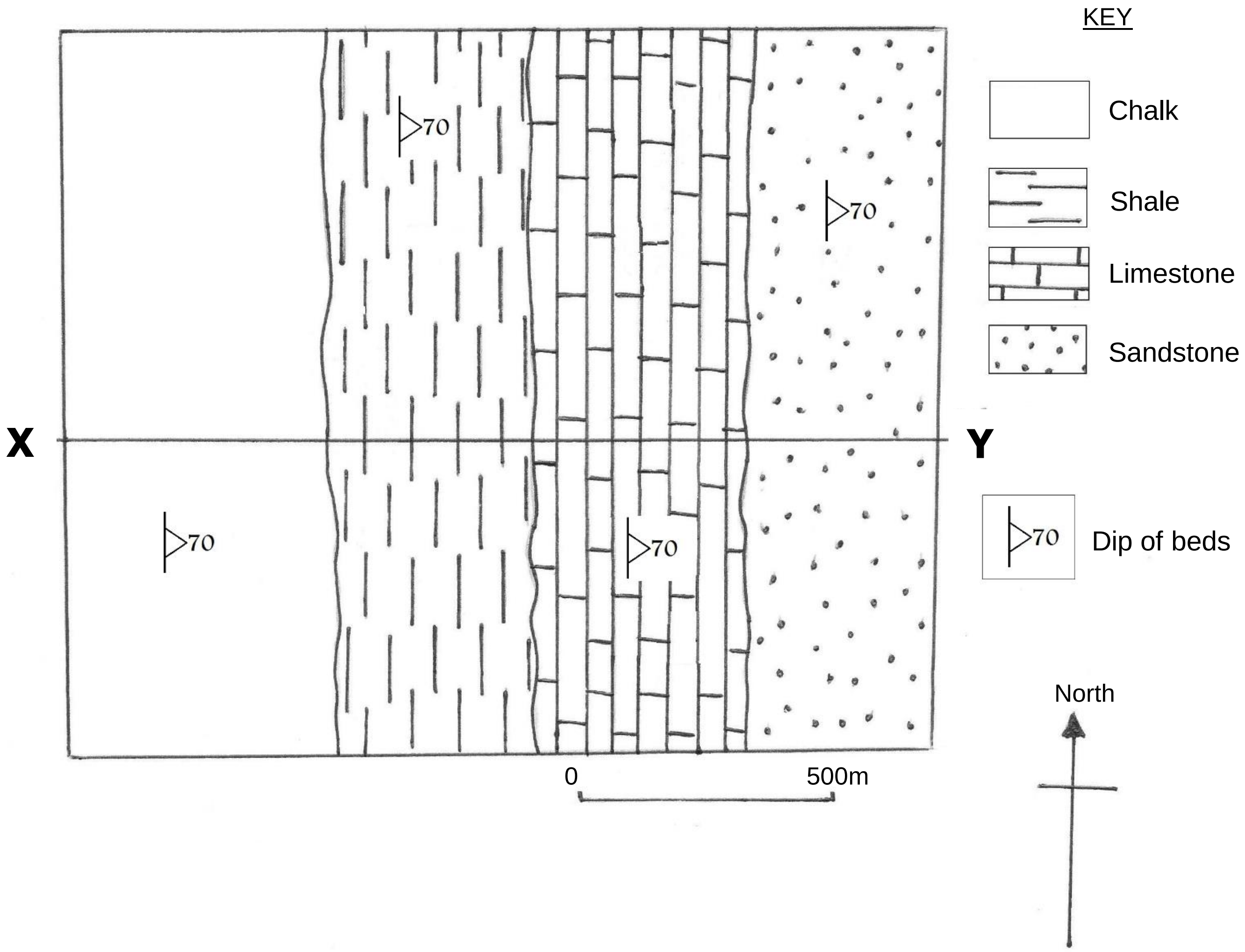
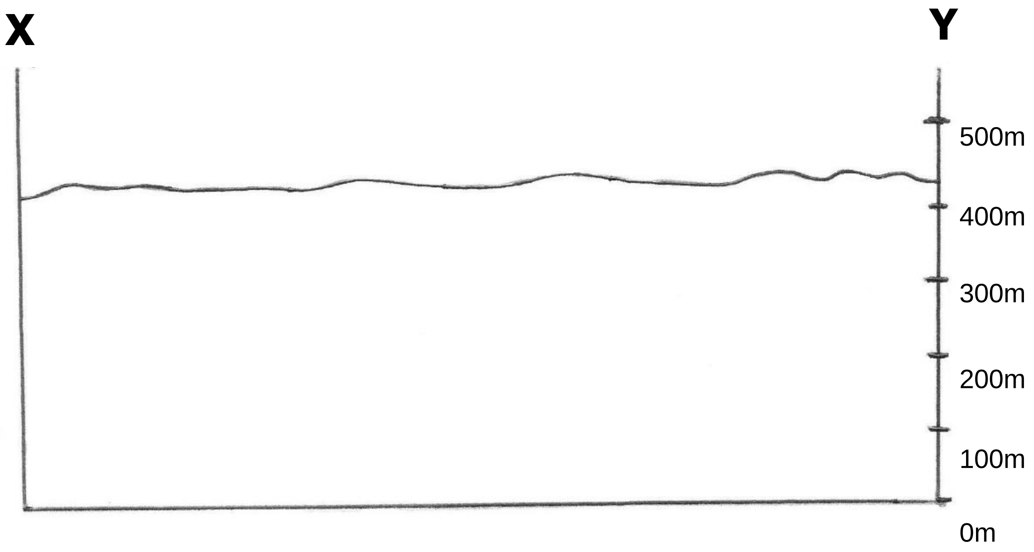


Figure 9

MAP EXERCISE 2: DIPPING BEDS

1) Complete the cross section X-Y below using the information on the map.





Section C: Folds

You can think of a fold as a bed that dips in two different directions, therefore it will show the features of dipping beds. You do need to know the terminology that goes with folded beds in order to understand them.

TASK 5: ANATOMY OF A FOLD

1) Annotate Figure 10 to explain the meaning of these fold terms: **limb, hinge, axial plane, axial plane trace, antiform and synform**

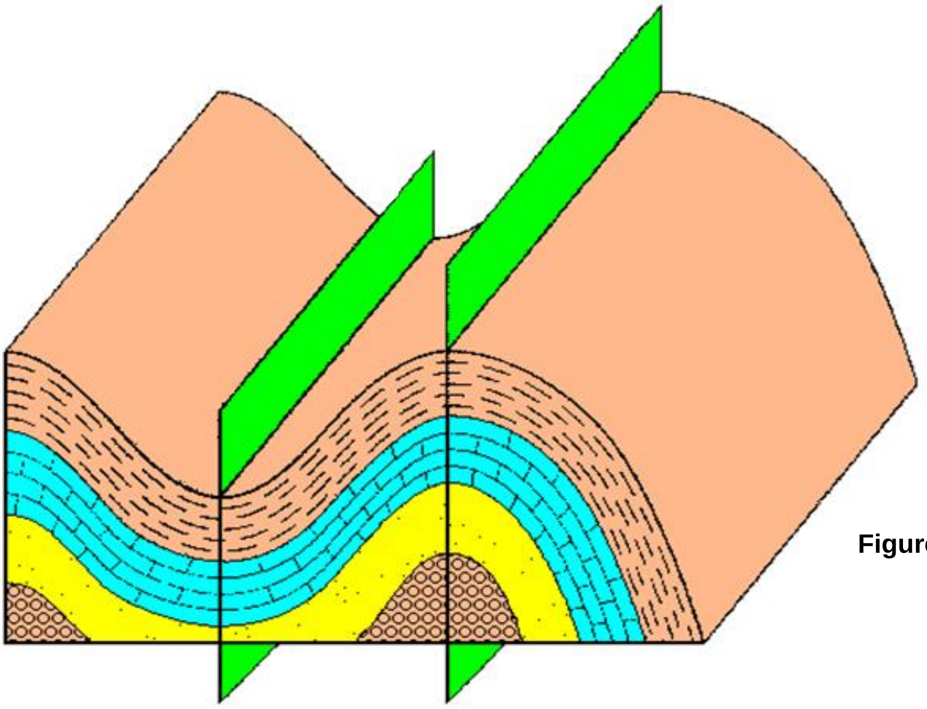


Figure 10

2) When does an antiform become an anticline and a synform a syncline?

____

____

____

____

3) What evidence would you look for to confirm that an antiform was indeed an anticline?

____

____

TASK 6: DESCRIBING FOLDS

1) Describe the folds in Figures 11&12 (below). Give reasons for your answers.
2) Add the key fold terminology onto each diagram.
3) Add symbols onto the map surface to show the direction and amount of dip.

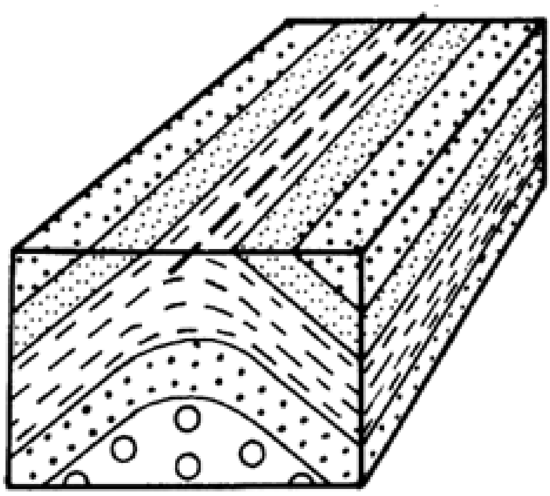
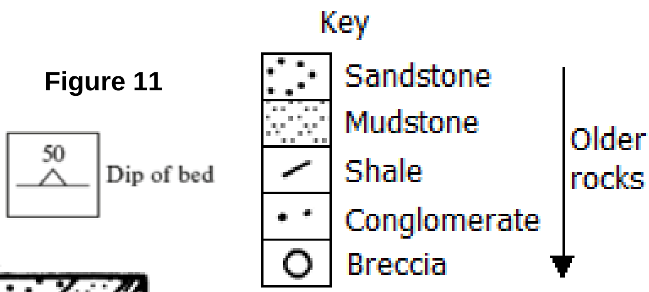


Figure 11



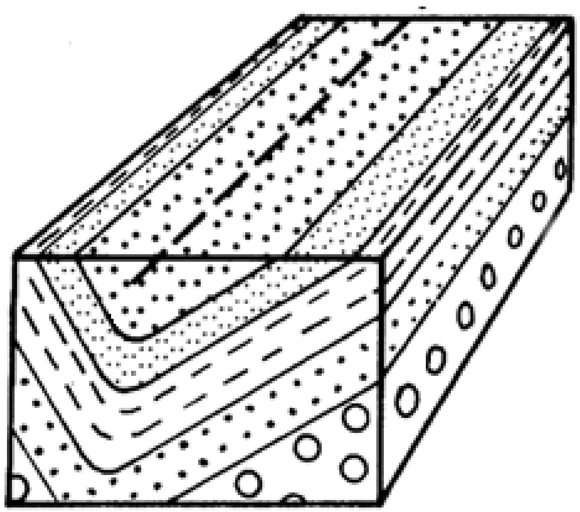


Figure 12

TASK 7: FOLDS ON MAPS

1) Annotate Figure 13 to show the pattern of beds that are shown on the geological map.
2) Add symbols onto the map surface to show the direction and amount of dip.

Figure 13 is a block diagram showing the outcrop pattern of a series of folds. The folds can be described as symmetrical with vertical axial planes.

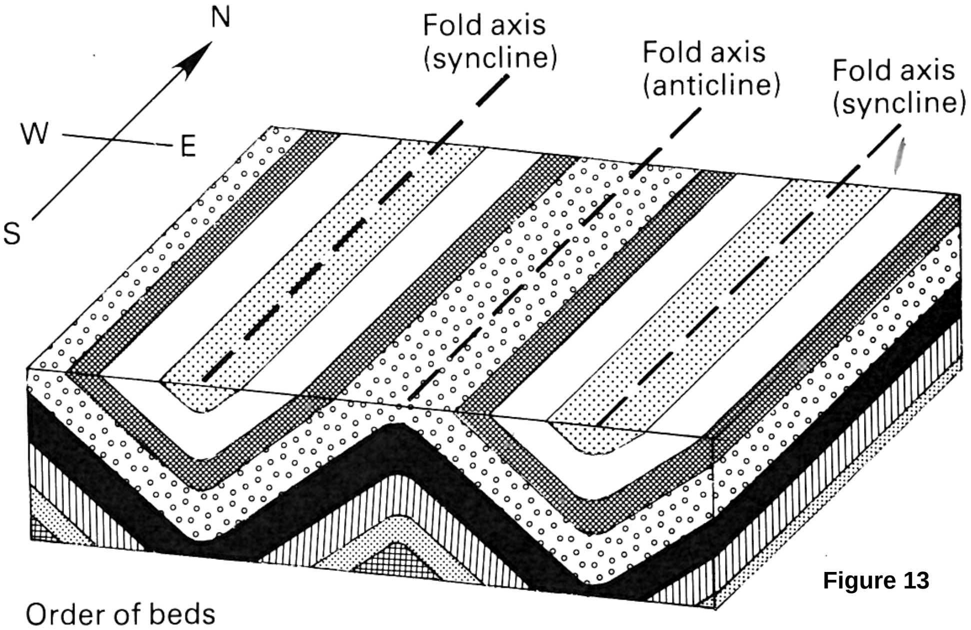
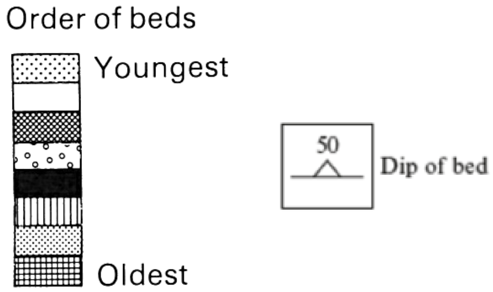


Figure 13



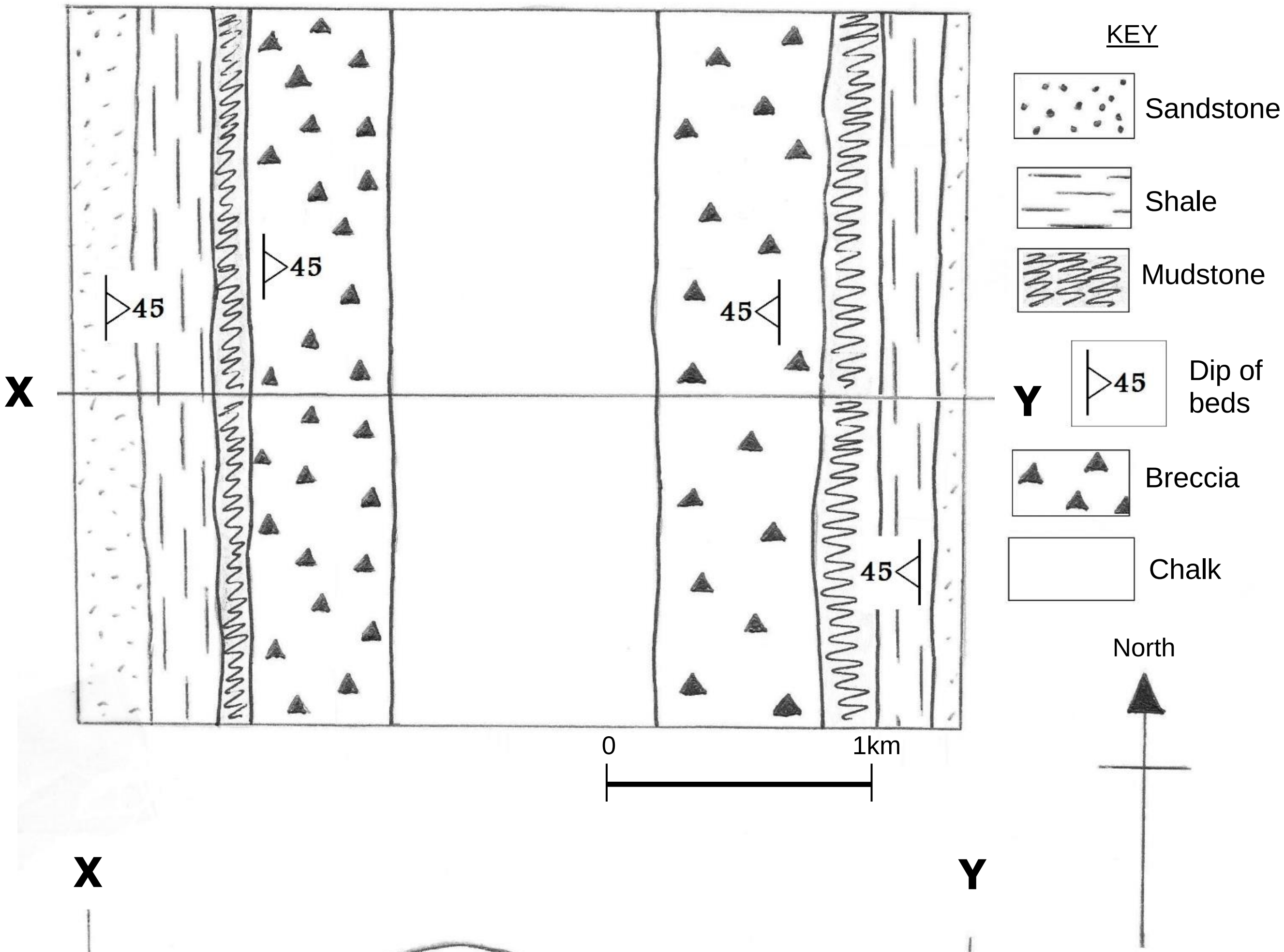
There are several terms that we can use to describe folds.

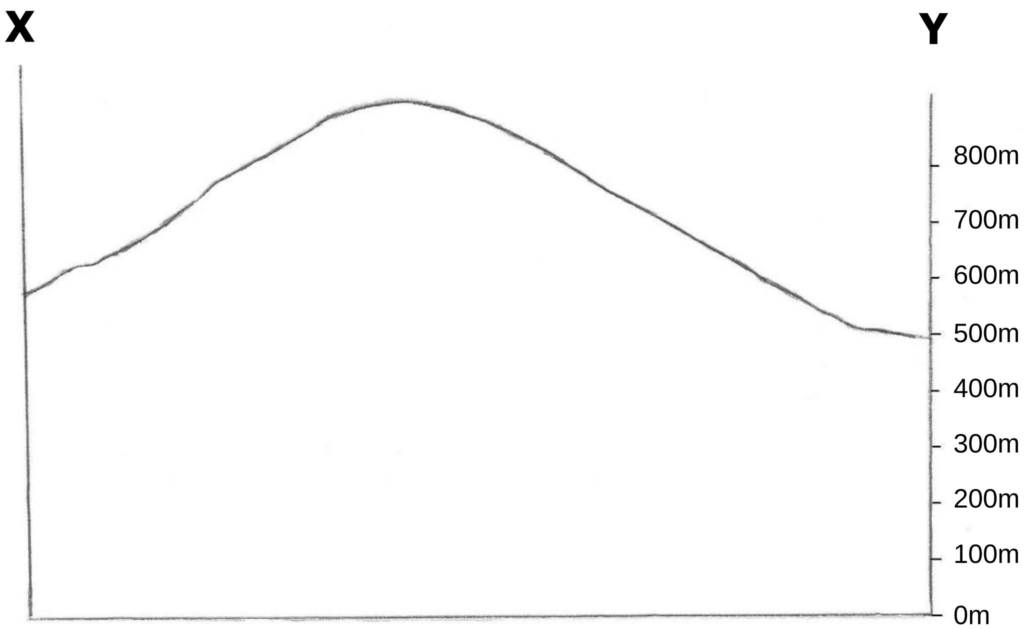
3) Draw diagrams to show the following fold features: symmetrical, asymmetrical, open, tight.

*Symmetrical folds have fold **limbs** of equal length and normally vertical axial planes. Asymmetrical folds usually have inclined axial planes, and fold limbs of different length.*

MAP EXERCISE 3: FOLDING

Complete the cross section X-Y below using the information on the map.

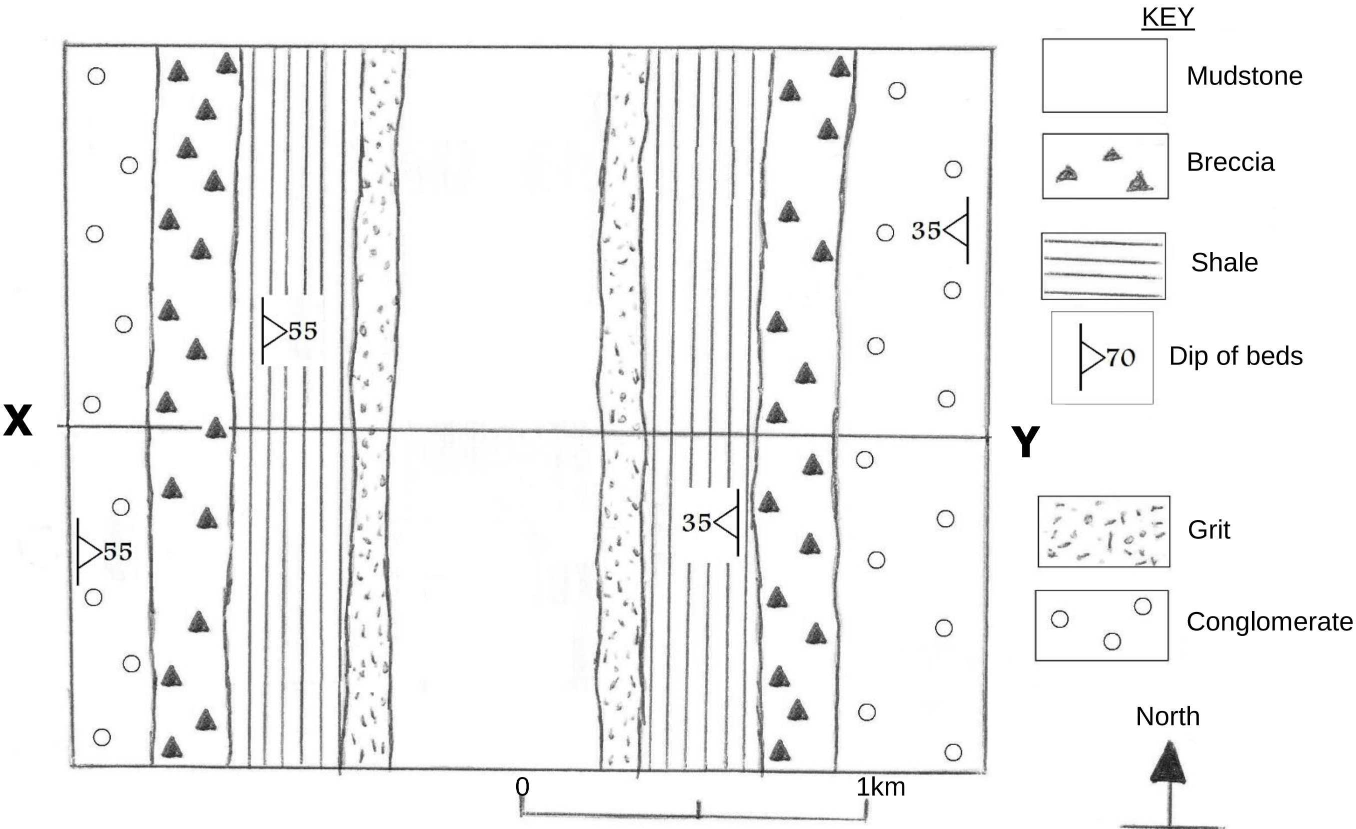


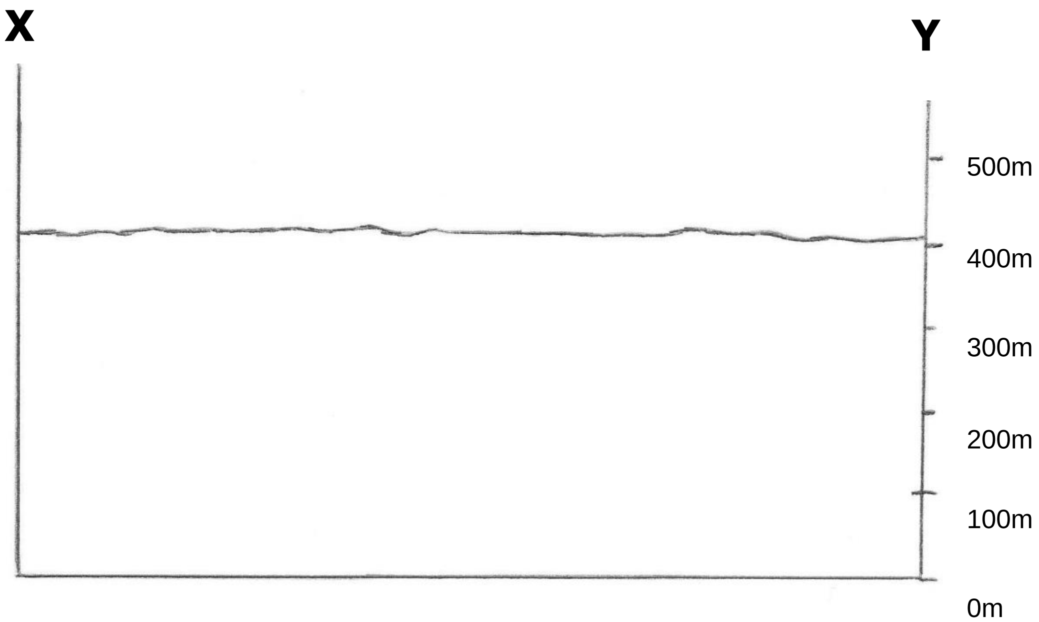


1) What is the height of the hill on the cross section? ________m
2) What type of fold is this? ________________
3) Add the axial plane of the fold onto the cross section and axial plane trace onto the map.

MAP EXERCISE 4: FOLDING

Complete the cross section X-Y below using the information on the map.



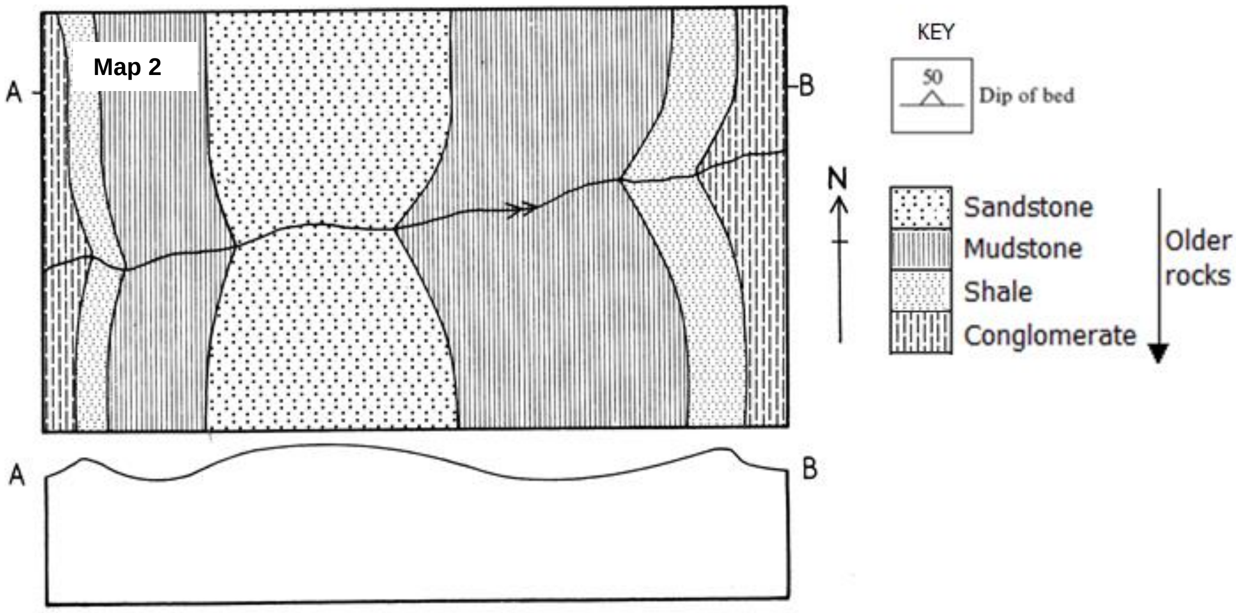


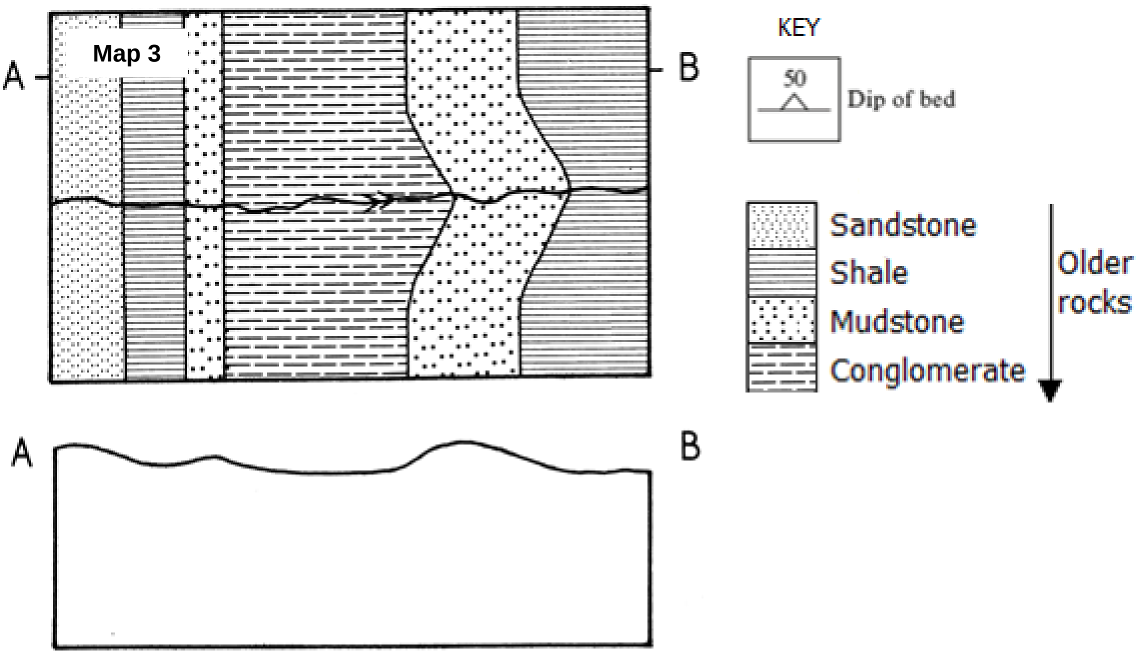
1) Put the rocks in the order that they were formed.
2) Describe the type of fold shown. ______________________________
3) Add the axial plane of the fold onto the cross section.

TASK 8: FOLDING EXAMPLES

Using the Maps 2 & 3:

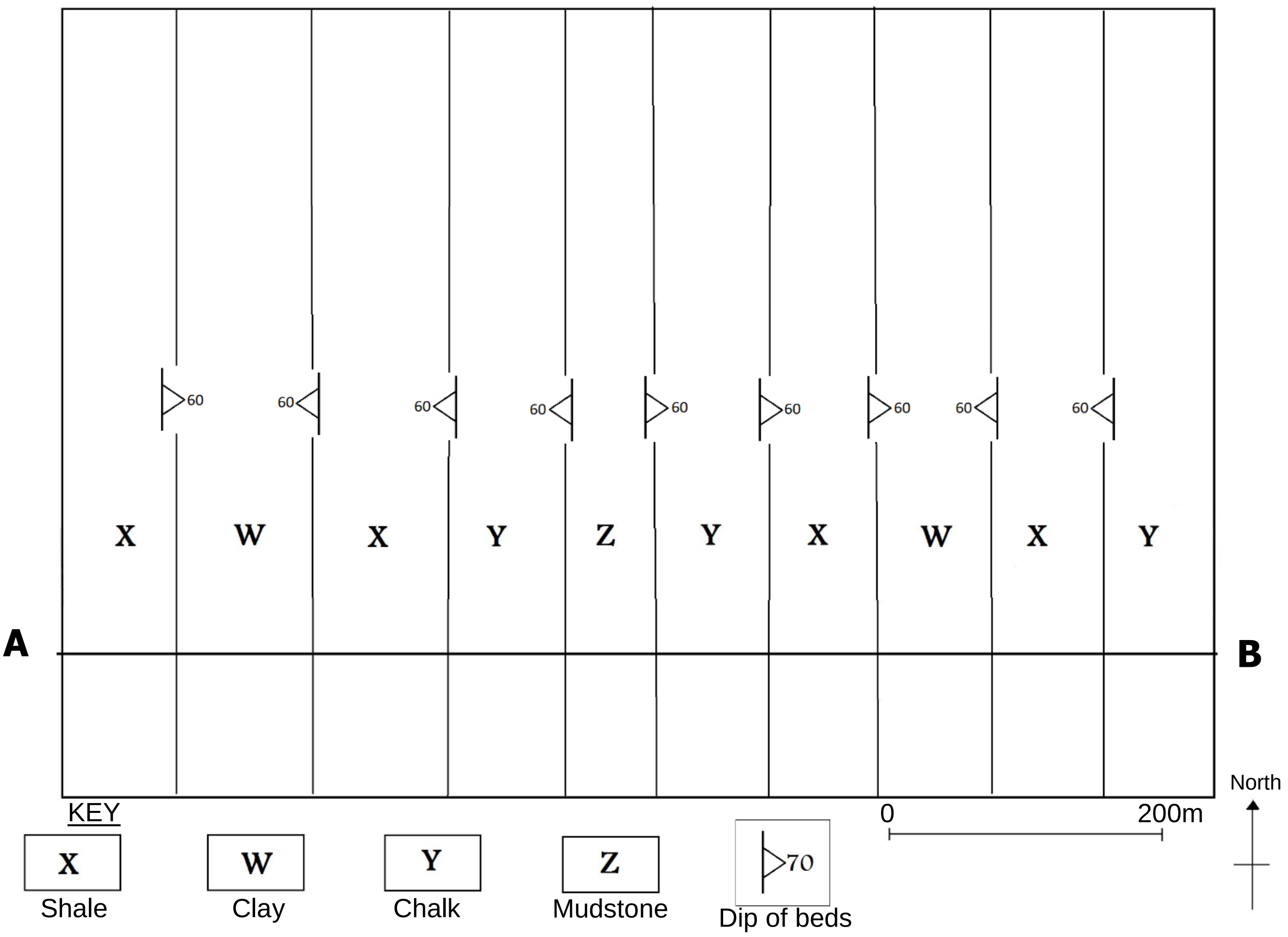
1) Mark on the map any other dip symbols that you can determine.
2) Mark on the map, using the appropriate symbol, the axial plane of any folds that you can identify.
3) Sketch cross-sections from A – B below.

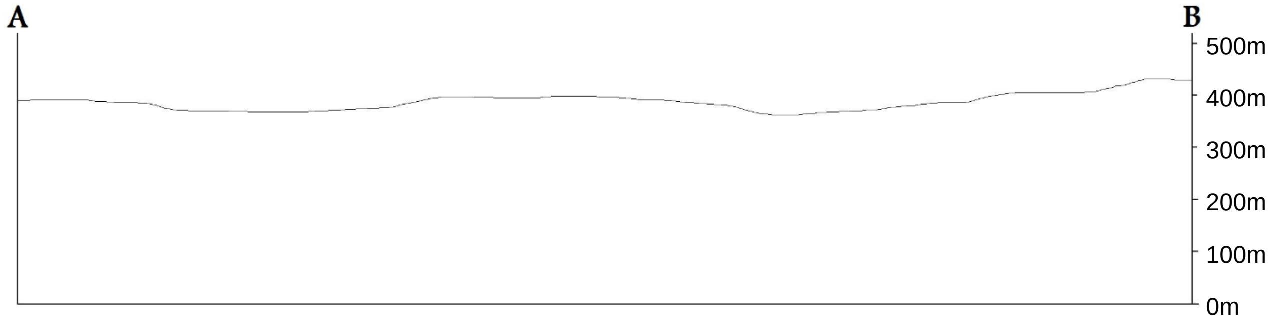




MAP EXERCISE 5: COMPLEX FOLDING

Complete the cross section A-B below using the information on the map.





1) Describe the folding on this map in detail ______________________________

____

____

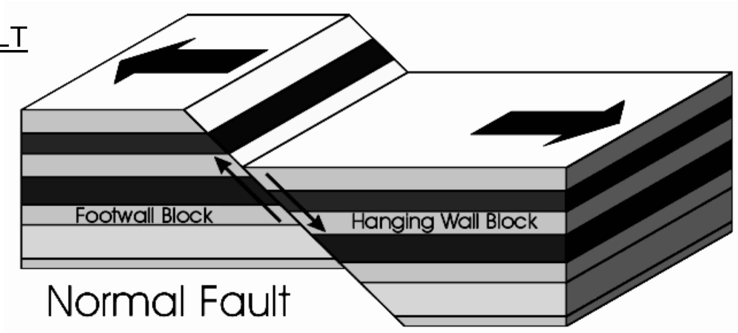
2) Add the axial plane traces of all of the folds onto the map.
3) Add the axial planes of the folds onto the cross section.

Section D: Faults

Faults are breaks in the rock along which there has been movement where a block of rock will move relative to an adjacent rock. As we start to look at the different types of fault, it is essential to learn the terminology.

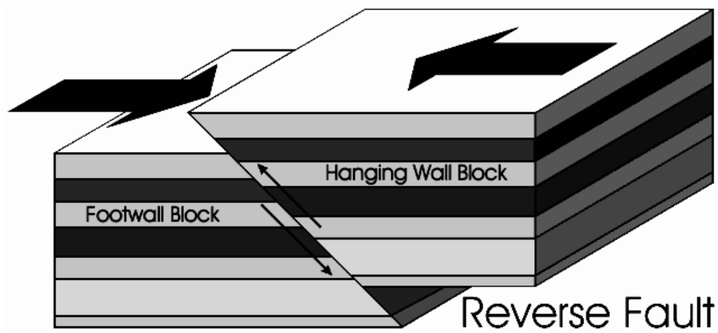
DIP SLIP - NORMAL FAULT

Figure 15



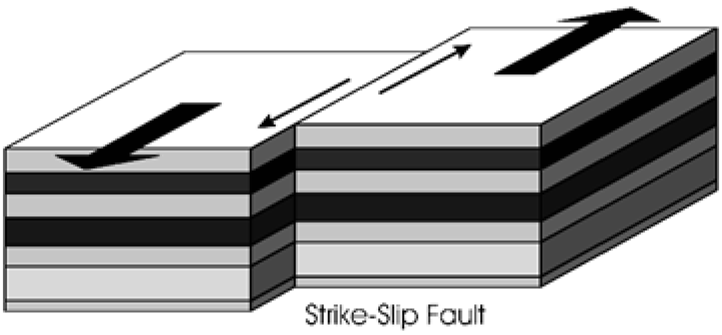
DIP SLIP - REVERSE FAULT

Figure 16



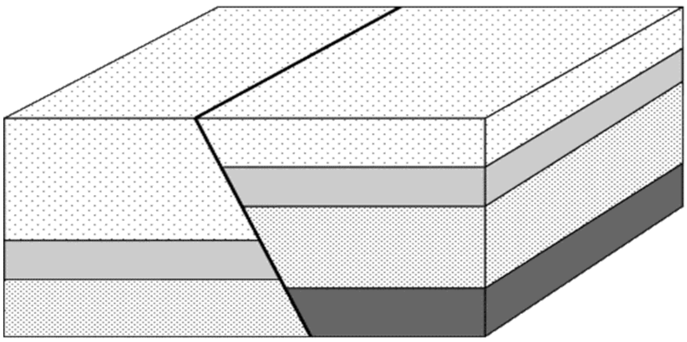
STRIKE-SLIP FAULT

Figure 17

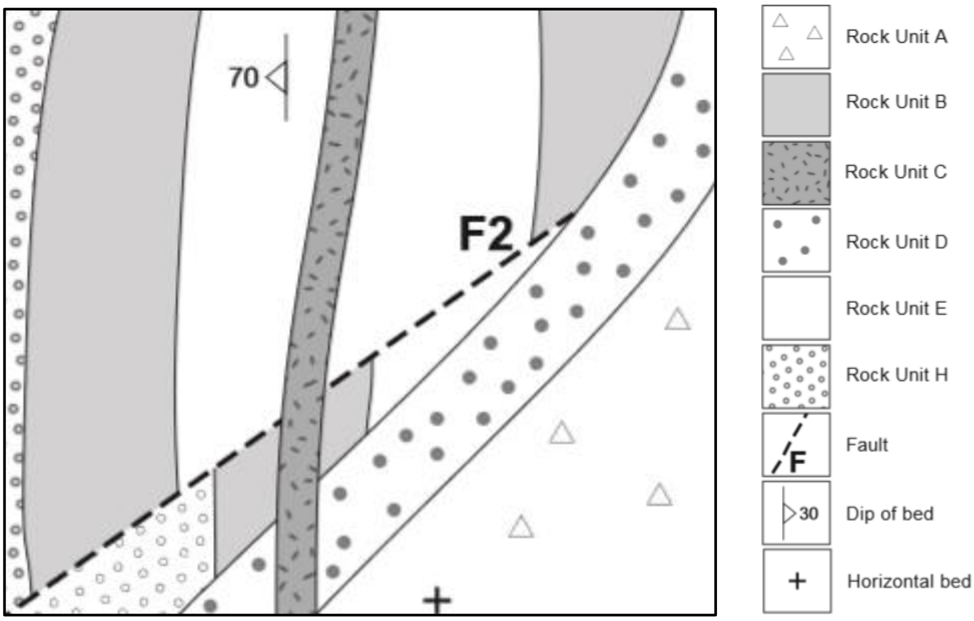


1) Annotate Figure 18 to explain the meaning of these fault terms: **fault plane, displacement, hanging wall, foot wall, downthrown block, upthrown block, strike of fault plane**

Figure 18



Map 4

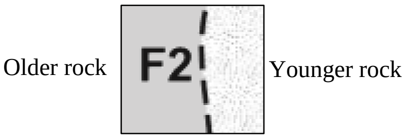


*** Remember that a fault must be younger than any bed or structure that it cuts. ***

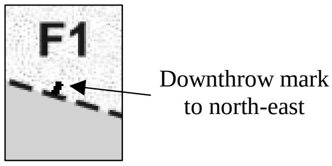
Faults are marked on geological maps with a dashed or thick black line – see above (check the key for the map you are working with). Their outcrop pattern depends on the angle of dip of the **fault plane**:

The **downthrown** side of a fault (only dip-slip faults) can be determined by:

- A small tick on the fault line on the map (check the key).
- The younger rock will outcrop on the downthrown side of the fault.



* Fault F2 must downthrow to the east



* Fault F1 must have younger rock to the north-east

TASK 9: RECOGNISING FAULTS

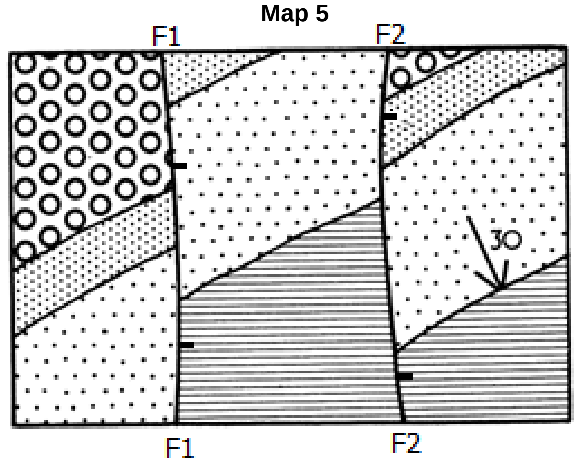
The type of fault can be recognised by combining the direction of dip with the **throw** of the fault:

- Normal faults (tensional faults) dip towards the downthrown side of the fault. **The hanging wall is downthrown**.
- Reverse faults (compressional faults) dip towards the upthrow side of the faults. **The hanging wall is upthrown**.
- Strike-slip faults (shear or tearing faults) move laterally.

For each of the maps below:

1) Name the type of fault shown.
2) Give reasons for your answer in each case.

Map 5



Both faults dip steeply to the East

Fault type: ____________________________

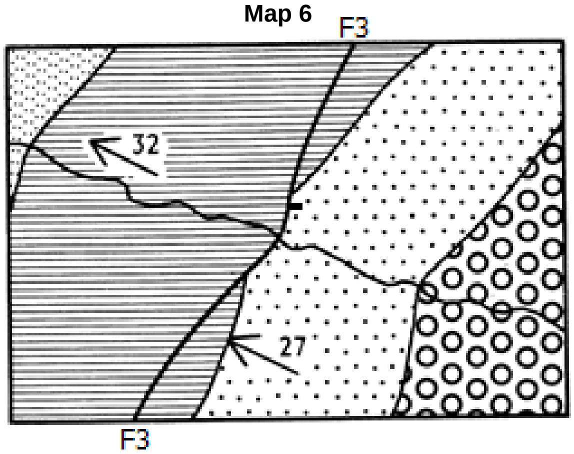
Reasons: ______________________________

____

____

____

Map 6



The fault dips at 30° to the West

Fault type: ____________________________

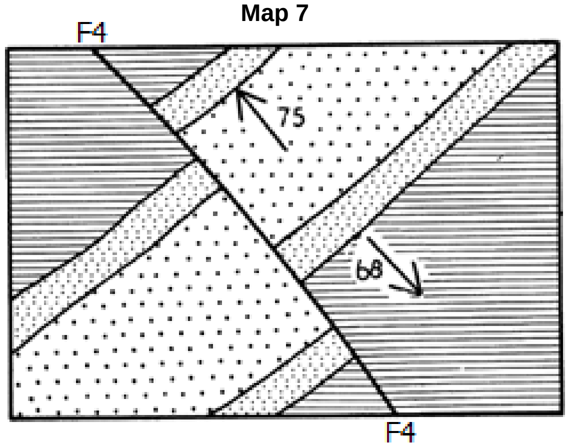
Reasons: ______________________________

____

____

____

Map 7



The fault is vertical

Fault type: ____________________________

Reasons: ______________________________

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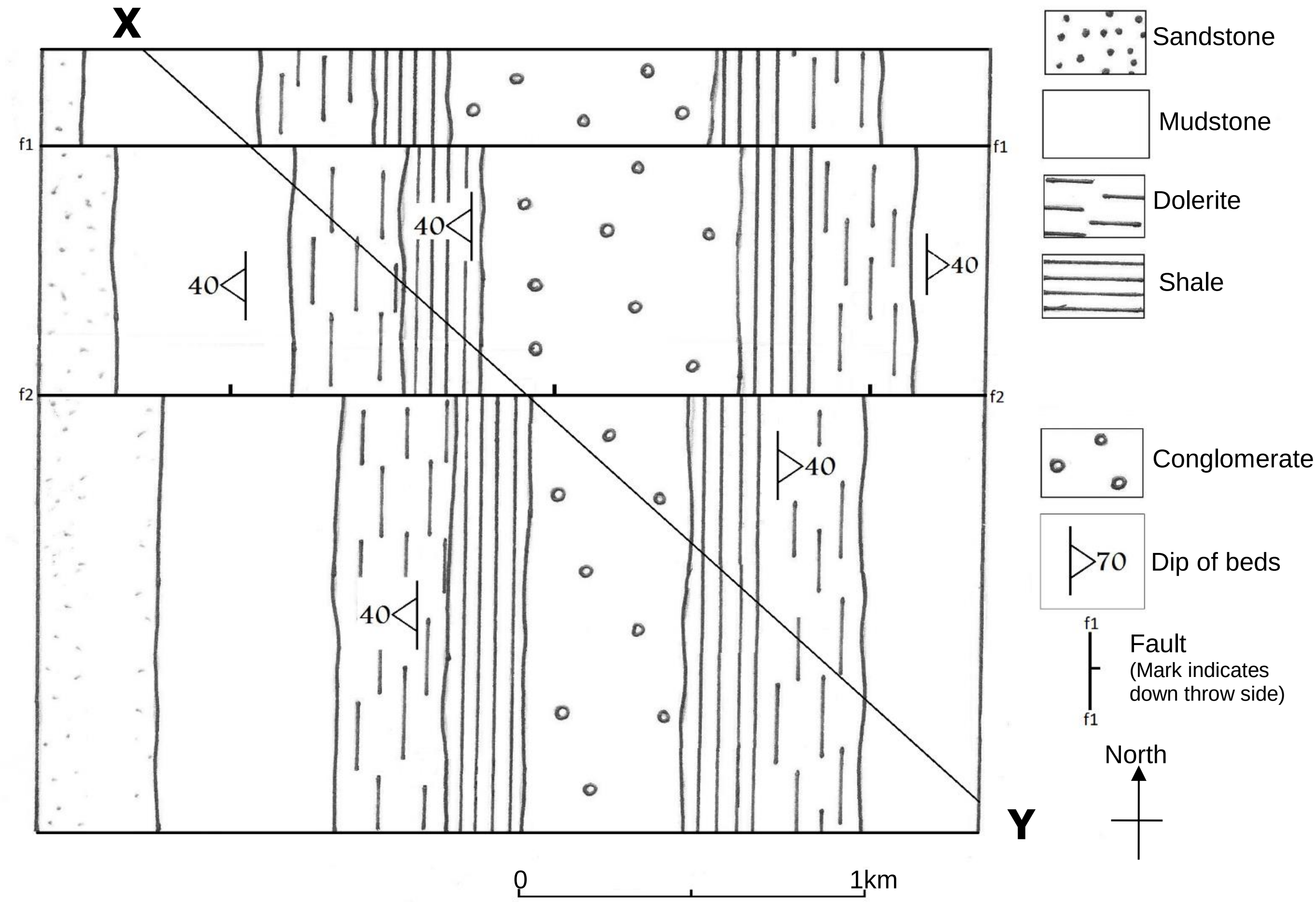
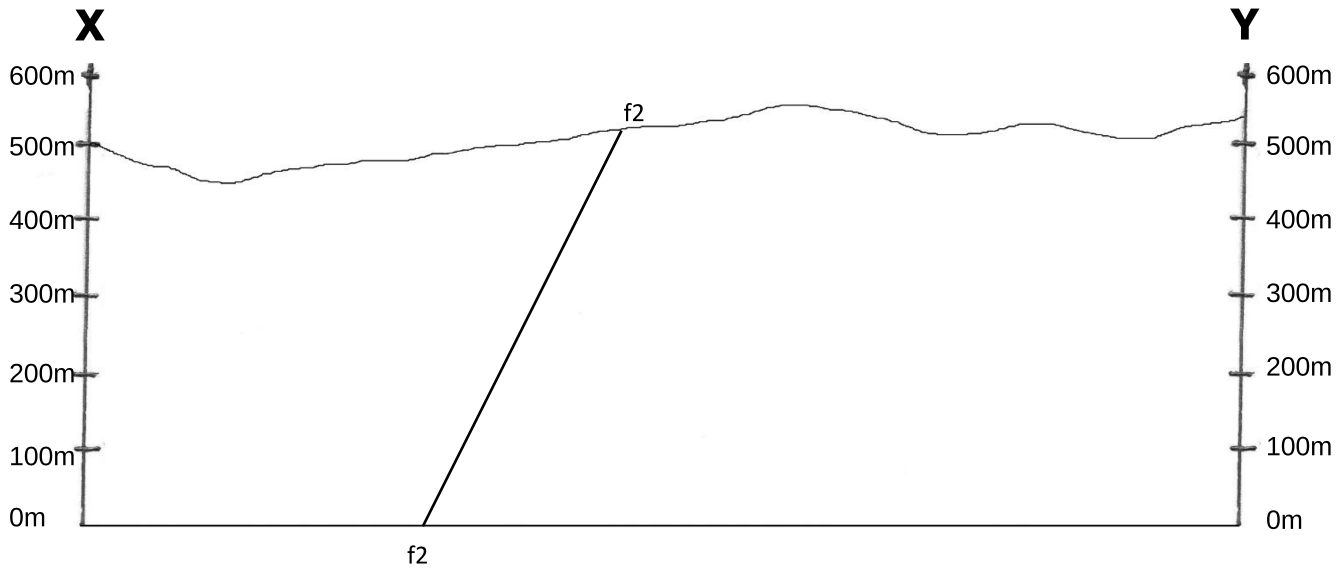
MAP EXERCISE 6: FAULTING

Complete the cross section X-Y below using the information on the map.





**** Note that fault f2 has already been completed on the cross-section. Assume that fault f1 is vertical.***

Questions:

1) The igneous feature made of Dolerite bakes both the rocks above and below it. What type of igneous feature is it? ______________________________________
2) Assuming that the rocks are all the correct way up, describe the fold found on the map. ____

____

____
3) Add the **axial plane trace** of the fold structure onto the map.
4) What type of fault is f1? (Give your evidence for this choice of fault).

____

____

____
5) What type of fault is f2? ______________________________________
6) Give one piece of evidence from the map and one from the cross-section that confirm your answer to question 5.

Map: ____

____

____

Cross-section: ____

____

____

7) Put the eight rock types and events listed below in order of their formation:

Dolerite Shale Fault f1 Sandstone Conglomerate Fault f2 Fold structure Mudstone

Oldest (first)	1st	2nd	3rd	4th
5th	6th	7th	8th	Youngest (last)

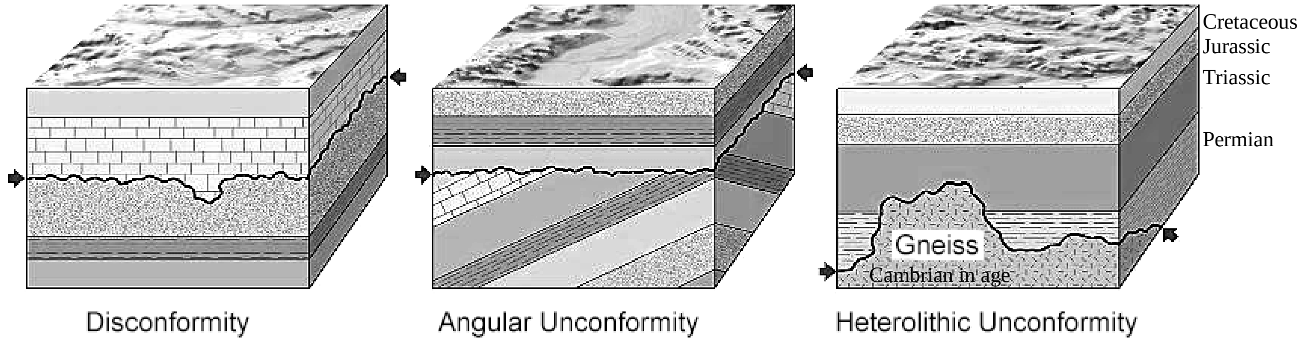
Section E: Unconformities

Unconformities are a significant feature on geological maps. They represent a part of the geological sequence that is missing (either as a result of erosion or from a period of no deposition).

TASK 10: UNCONFORMITIES

1) Annotate Figure 18 to describe the different types of unconformity.

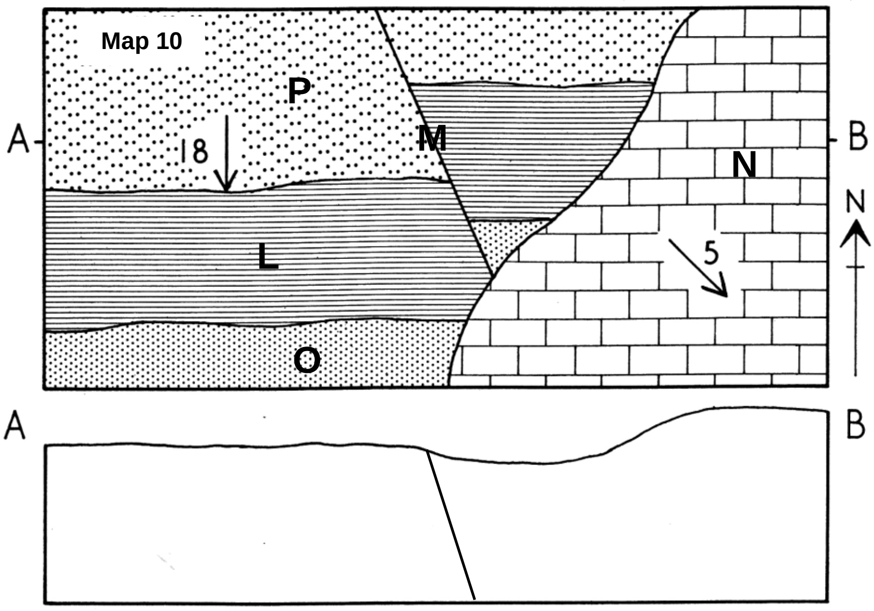
Figure 18



Unconformities can be easily recognised on a map by a number of key features:

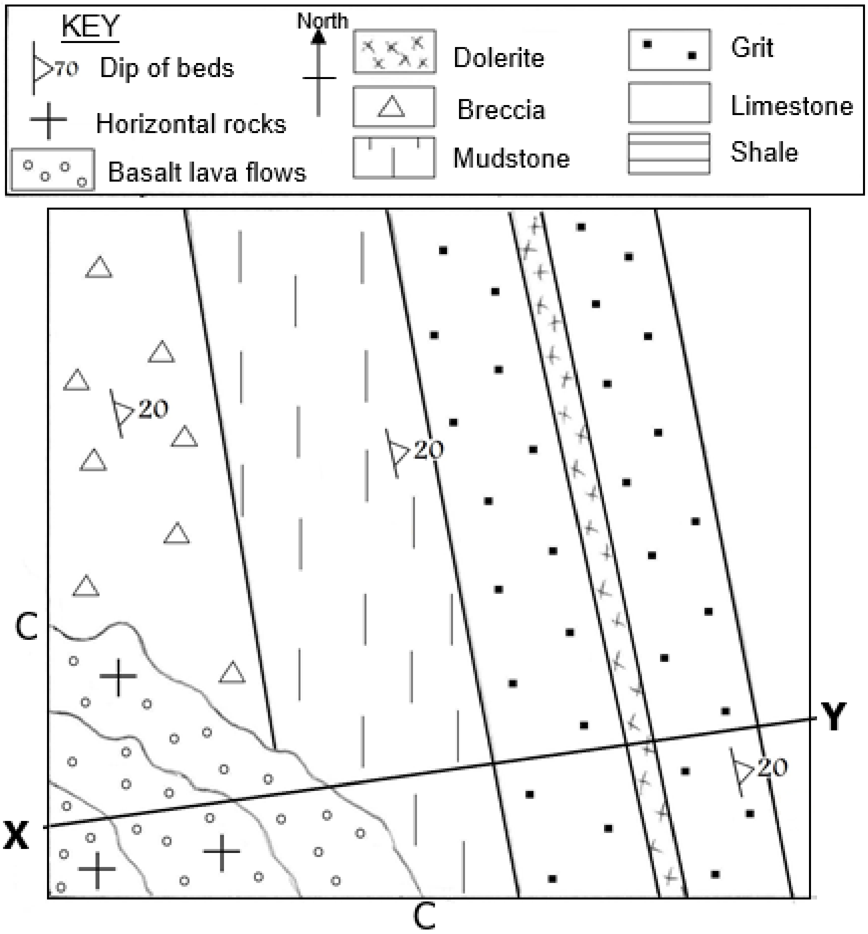
- *On the map an unconformity is shown as an irregular line cutting across geological boundaries between the older beds while the outcrop of the younger beds follows the line of the unconformity.*
- *A difference in the dip (angular unconformity) above and below the unconformity. The younger series (above the unconformity) usually has a shallower dip than the older series.*

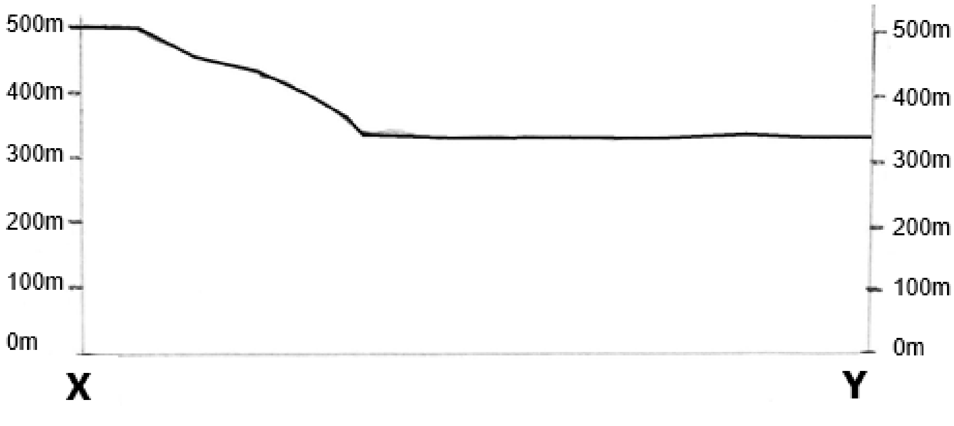
2) Draw a rough cross section using Map 8 from A - B on the profile provided.
3) Work out the order of formation of the features (L-P) on this map.



MAP EXERCISE 7: UNCONFORMITY

Complete the cross section X-Y below using the information on the map.





Questions:

1) Which is the oldest rock type on the map, and why? ________________________

____

2) What type of boundary is there between the basalt and the breccia and mudstone (labelled C-C)? ________________________

3) How did you identify this boundary (C-C)? ________________________

____

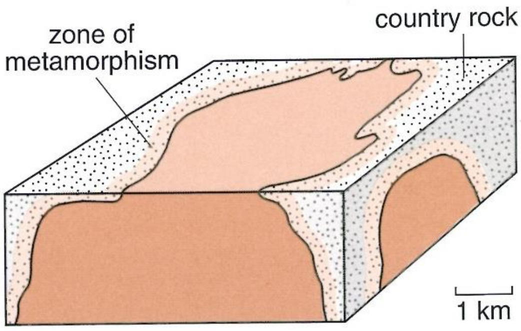
Section F: Igneous Intrusions

The intrusions you will see on a geological map fall into two broad types: large, rounded **plutons** and thin, sheet-like bodies (**dykes** & **sills**).

Plutons can be recognised very easily on a geological map.
- *The rock will be shown on the key as an intrusive igneous rock (granite, gabbro).*
- *The boundary of the rock will be irregular and rounded.*
- *There may be a **metamorphic aureole** surrounding the outcrop (check the key for its symbol). This follows the edge of the pluton.*
- ***Mineral veins** are commonly found near plutons, these can be treated in the same way as dykes.*

Figure 19 shows the 3-dimensional shape of a pluton, showing the side walls and the zone of metamorphism (aureole) that surrounds it.

Figure 19



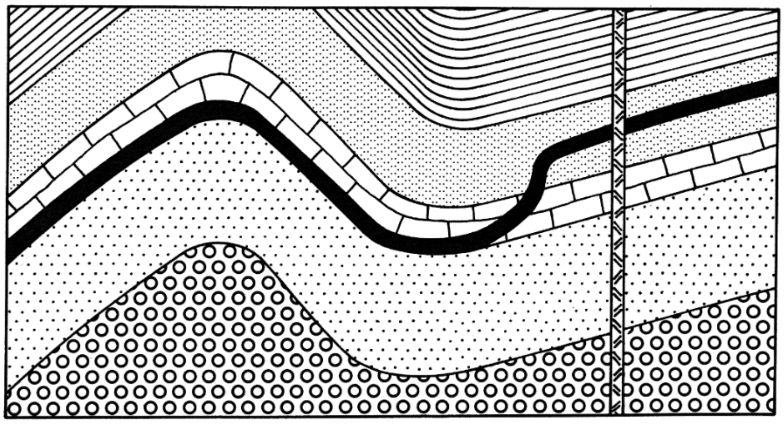
Dykes and sills can be interpreted using the same rules as beds:
- *Dykes cut across the structure of the country rock (**discordant**).*
- *Sills follow the structure of the country rock (**concordant**).*

<u>TASK 11: INTRUSIONS</u>

Figure 20 is a cross-section showing folded beds with a dyke and a sill.

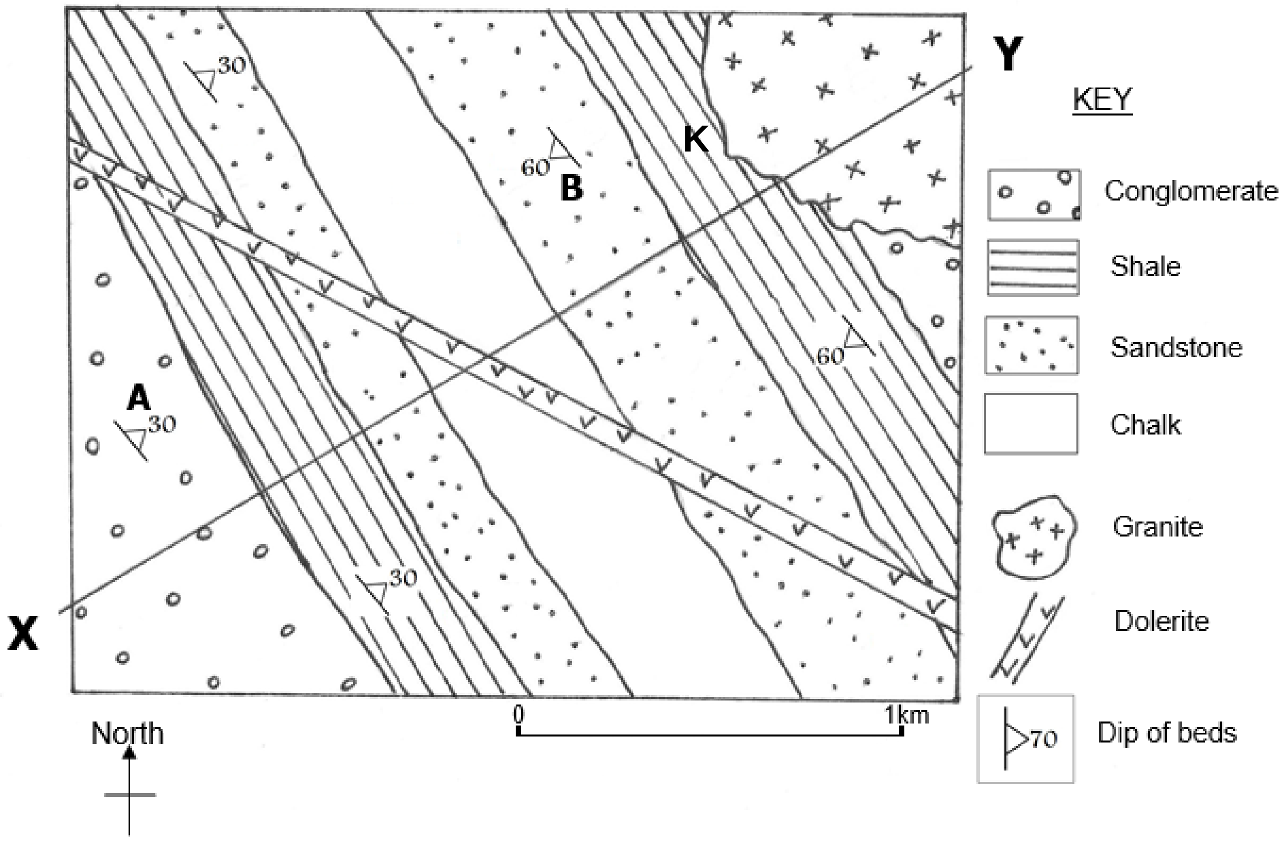
1) Label the cross-section to show any igneous intrusions. Give reasons for your answer and state their relative age.

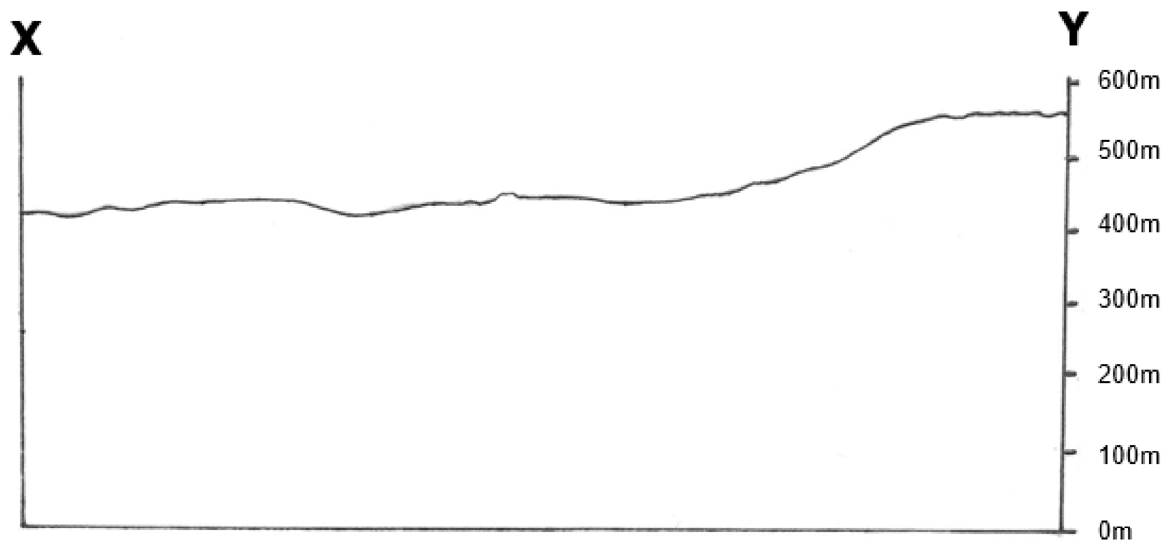
Figure 20



MAP EXERCISE 8: IGNEOUS BODIES

Complete the cross section X-Y below using the information on the map.





Questions:

1) Describe the fold on this map in detail ___________________________________

____

2) Add the **axial plane** of the fold onto the cross section.
3) Add the **axial plane trace** of the main fold feature onto the map.

4) What type of igneous intrusions are made of (give reasons for your decision in each case):

   a) Granite ____

   ____

   b) Dolerite ____

   ____

5) What is the granite likely to have done to the rocks close to it?

   ____

6) Which rock type is likely to have formed at point K on the map? Explain how this rock is likely to have formed. ____

   ____

7) State which of the following pairs of rocks is the ***oldest***, and give your reasons why:

i) The shale and the chalk.

   Oldest: _________________

   Reason: ____

   ____

ii) The dolerite and the sandstone.

   Oldest: _________________

   Reason: ____

   ____

8) a) In which *direction* do the rocks dip at **A** on the map? _______________

   b) What is the *strike direction* of the shale at point **B**? _______________

9) a) Which igneous rock formed first, the dolerite or the granite?

   ____

   ____

   b) Which is the oldest rock type on the map (state reasons for your choice)?

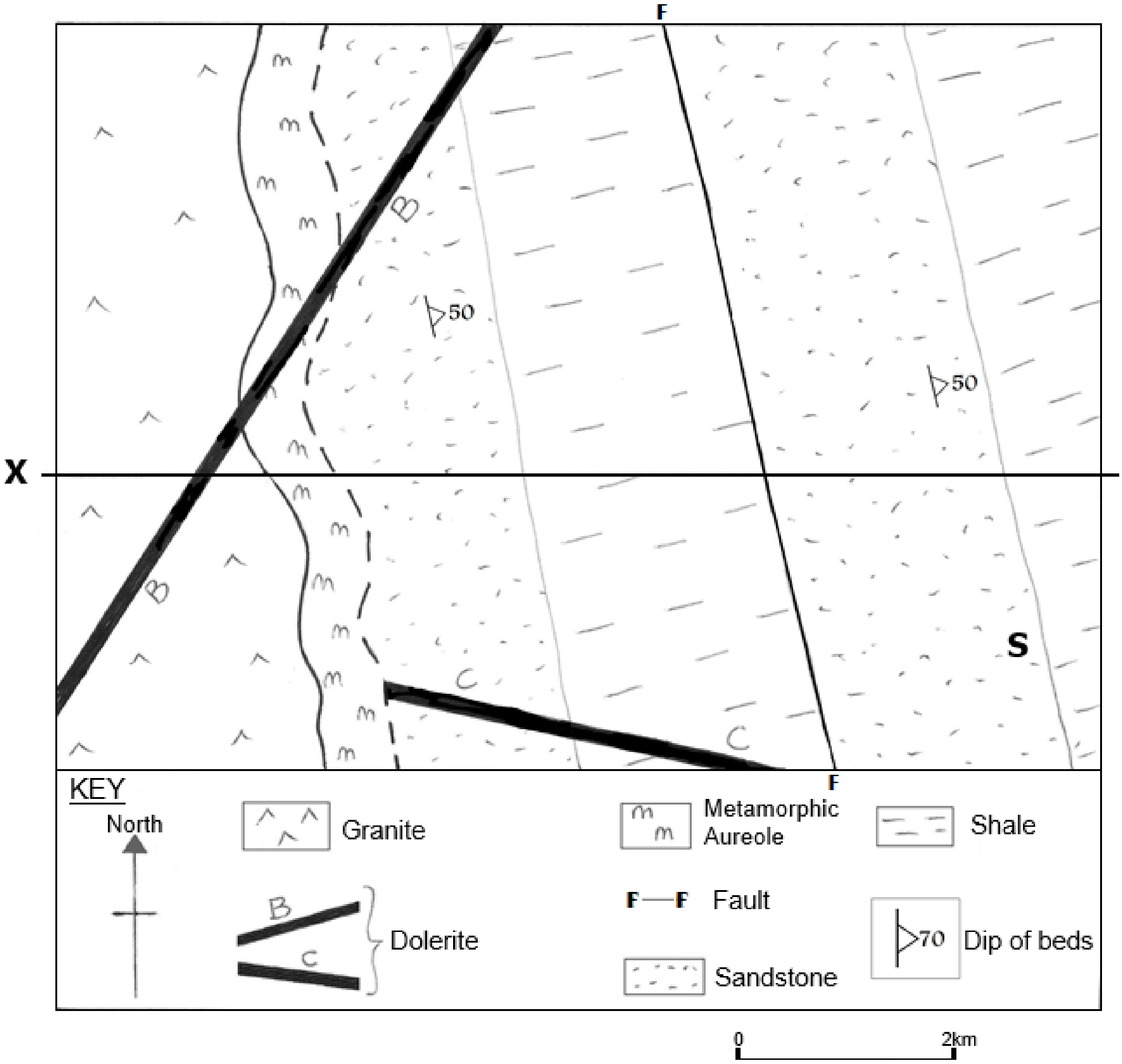
   ____

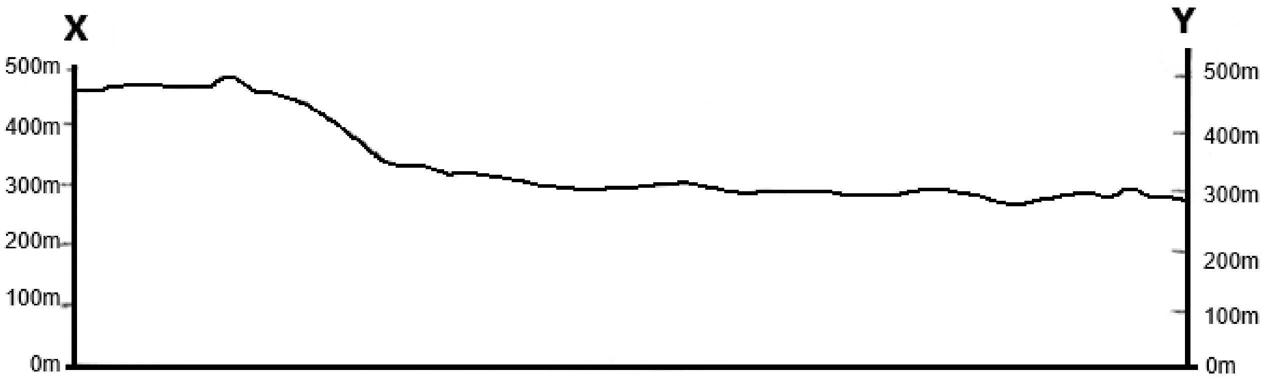
   ____

   ____

MAP EXERCISE 9: IGNEOUS BODIES

Complete the cross section X-Y below using the information on the map.





Questions:

1) What type of igneous intrusions are the dolerite features? ___________________
2) Which rock has been metamorphosed by the granite? ______________________
3) Which rock will have formed as a result? __________________________________

4) What is the *dip amount* at point **S** on the map? ____________

5) What is the direction of strike the sandstone and shale beds? ____________

6) Why do you think the land near point **X** on the cross section is higher?

____

____

7) State which of the following pairs of rocks or features is the ***youngest***, and give your reasons why:

i) The shale and the sandstone.

Youngest: __________________

Reason: ____

____

ii) The dolerite C and the granite.

Youngest: __________________

Reason: ____

____

iii) The metamorphic aureole and the sandstone.

Youngest: __________________

Reason: ____

____

iv) The fault and the shale.

Youngest: __________________

Reason: ____

____

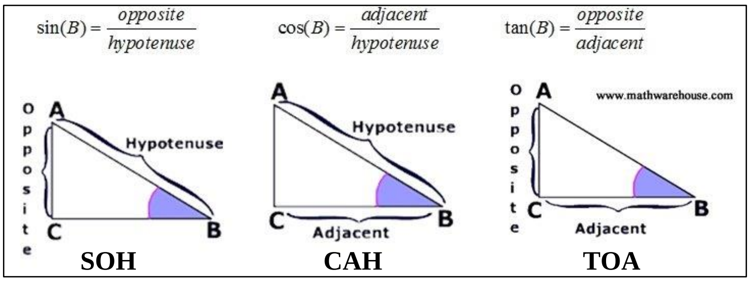
8) In your exercise book give a detailed **geological history** of the area.

- Put the rocks and events (structures) in order of formation from oldest to youngest.
- State what type of environment each of the rocks types is likely to have formed in.

TASK 12: USING MATHS TO SOLVE GEOLOGICAL PROBLEMS

Figure 21 is a cross section through a dipping bed where:

- **W** is the outcrop width
- **t** is the true thickness of the bed
- **V** is the vertical thickness of the bed
- θ is the angle of dip



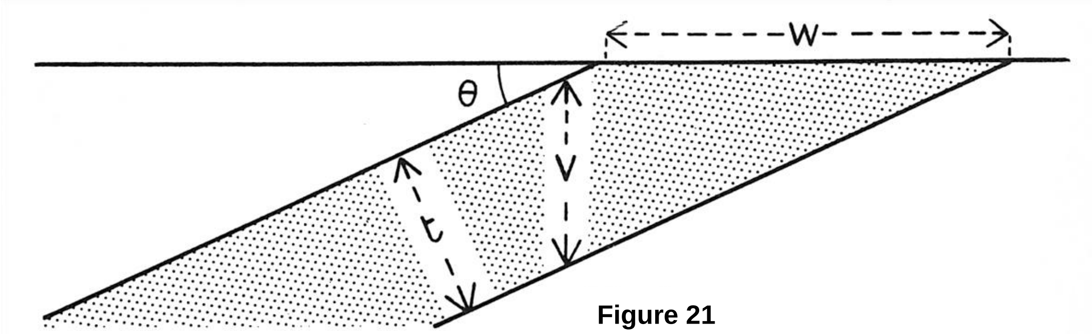


Figure 21

3) Show how you can use trigonometry to work out the value for each of the four variables using the other variables. (Remember SOHCAHTOA)

W =

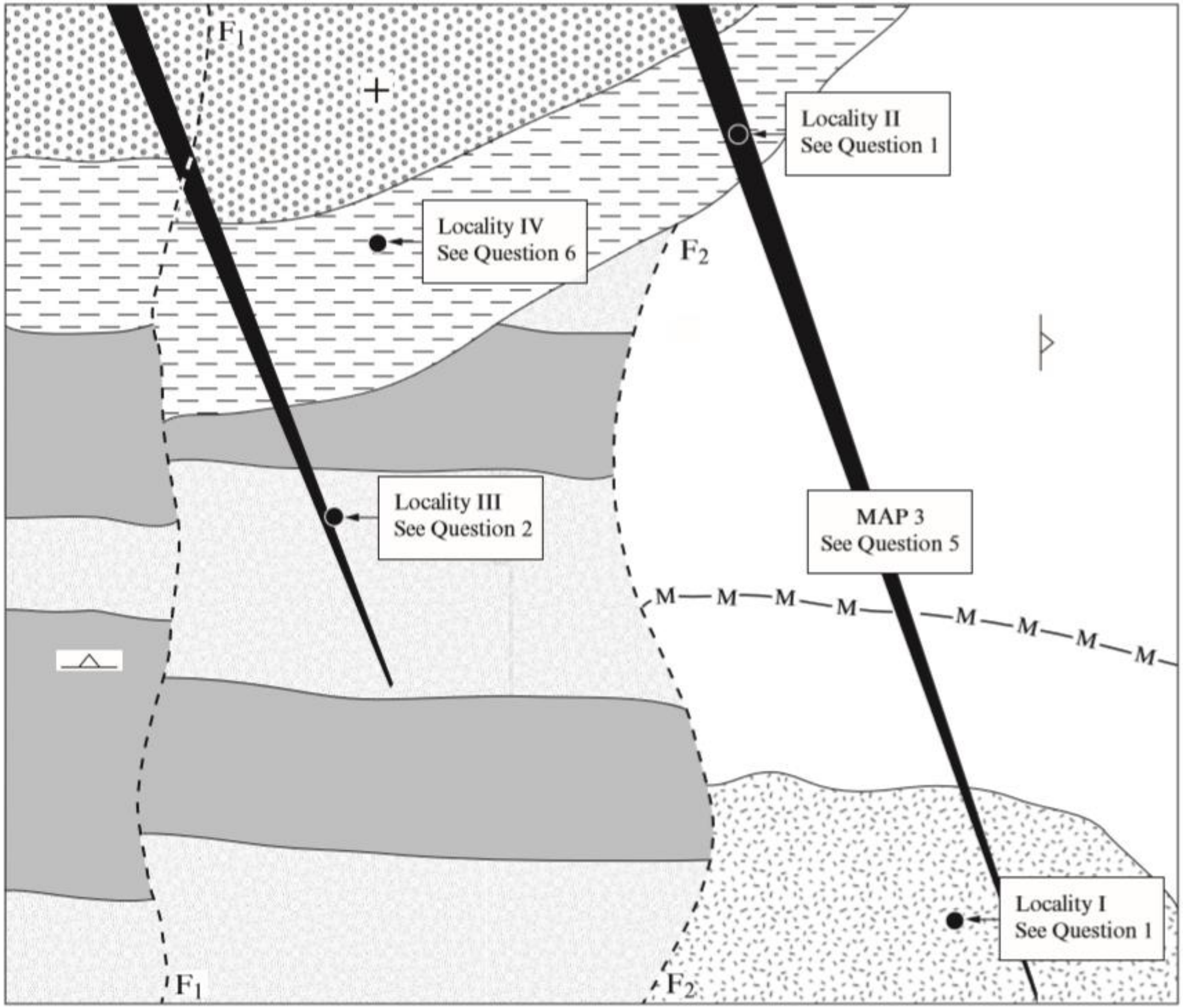
t =

V =

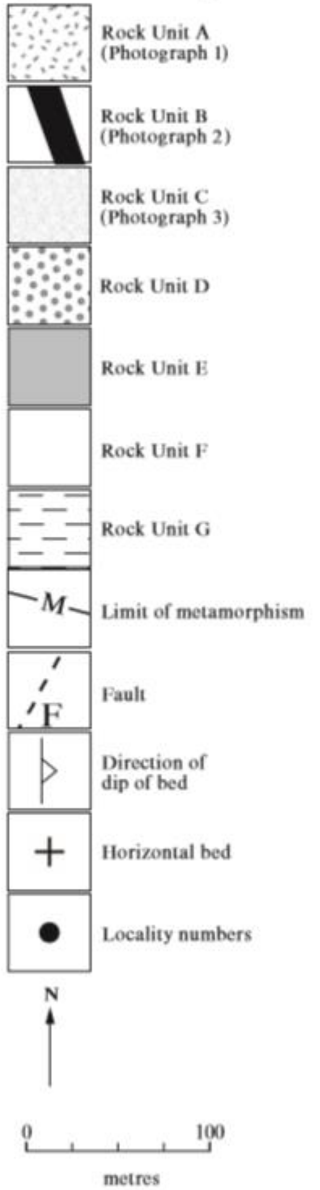
θ =

Past Paper Maps – 1 (2012)

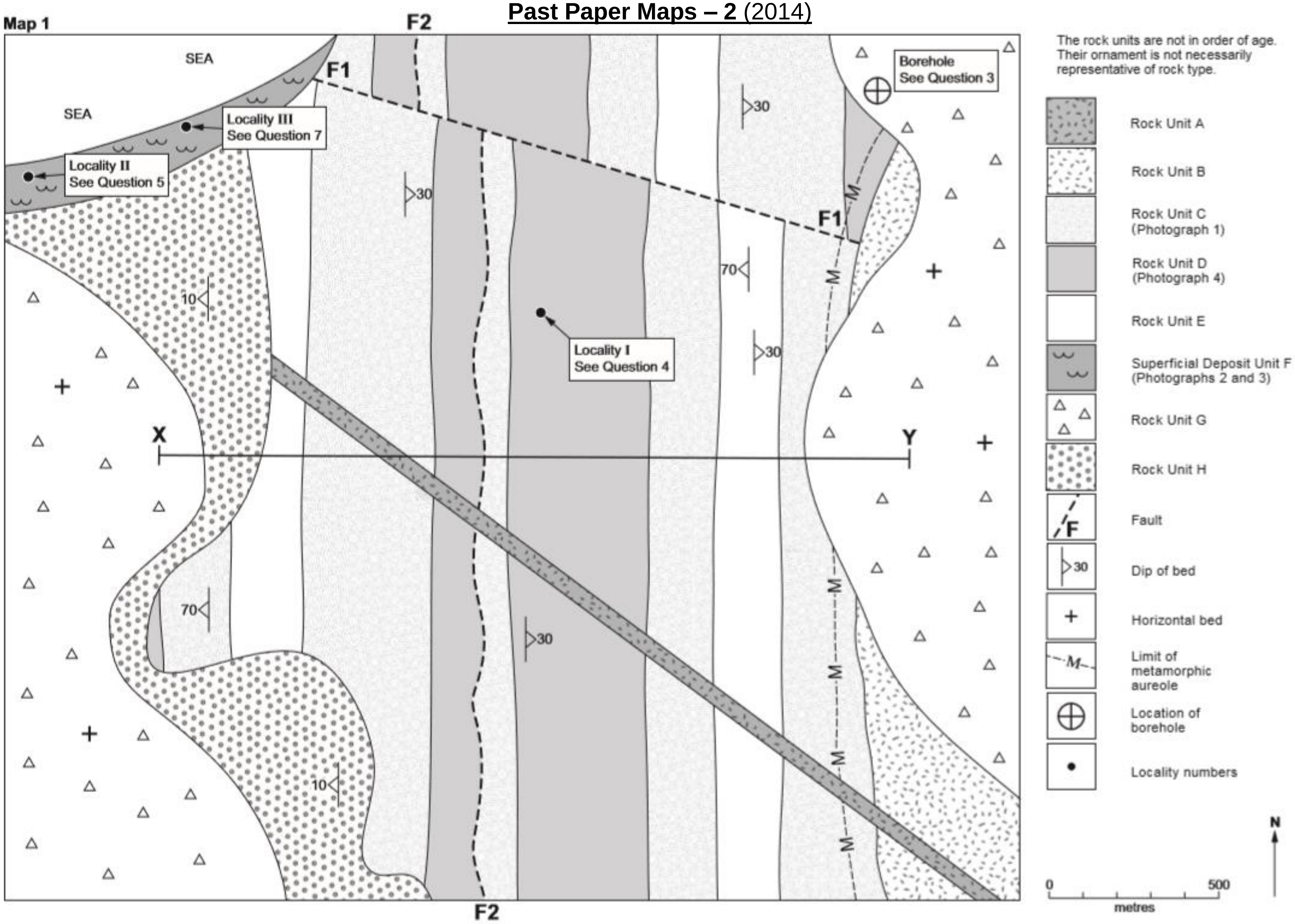
MAP 1



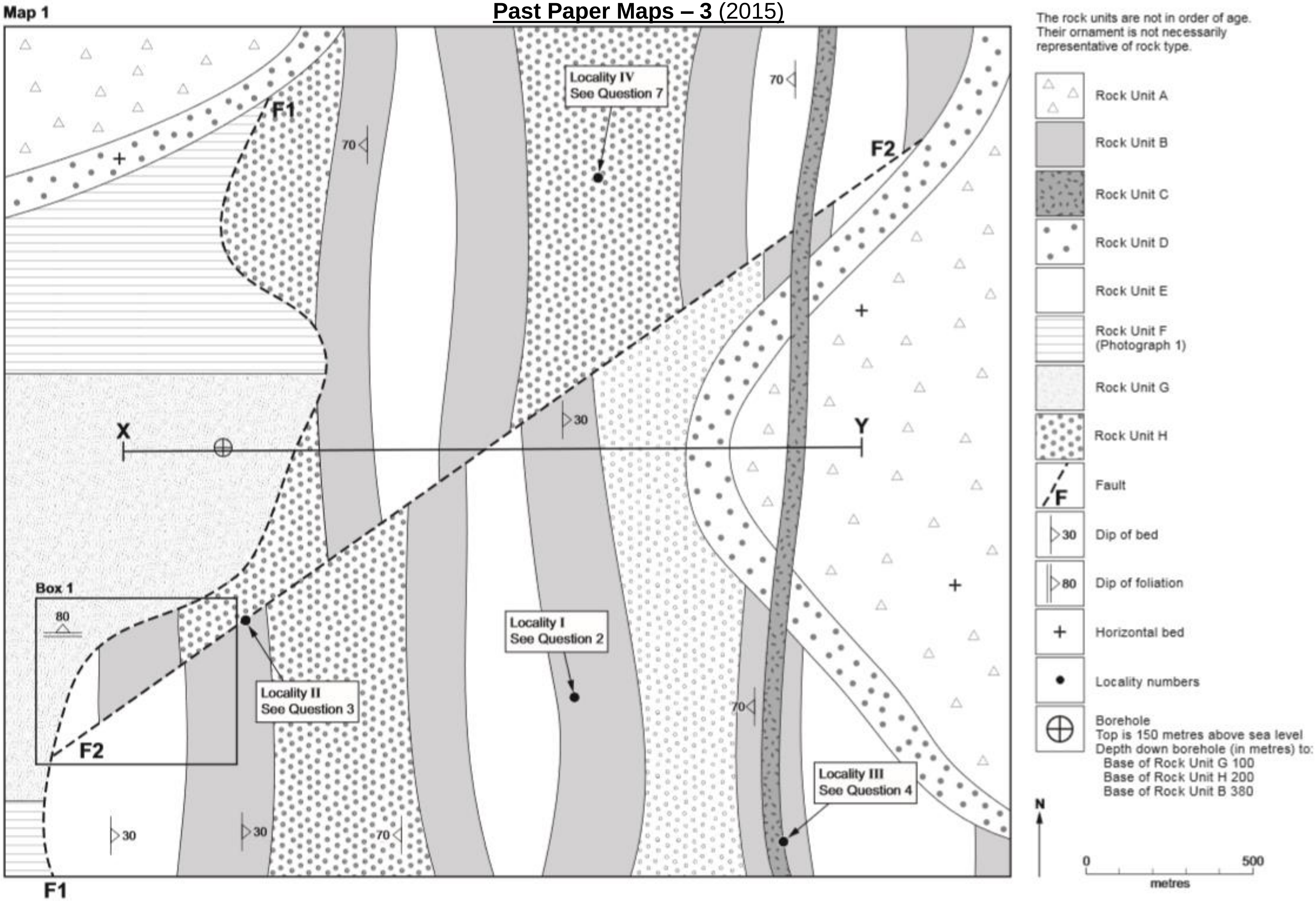
The rock units are not in order of age.
Their ornament is not necessarily representative of rock type.



Past Paper Maps – 2 (2014)



Past Paper Maps – 3 (2015)



MAP 1

Past Paper Maps – 4 (2016)