CHAPTER 4

Folding and Faulting in the Earth's Crust

Key Theme

Rocks of the earth's crust are folded and faulted by forces within the earth.

Learning Outcomes

At the end of this chapter you should be able to:

- Name the parts of a fold and draw the main types of folds.
- Name and describe the three phases of fold mountain building.
- Explain what a fault is and describe the main types of faults.
- Describe the formation of fold mountains in southern Ireland.
- Describe the landforms created by faulting of the earth's crust.

Contents

Revision Space

4.1 Folding

When tectonic plates collide, they place huge pressure (plate **compression**) on the rocks of the earth's surface. When rock layers are crumpled up by these forces, they **fold** up into ridges called **anticlines** and valleys called **synclines.**

Folds can be seen very easily in sedimentary rocks, e.g. Loughshinny in north County Dublin and the Rock of Cashel in County Tipperary. Rocks can be folded because at depth they are subjected to great heat and pressure which allows the rock to bend without breaking. Different types of fold are formed depending on the strength and direction of the pressure put on the rock. These are shown in Figs. 2 and 3.

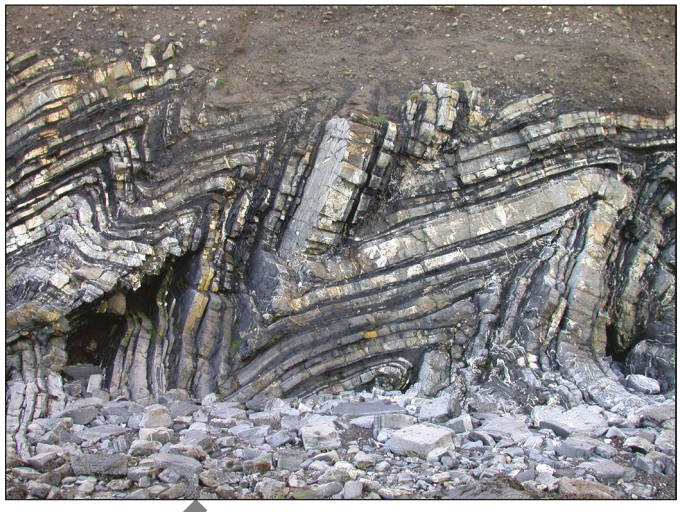


Fig. 1 Folded limestone rock at Loughshinny, North County Dublin

Types of folding

Symmetric/simple folds

Symmetric folds are formed when pressure is applied gently and equally from both sides of the rock layers. They have nearly vertical axial planes and the limbs dip at a similar angle to each other. Symmetrical folds are found near the edges of mountain ranges where tectonic activity is relatively quiet.

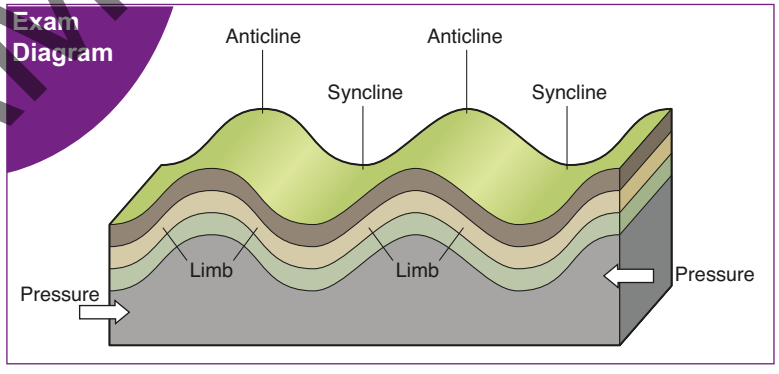


Fig. 2 The parts of a fold: anticlines are upfolds, synclines are downfolds.

Asymmetrical folds

Asymmetrical folds are formed when the pressure applied to the rock layer is greater on one side than the other. In asymmetrical folds the fold axis is tilted relative to the surface and fold limbs may be of unequal steepness.

Overfold/recumbent fold

An **overfold** is formed when larger amounts of pressure are applied to one side of a rock layer. The rock fold is turned over on itself so that one or both limbs dip in the same direction. If the axial plane is nearly horizontal the fold is called a **recumbent** fold.

Overthrust fold

When the compression of rock layers is very great, a crack or fault occurs in the fold. One limb is then pushed over the other limb forming an **overthrust** fold, e.g. the Rocky Mountains, USA.

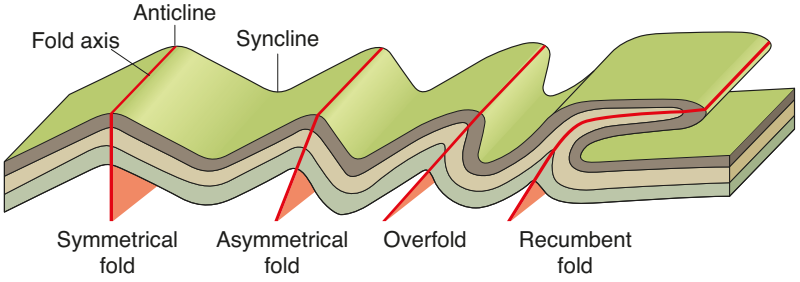


Fig. 3 Types of fold

Fold mountain building

The formation of fold mountains is also called **orogeny**. Over the last 500 million years there have been several fold mountain building phases across the world.

Fig. 4 Recumbent fold in the Swiss Alps

1. **Caledonian folding** occurred around 400 million years ago. The mountain ridges run or **trend** from north-east to south-west, e.g. the Leinster mountains and the mountains of north-west Ireland and Scotland. As these are extremely old mountains, they have been worn down and today are rounded in shape.
2. **Armorican folding** occurred around 300 million years ago. The mountain ridges trend from east to west, e.g. the Munster ridge and valley province, Paris Basin in France. These are higher and more rugged than the Caledonian mountains because they are younger.
3. **Alpine folding** occurred 50 million years ago. This is not found in Ireland. Mountain ridges trend from east to west, e.g. Alps and Himalayas. These are the highest and most jagged mountains in the world because they are so young.

Activity

In your copybook, draw the map on the right and mark the following fold mountain ranges on it:

(a) Derryveagh Mountains
(b) Wicklow Mountains
(c) Macgillycuddy's Reeks Mountains
(d) Comeragh Mountains.

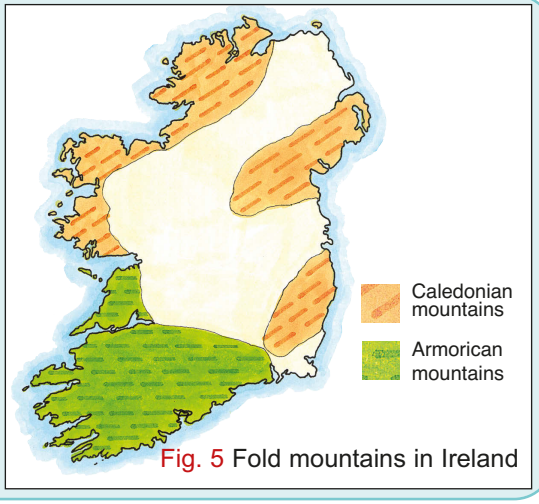


Fig. 5 Fold mountains in Ireland

CHAPTER 4
Case Study 1

4.2 Fold mountains in Ireland

The Munster Ridge and Valley Province

1. Between 350 and 400 million years ago Ireland lay closer to the equator and experienced a dry desert climate. Huge amounts of sand were deposited in an enormous hollow called a **geosyncline** that is now the south and south-west of Ireland. Today this is known as **Old Red Sandstone**. Later, a warm shallow sea covered the area and limestone was laid down on top of the sandstone.
2. About 300 million years ago, during the Armorican orogeny, the rocks of Ireland were squeezed by plate collision, forming **fold mountains**.
3. These fold mountains stretch from Waterford to Kerry. Their east-west trending anticlines, or ridges, are responsible for mountains such as the Comeraghs, Silvermines and Galtee Mountains (see Fig. 7). These ridges are made of resistant sandstone rock. During folding, rocks in the anticlines were stretched and cracks formed, weakening the overlying limestone. Over time, weathering and erosion removed the limestone from the anticlines exposing the sandstone beneath.
4. Today the fold synclines are still covered with this limestone and form wide valleys. The Golden Vale and the Blackwater Valley are examples.

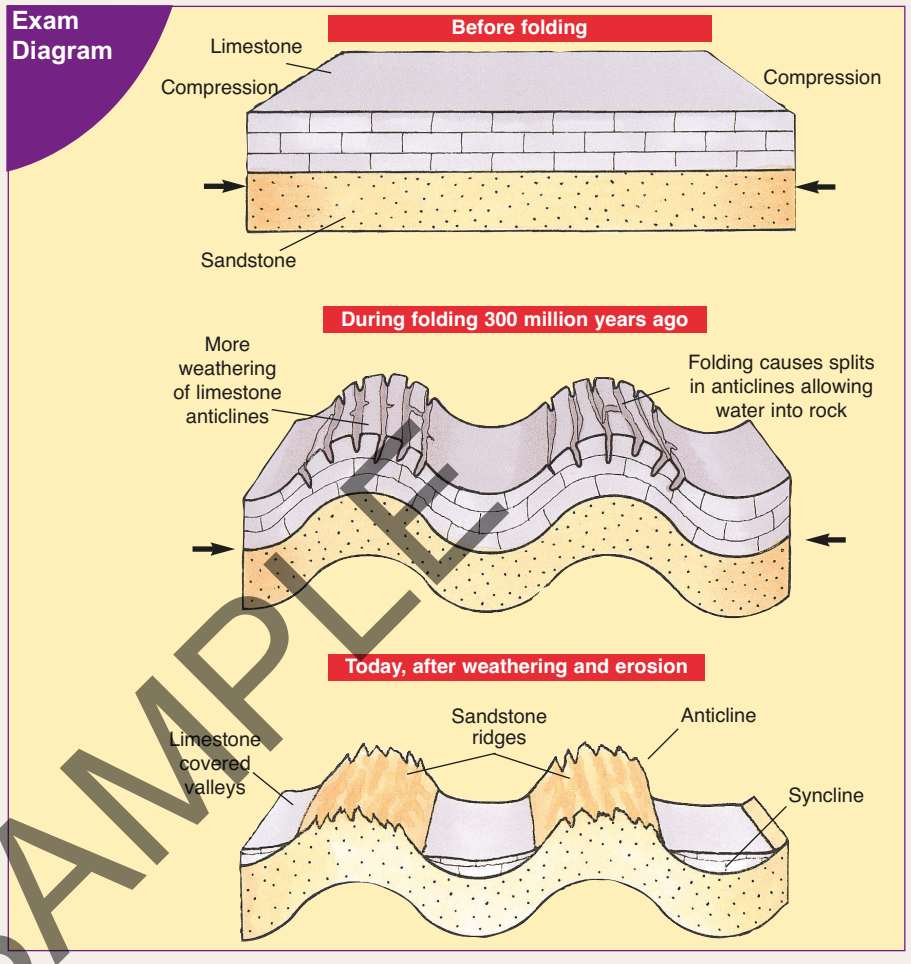


Fig. 6 The formation of the Munster ridge and valley province

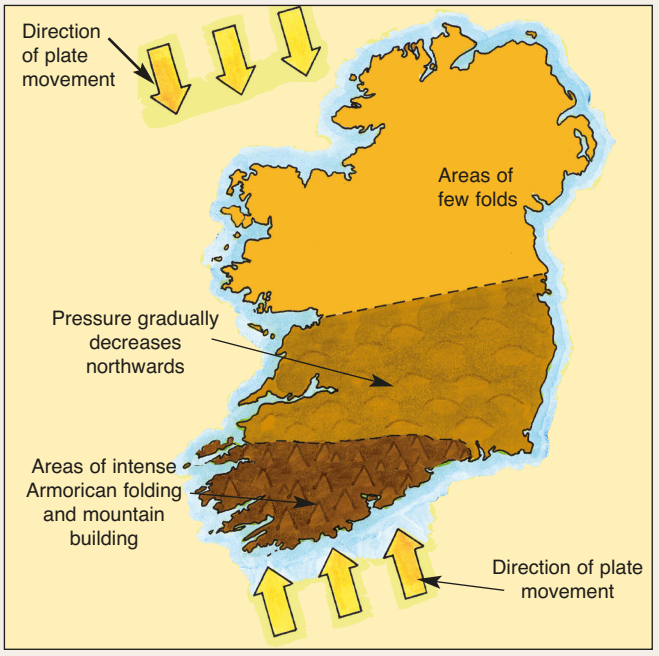


Fig. 7 Location map of Munster ridge and valley province

4.3 Faulting and associated landscapes

Near the surface of the earth, rock is brittle and will crack or fracture when placed under great stress by earth movements. Rocks contain many small fractures or joints. When movement happens along a rock fracture, it is called a **fault**.

Faults often occur in parallel sets because the stress that produces them operates over a large area. Pressure and **tension** make the land either side of the fault move up, down or sideways.

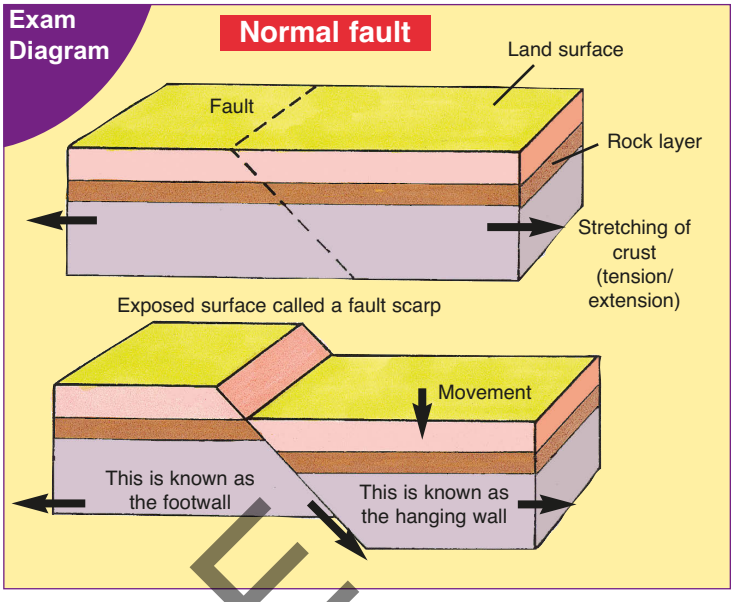


Fig. 8 A normal fault

Normal faults

When a sloping fault is created and land slips down along one side of it, a **normal fault** is formed. These are caused by the land being pulled apart (tension), sometimes making a rift valley. The exposed face of the fault is called the **fault scarp**.

Fig. 9 A normal fault in sedimentary rock in El Salvador

Landform made by normal faulting

A **rift valley**, or **graben**, is formed when a block of land slips down between sets of parallel normal faults. This is due to stretching of the crust. Lough Neagh and the lower Bann valley occupy such a rift valley.

Larger rift valleys occur in Germany, such as the Rhine Rift Valley between the Vosges and Black Forest Mountains. The Midland Valley of Scotland is another example. (See the case study on the Great African Rift Valley on page 63.)

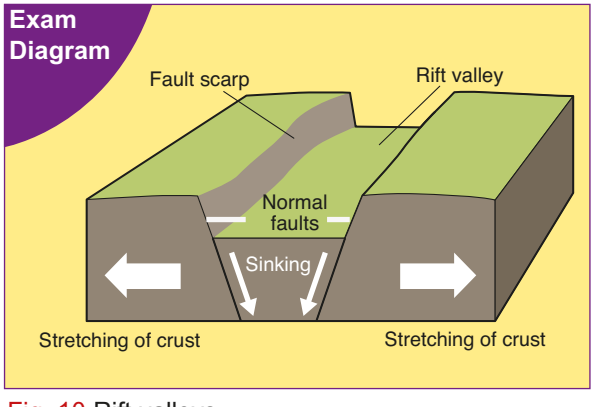


Fig. 10 Rift valleys

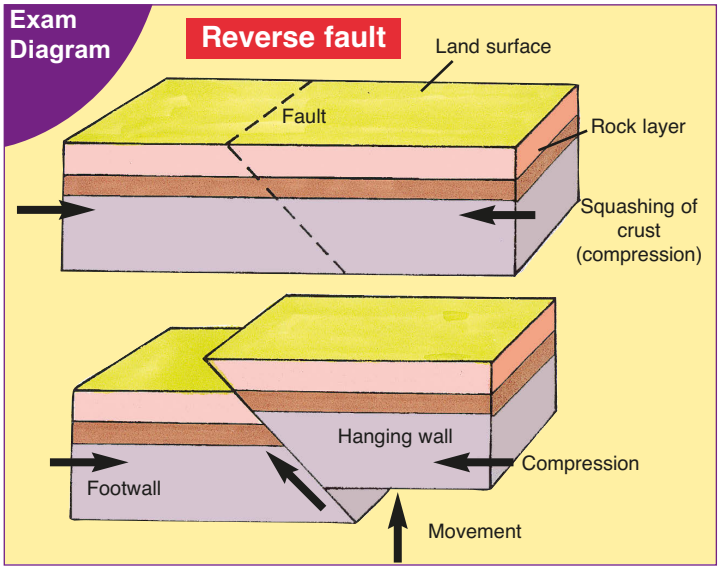


Fig. 11 A reverse fault

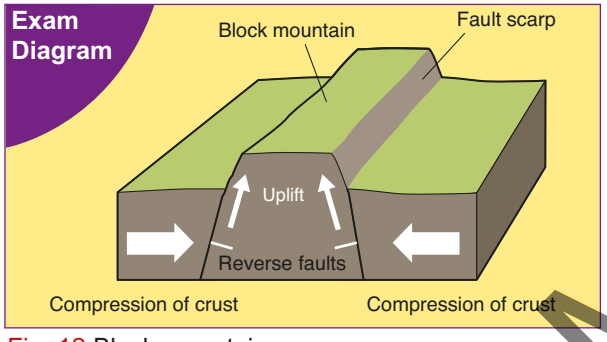


Fig. 12 Block mountains

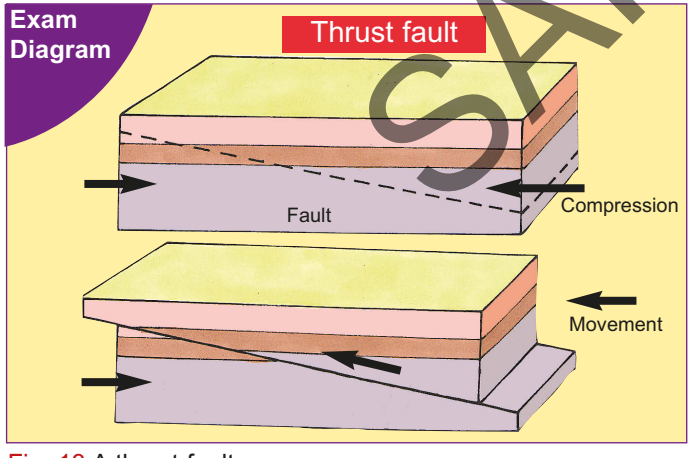


Fig. 13 A thrust fault

weblink
Fault motion

Reverse faults

If pressure from earth movements (compression) causes land to move up along a sloping fault line a **reverse fault** is formed, sometimes making block mountains, for example the Ox Mountains of County Sligo.

Landform made at a reverse fault

A **block mountain** (**horst**) is a block of land left standing between two reverse faults, e.g. Vosges and Black Forest mountains. The Ox Mountains of Sligo were formed in this way. Here a block of gneiss was pushed up between reverse faults in limestone and conglomerate rocks.

Thrust faults

A **thrust fault** is a type of reverse fault where the angle of the fault plane is very low, < 20° (i.e. less than 20°).

Tear faults

Tear faults (**transform faults**) occur when there is a vertical fault in the landscape but movement has been horizontal. This is similar to the movement along the San Andreas fault in California.

The long east to west anticlines of Cork and Waterford are crossed by many tear faults. Geological maps show that a movement of 2 km occurred along tear faults close to Slieve Gullion in County Armagh.

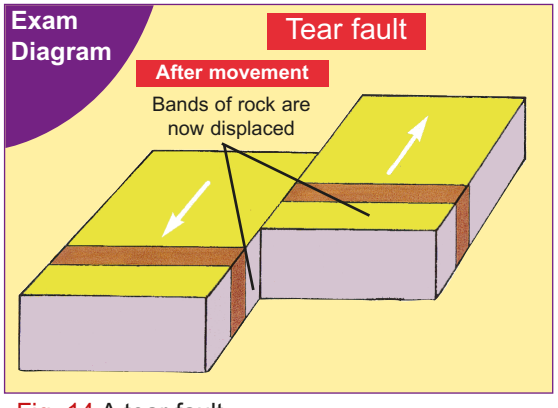


Fig. 14 A tear fault

CHAPTER 4
Case Study 2

The Great African Rift Valley – A landscape formed by faulting

1. The African Rift Valley is a landform made by faulting. This huge rift valley is visible from space as it is the world's largest surface fracture. It extends more than 6,000 kilometres from the Red Sea in the north to Mozambique in the south.
2. The African Rift Valley formed during the last 20 million years due to the presence of a hotspot beneath the crust. The hotspot is causing the African continent to bulge, stretch and split. As the crust is pulled apart, long parallel cracks called normal faults are formed.
3. Huge blocks of crust are sinking between the normal faults forming a large flat-floored rift valley or graben.
4. The land has subsided so much in places that it lies more than 153 m below sea level. The fault lines are marked by high fault scarps or escarpments rising steeply several thousand metres from the valley floor.
5. At the same time magma is forced up to the surface in places and erupts, forming volcanoes, e.g. Mount Kilimanjaro and Mount Kenya.
6. The African Rift Valley varies in width from 40 to 100 km and is widening at a rate of up to 4 mm per year.
7. Many lakes have also formed in the floor of the rift valley. The deepest is Lake Tanganyika which is nearly 1,420 m deep.

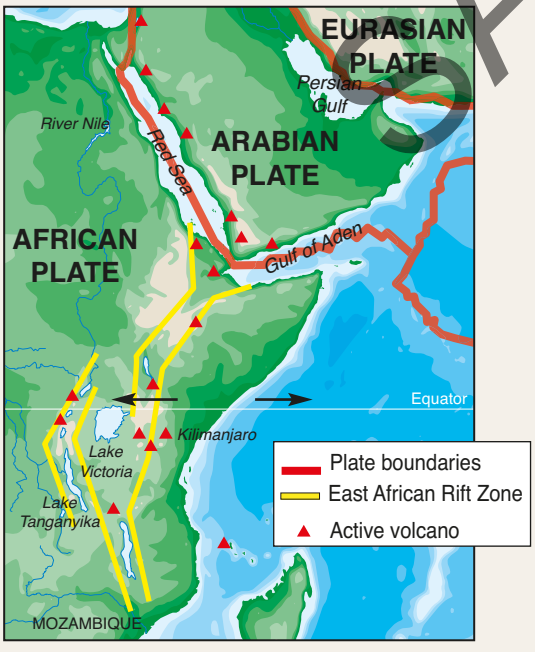
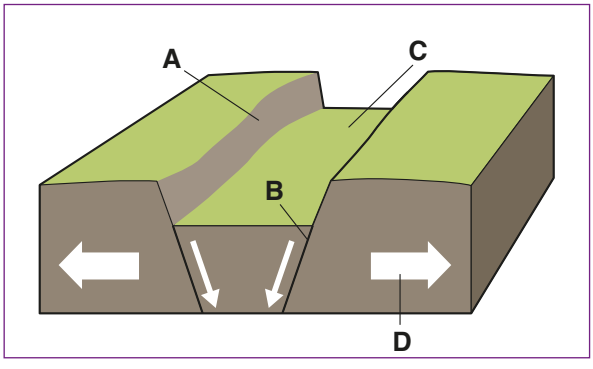


Fig. 15 Plate map of East Africa

Fig. 16 Fault scarp in the African Rift Valley

Chapter Revision Questions

1. Draw and label a symmetric fold. In your diagram show the limb, anticline, syncline and fold axes.
2. Explain the difference between the formation of a symmetric fold and an overfold.
3. Explain the terms (a) compression and (b) tension.
4. Name and briefly describe the three orogenies you have studied. Give an example of each.
5. Describe the formation of the Munster ridge and valley province.
6. What is a fault?
7. Draw labelled diagrams of normal, reverse and thrust faults.
8. Using examples and diagrams, describe the formation of a block mountain and rift valley.
9. Describe the formation of the Great African Rift Valley.
10. Copy the diagram below into your copybook. Using the words provided, label the diagram.
    - Fault scarp
    - Rift valley
    - Stretching of crust / tension
    - Normal fault



LC Exam Questions

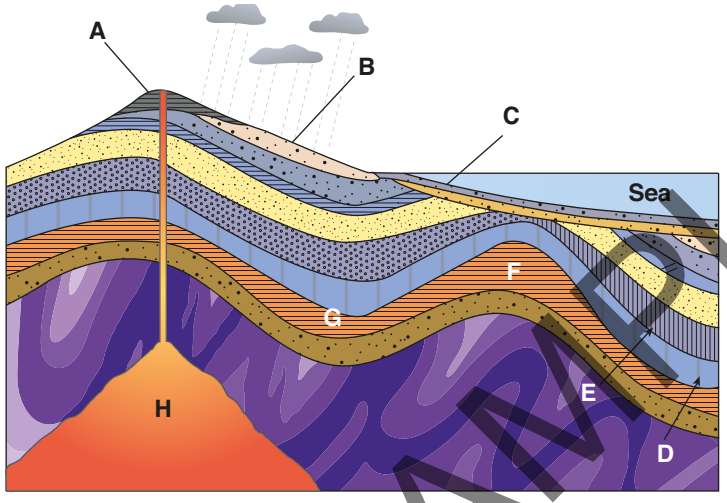
Higher Level students must be able to answer Ordinary and Higher Level questions.

OL Questions

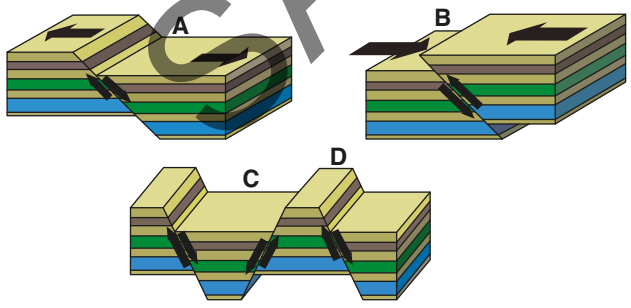
11. (i) Name **one** example of fold mountains.
    (ii) With the aid of a diagram(s) explain how fold mountains are formed.

HL Questions

12. Examine the diagram below. Match each of the letters A - H with the feature or process that best matches it in the table below.



Feature / Process	Letter
Joint	
Syncline	
Volcano	
Coastal deposits	
Bedding plane	
Magma chamber	
Weathering	
Anticline	



13. Examine the diagrams above and answer the following questions.
    (i) Name the type of fault at A and the type of fault at B.
    (ii) Explain briefly what causes the type of faulting at A or at B.
    (iii) Name the landform at C and the landform at D that result from faulting.
14. Explain how the study of plate tectonics has helped us to understand the global distribution of fold mountains.
15. Explain how **one** of the following influences the development of landforms:
    - Folding
    - Faulting.

Key Words
Chapter 4

Key Words

You should be able to explain both verbally and in writing each of the key words listed below.

Alpine folding
anticline
Armorican folding
asymmetric fold
block mountain/horst
Caledonian folding
fault
fault scarp
fold
geosyncline
normal fault
Old Red Sandstone
orogeny
overfold/recumbent fold
overthrust fold
plate compression
reverse fault
rift valley/graben
symmetric fold
syncline
tear/transform fault
tension
thrust fault
trend

Digital Resources are available for this chapter at mentorbooks.ie/resources