THE ROCK CYCLE

by Robert Burn

ROCKS: you see them every day – on the pavements you walk on, in the buildings you pass, on holiday at the coast, by the river, or even when digging in the garden. Have you ever given them a second thought? What are they made of? Where do they come from? Why do they look different from each other?

This unit will answer many of these questions and provide you with a greater understanding of rocks, which you may find helpful in other areas of geography such as landforms, primary industry and erosion processes.

So what are rocks?

There is such a massive range of different rocks in the Earth's crust that there is a whole subject devoted to their study, called Geology. However, all rocks have one thing in common: they are made up of **minerals**.

What are minerals?

Minerals are a solid chemical element or compound which forms naturally in the earth. Some are rare and precious, such as diamonds, rubies and opals, while others are more common, like quartz or talc (which is used to make talcum powder). Minerals normally grow as crystals under very particular conditions. However, if several minerals occur together they make up a rock.

Why do rocks look different from each other?

There are several thousand different minerals in the Earth and they can come together in lots of different combinations and quantities which leads to a very wide range of rocks. However, only about 30 or so minerals are really common and this makes a geologist's job much easier. To help recognise rocks and group them into common types we can split all rocks into one of three groups based on they way they are formed:

1 igneous rocks
2 sedimentary rocks
3 metamorphic rocks.

Each of these rock types is then further subdivided based on the minerals it contains and the method of its formation.

Igneous rocks

Igneous means 'formed by fire'. You will have seen some of these rocks erupting from the ground at volcanoes. Igneous rocks start life as a molten mixture of minerals called **magma** which comes from the upper part of the mantle, 10 to 70 km beneath the ground surface (Figure 1).

In places called hot spots, where the crust is very thin or heavily cracked such as at constructive plate margins, magma can easily escape from the mantle and oozes out of the ground to form volcanoes. However, at destructive plate boundaries the subducting (moving down) oceanic plate melts and mixes with the mantle to produce magma with a different mix of minerals. This magma is less dense (lighter) than the surrounding rocks and slowly moves towards the surface, eating its way through the overlying rock. As the magma consumes more of the overlying rock, the quantity of certain minerals like silica changes, giving a wider range of igneous rocks, as shown in Figure 2.

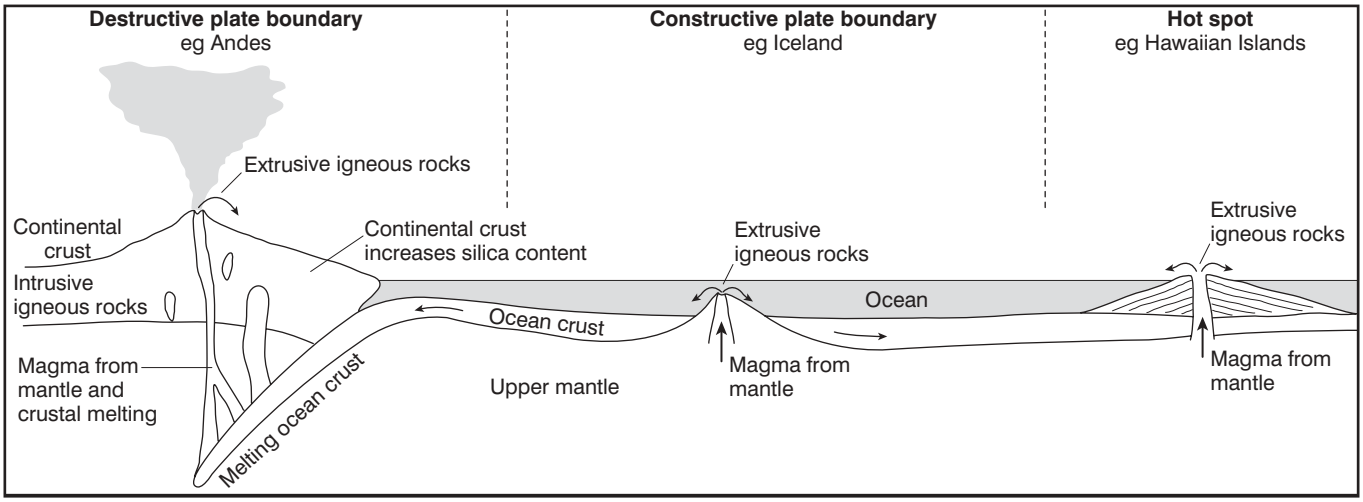

Figure 1: **Formation of igneous rocks**

Amount of silica	Basic (45%) ⟶		Acid (75%)
Intrusive rock Extrusive rock	Gabbro Basalt	Diorite Andesite	Granite Rhyolite
Location	Produced at hot spots and constructive plate margins	Produced at destructive plate boundaries. The more continental crust is consumed by the magma, the more acidic it becomes.	

Figure 2: **Silica content of igneous rocks**

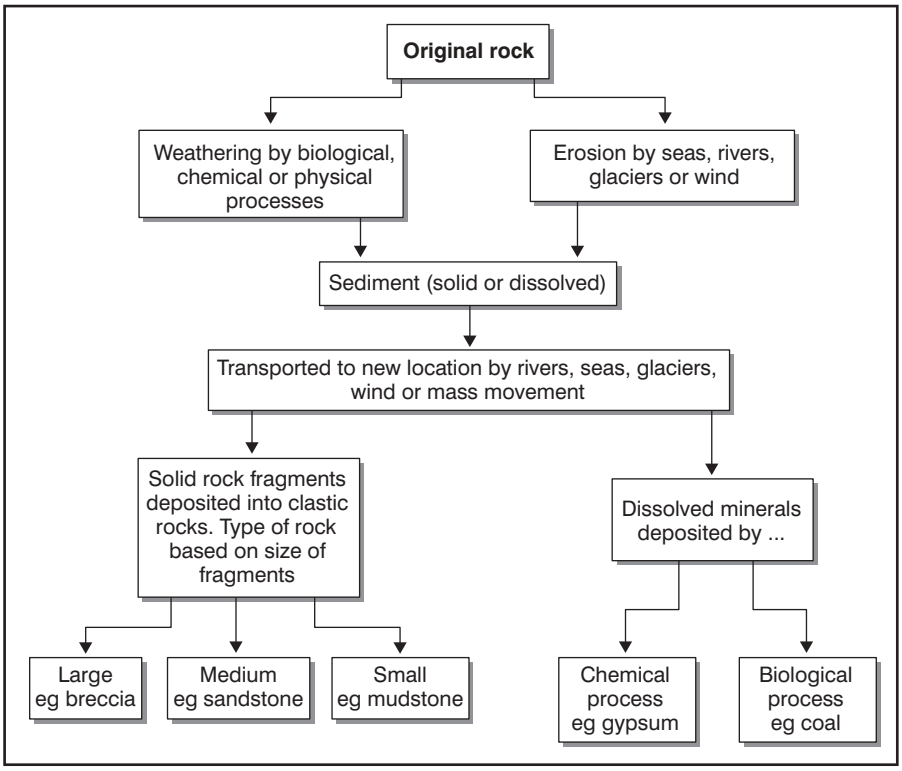

Figure 3: **Formation of sedimentary rocks**

Much of the magma produced cools and becomes solid below the surface. This produces a range of igneous rocks, called **intrusive**, which may later be exposed at the surface by erosion. If magma does reach the surface it is called **lava**. Once cooled it produces a range of **extrusive** igneous rocks, which are often described as **volcanic** rocks.

Although all igneous rocks are made up of only eight different minerals, the variety of combinations that can occur as magma moves to the surface leads to a wide range of different intrusive and extrusive igneous rocks.

Sedimentary rocks

All rocks exposed at the Earth's surface are worn away by weathering (wind, rain, temperature changes) and erosion (rivers, glaciers or the sea). The fragments worn away or dissolved from rocks are then transported to another place by gravity, wind, glaciers, rivers and the sea. These fragments of rock are called **sediments** and will eventually be dropped (deposited) to form a layer. As new layers are deposited on top of older layers the weight compresses sediments, making them stick together and eventually turn to rock (**lithification**). Sedimentary rock layers or strata are formed horizontally but it is common for the strata to become tilted or folded after they are laid as a result of earth movements.

Just as with igneous rocks there are two main types of sedimentary rock. **Clastic** rocks are made up of broken rock fragments stuck together and these are subdivided into different types based on the size of the individual rock fragments, how rounded they have become, what minerals make up the fragments and the degree to which the particles have been sorted by size. For example, a collection of fine clay sediments can build up on the bottom of a lake over a long period of time and will eventually form a mudstone. However, a fast-melting glacier might drop a random collection of sediment sizes in the same place to form a breccia.

Non-clastic rocks are made up of sediment that was dissolved in water during weathering or erosion and are deposited either because of a chemical reaction or a biological process. One of the best-known examples of this type is chalk. As sea creatures with shells grow they make their shells bigger by extracting dissolved calcium carbonate from the water. When the animal dies its shell sinks to the bottom of the ocean. Layer upon layer of these shells will eventually form a limestone such as chalk.

Figure 3 shows the main processes and classification of sedimentary rocks but it hides the huge range of different rocks that can form as a result.

Metamorphic rocks

Sometimes rocks are exposed to high levels of heat, for example when magma intrudes into a rock on its way to the surface, or lava runs over the top of another rock. This heat is not enough to melt rocks but it is great enough to change some minerals into new ones. You may be familiar with an example of this change, marble, which is a hard metamorphic rock often used to make kitchen worktops, fireplaces and statues. However, before being exposed to heat the same rock would have been a limestone (Figure 4a). This type of metamorphic rock is the

result of **thermal** or **contact metamorphism** because it is contact with heat that changes the minerals to form a new rock. Thermal metamorphism usually only occurs on a small scale near volcanoes or intrusive igneous rocks. However, when two continental plates collide they squeeze all the sedimentary rock from the bottom of the sea up above the surface to form large fold mountains like the Himalayas (Figure 4b). This process creates huge amounts of pressure and heat which change more minerals than can be changed by heat alone, to make new metamorphic rock types. It can also cause some rocks to arrange themselves into bands (eg slate). This process can affect very much larger areas of rock and is called **regional metamorphism.**

So what is the rock cycle?

The Earth's crust is made up 65% igneous rocks, 27% metamorphic and only 8% sedimentary rocks. As you have seen, both sedimentary and metamorphic rocks started life as a different rock that has been recycled and only igneous rocks appear to be 'new'. However, if any rock is buried deep enough, such as at the bottom of a collision plate boundary (Figure 4b), it will become hot enough to melt completely and form part of new igneous rocks. Also, any rock can be absorbed into new igneous rock as part of the process of magma rising to the surface at destructive plate boundaries (see Figure 1). Therefore, in a series of continuous processes, all rock types can be converted into other rock types.

The rock cycle (Figure 5) shows how the main rock types are formed by a set of interlinking processes and products that occur at or near the Earth's surface. Although this process is continuous, it is quite slow: many of the rocks on our planet were formed between 100 and 300 million years ago!

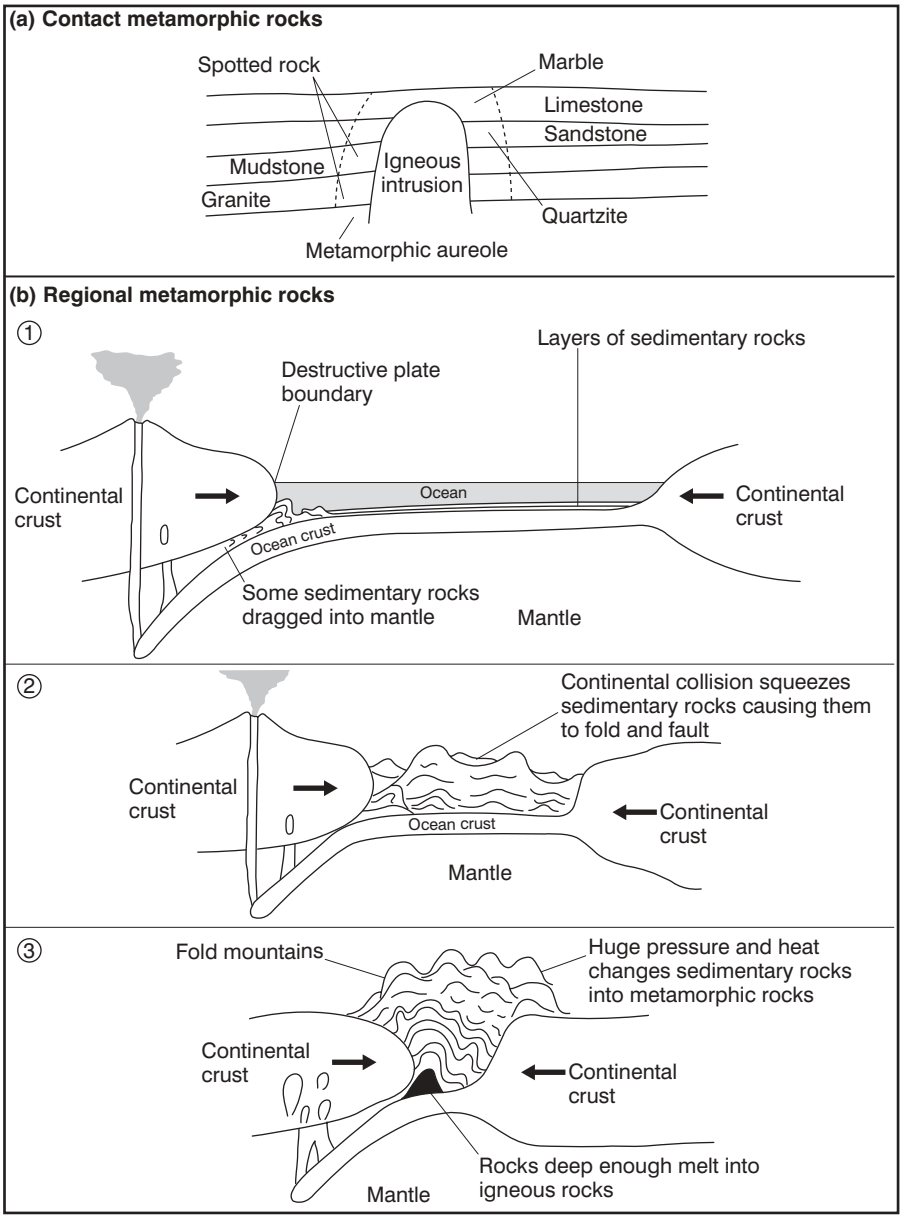

Figure 4: **Formation of metamorphic rocks**

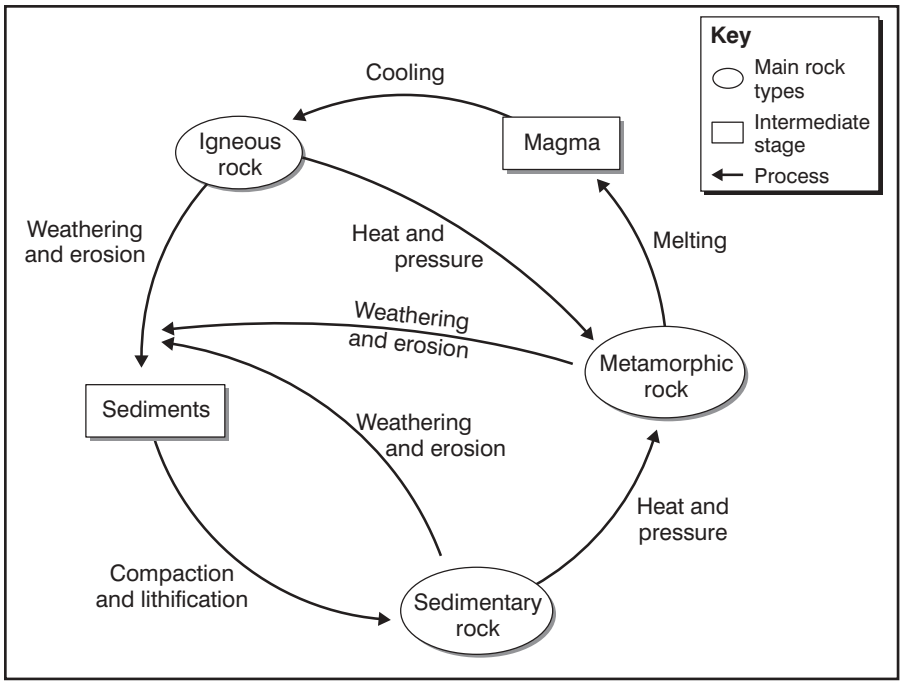

Figure 5: **The rock cycle**

Activities

1 There is a wide variety of rocks on Earth but they all have something in common.
(a) What are all rocks composed of?
(b) Give two examples of these.
(c) How many of these are common in rock formation?

2 Rocks can easily be split into three main types, each of which is subdivided into two further groups. To help you learn this:
(a) Copy Figure 6.
(b) Use information from this unit to fill in the empty boxes showing the major rock types and their sub-types.
(c) Add a new layer to the web by adding a named example of each rock type to each of the outside boxes.
(d) Produce a pie chart to show the percentage of each major rock type in the Earth's crust.

3 Igneous rocks are the most common type.
(a) Where do igneous rocks come from?
(b) Which two factors determine which type of igneous rock forms?
(c) How can igneous rocks lead to the formation of metamorphic rocks?
(d) Intrusive igneous rocks have larger crystals than extrusive igneous rocks. Can you suggest why this might be?

4 Sedimentary rocks are the least common type.
(a) Which two processes at the Earth's surface start the process of sedimentary rock formation?
(b) What is the difference between clastic and non-clastic sedimentary rocks?
(c) Sedimentary rocks form in layers, with the oldest rocks at the bottom. Can you explain why?

5 *Metamorphic* means 'change'.
(a) What are the two ways in which change can occur?
(b) What happens to rocks if too much heat is applied? What is the end result?
(c) Traces of fossils can be found at the top of large mountain chains like the Alps and Himalayas. Why do you think this is?

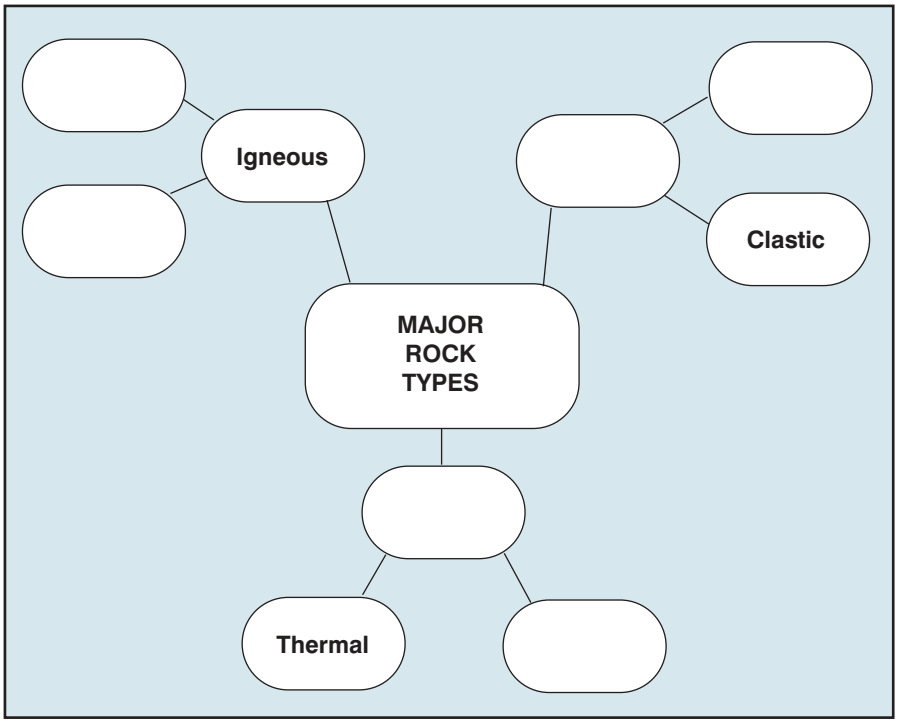

Figure 6: **Major rock types**

6 Figure 7 shows a simplified rock cycle.
(a) Name the rock cycle processes shown by arrows X, Y and Z.
(b) This diagram is very simple. Suggest three improvements that would make it more accurate.
(c) 'Plate tectonics is the most important process in the rock cycle.' Write a short essay to explain whether you think this statement is true or not. You may like to use diagrams to make your points clear.

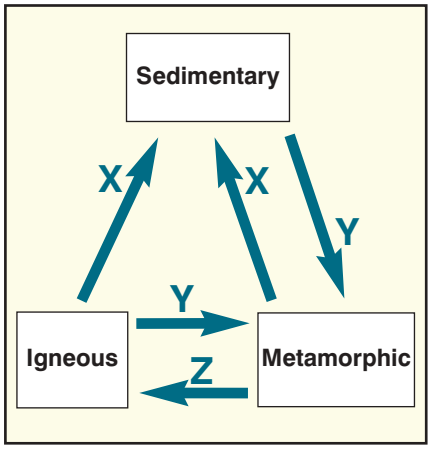

Figure 7: **The rock cycle**

7 Weathering, erosion and transport are key processes in the formation of sedimentary rocks. Find out more about these processes. Use a textbook or the internet to answer the following questions:
(a) Explain the difference between *weathering* and *erosion*.
(b) Describe the three major types of weathering. Explain in detail one example of each type.
(c) Name three different types of erosion and explain how each one works.
(d) Use an annotated drawing to explain the different ways in which sediment is transported by either the sea or a river.

Extension

8 Rocks play an important role in many areas of Geography. Research one of the listed areas mentioned below and produce a PowerPoint presentation on 'How different rock types influence...'
- Urban areas
- Farming types and locations
- Landscape features
- Water supply
- Tourism.