



CHAPTER SIX

Rocks

Syllabus

Rocks: Rocks — difference between minerals and rocks, types of rocks: igneous, sedimentary, metamorphic, their characteristics and formation; rock cycle.

A rock can be defined as an aggregate of minerals that forms more or less a definite unit of the earth's crust. The term rock refers not only to any hard solid matter like granite, but also to soft and loose particles like sand, silt and clay derived from the earth. The earth's crust is made up of various types of rocks that differ from one another in texture, structure, colour, permeability, mode of occurrence and degree of resistance to denudation.

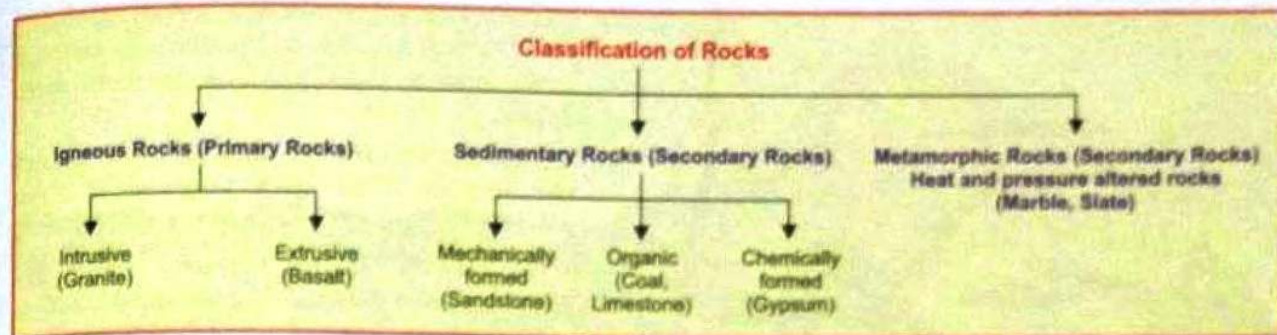
ROCKS AND MINERALS

Rocks consist of mineral elements. Though scientists have identified more than 2000 mineral elements, yet only a few of these are important as constituents of rocks. Distinction must be drawn between mineral elements found in the earth's crust and the earth as a whole.

The most abundant mineral elements of the earth, as a whole, are iron, silicon, magnesium, nickel, sulphur and calcium. The most abundant mineral elements of the crust are silicon, aluminium, iron, magnesium, calcium, potassium and sodium. The earth's crust contains more of silicon and aluminium whereas the earth as a whole contains more of iron, silica and magnesium.

Table 6.1. Difference between Rocks and Minerals

Rocks	Minerals
1. Rocks are aggregates of mineral elements.	1. Minerals are solid inorganic substances occurring naturally.
2. A rock has no definite chemical composition.	2. Minerals have a definite chemical composition.
3. Minerals are organised to form rocks.	3. Elements are organised to form compounds which are known as minerals. An element is a pure substance.
4. Three chief types of rocks are <i>Igneous</i> , <i>Sedimentary</i> and <i>Metamorphic</i> .	4. Four chief mineral groups are <i>silicates</i> , <i>carbonates</i> , <i>sulphides</i> and <i>metallic</i> minerals.
5. Basalt, granite, sandstone, slate and quartz are some important types of rocks.	5. Iron, silicon, magnesium, nickel, calcium, potassium, sodium are abundant minerals of the earth.



TYPES OF ROCKS

Rocks are classified in several ways but important classification is done on the basis of their origin. Three main types of rocks based on origin are:

- (i) *Igneous*;
- (ii) *Sedimentary*; and
- (iii) *Metamorphic*.

IGNEOUS ROCKS

Formation: The word 'Igneous' is derived from the Latin word 'ignis' meaning fire. These rocks were formed due to cooling, solidification and crystallisation of hot molten material of the earth known as magma found at great depths in the interior of the earth. The chemical composition of these rocks varies from aluminosilicate minerals like quartz and feldspar to granite and rhyolite collectively known as *Sialic rocks*. Since the igneous rocks were the first to be formed, they are called *primary rocks*. They form the basis of formation of other types of rocks.

Characteristics of Igneous Rocks

1. They are hard and compact.
2. They are formed by solidification of molten magma.

3. They are granular and crystalline.
4. They are either fine grained, smooth and compact or may have large crystals with coarse texture.
5. The size of their crystals depends upon the rate of cooling of the molten material.
6. These rocks are less affected by chemical weathering because water does not percolate in these rocks.
7. Most of them consist of silicates.
8. They do not have layers. They are generally weathered by mechanical weathering.
9. Igneous rocks are associated with volcanic activity and are found mostly in volcanic regions.

Classification Based on Origin

Based on their origin, the igneous rocks are classified into two types — (i) *Extrusive Igneous Rocks* and (ii) *Intrusive Igneous Rocks*.

(i) **Extrusive Igneous Rocks:** They are formed by the cooling of molten magma on the earth's surface. The magma which is brought to the surface through fissures or volcanic

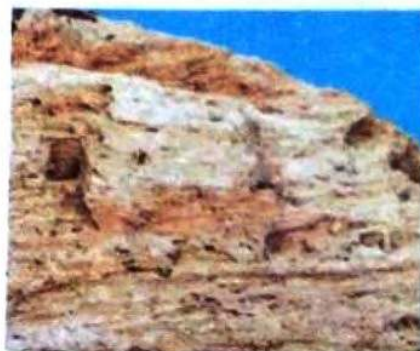


Fig. 6.1. (a) Igneous Rocks

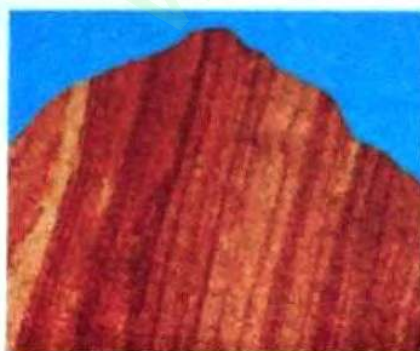


Fig. 6.1. (b) Sedimentary Rocks



Fig. 6.1. (c) Metamorphic Rocks

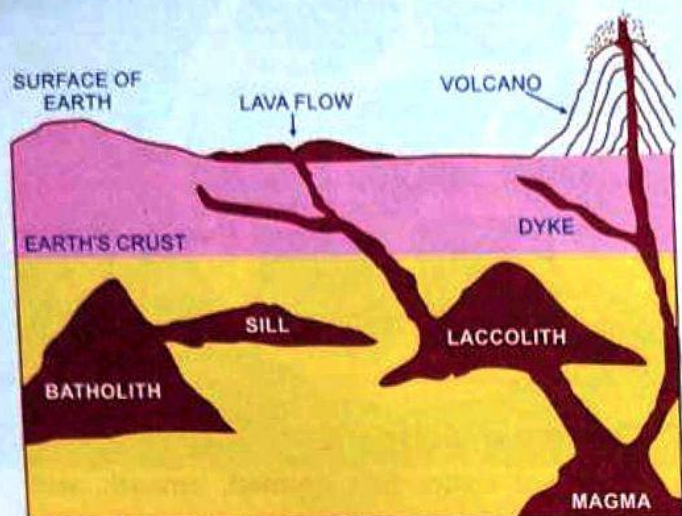


Fig. 6.2. Intrusive Igneous Rocks

eruptions, solidifies to form rocks. Hence, such rocks are smooth, crystalline and fine grained. They are also called as **volcanic rocks**. Basalt is a common extrusive igneous rock and forms lava flows, lava sheets and lava plateaus. Some kinds of basalt solidify to form long polygonal columns. For example, the Giant's Causeway in Northern Ireland.

(ii) Intrusive Igneous Rocks: When the magma solidifies within the earth's crust it cools slowly forming coarse textured, hard rocks with large crystals, eg., granite, gabbro, dolomite. When the magma solidifies below the earth's surface it forms different types of intrusive rocks like batholiths, laccoliths, sills, dykes, necks, etc. (Fig. 6.2)

- (a) **Batholiths:** They are deep-seated intrusion of igneous rocks. They are usually dome-shaped with no definite floor and they form cores of mountain ranges (Bathos meaning 'depth'). They may be exposed to earth's surface through continued erosion. They are chiefly composed of granite. Some of the important examples are Ranchi Batholiths.
- (b) **Laccoliths:** The magma does not reach the crust of the earth. Magma becomes solid just below the crust. Different types of intrusions of magma form differently shaped landforms. The upper surface is dome-shaped but the bottom is flat (from Greek *lakkos* meaning cistern).
- (c) **Sills:** Sometimes magma flows between layers of rocks horizontally. It then hardens there. This layer of intrusive rock is called Sill.

- (d) **Dykes:** The magma when forced upwards fills vertical cracks or fissures in existing rocks and it then hardens there to form dykes.
- (e) **Necks:** Sometimes the passage of an extinct volcano is filled with magma. It then solidifies there and is known as volcanic neck or plug.

Intrusive igneous rocks are also called *plutonic rocks* because of slow cooling of magma at great depth which leads to the formation of crystals of large size.

When magma cools at intermediate depth and forms minor rocks like sills and dykes it is called *Hypabyssal rocks*.

Classification on the Basis of Chemical Composition

Igneous rocks are classified into (i) *Acid Igneous rocks* and (ii) *Basic Igneous rocks* on the basis of their chemical composition.

(i) Acid Igneous Rocks: These rocks have a silica content between 65 to 85 per cent. They generally lack in iron and magnesium. Granite is acid igneous rock. It is made up of large crystals of quartz, feldspar and mica. It is commonly used as a building material.

(ii) Basic Igneous Rocks: They have higher percentage of oxides of denser elements and silica content varies between 40 to 60 percent. It is heavy and dark in colour. *Basalt*, *dolerite* and *gabbro* are typical examples of this group.

Igneous rocks are usually compact and are of interest to builders and sculptors. They may also be associated with ores of metals. Important



Fig. 6.3. Pumice (an igneous rock)

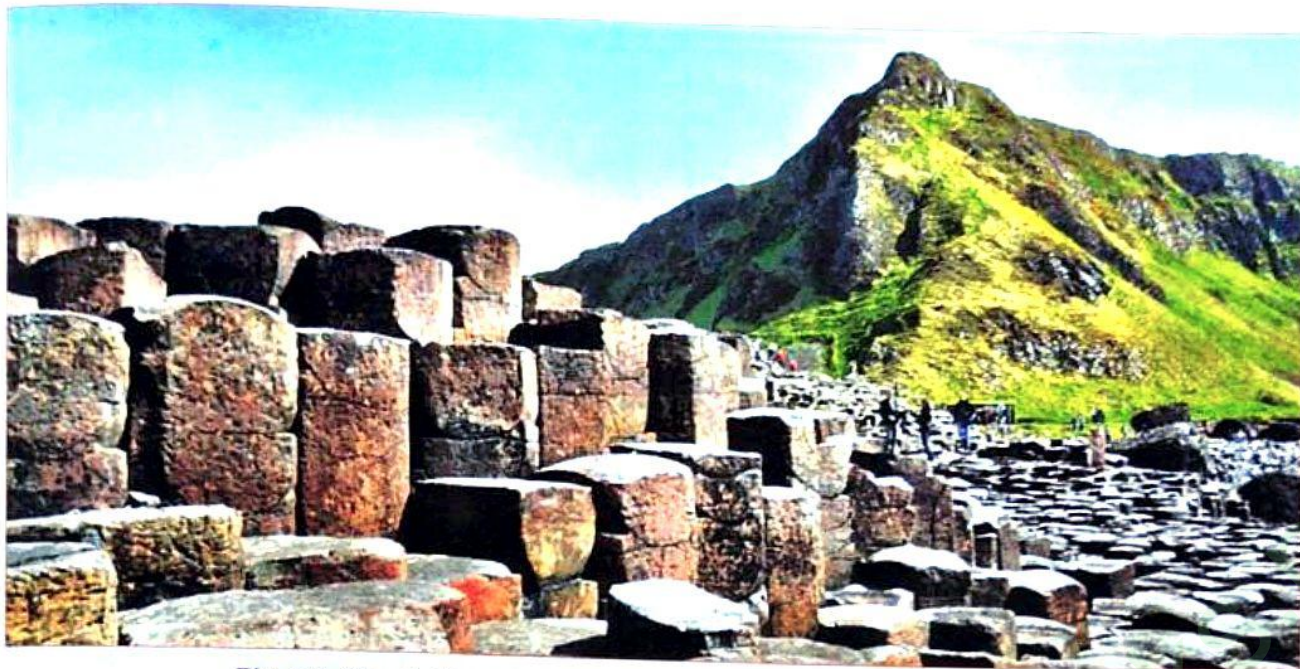


Fig. 6.4. Giant's Causeway, Northern Ireland. Note the columns of basalt

igneous rocks are *gabro*, *basalt*, *granite*, *dolerite*, *feldspar*, *pumice*, *obsidian*, *permadite* and *soria*.

SEDIMENTARY ROCKS

Formation: When igneous rocks are exposed on the surface of the earth, they are broken down by weathering and carried away by forces of gradation like rivers, glaciers and ocean waves. They are then deposited as sediments. Any exposed rock, due to the various agents of erosion may weather and disintegrate. The sediments are deposited over long periods in seas, lakes, streams, etc. Subsequent layers are added and due to their own weight from above, the sediments get cemented together to form *sedimentary rocks*. They are secondary rocks because they are formed by the solidification of sediments of original igneous, sedimentary or metamorphic parent rocks.

Characteristics of Sedimentary Rocks

1. Sedimentary rocks are formed from materials derived from other rocks. They may also have plant and animal remains. These rocks may thus contain fossils.
2. They may be formed through different processes and are also classified on the

basis of their formation. The process that turns loose sediments into rocks is called *lithification*.

3. They are most widespread on the surface of the earth and constitute about 75 per cent of the surface area of the globe.
4. Sedimentary rocks are generally not crystalline. They are soft (as compared to igneous rocks) and layered as they are formed by deposition of sediments. The different types of sediments are consolidated and compacted by different types of cementing elements like calcium, silica, etc.
5. Sedimentary rocks make extensive landforms. They do not make massive rock forms like batholiths and laccoliths.

Processes Involved

Lithification means turning the loose sediments into hard rock (*lith*). Transported sediments are deposited layer upon layer. This builds up pressure and temperature. Three processes are involved in turning the loose materials into hard rocks—*evaporation*, *compaction* and *cementation*.

(i) Evaporation: In this case, water from loose materials is evaporated as in the case of



Fig. 6.5. Sandstone

rock-salt. The accumulation of rock salt mainly takes place through evaporation before being compacted and cemented.

(ii) Compaction: In this process, sediments after piling up are gradually squeezed by the weight of overlying layers and hardness of underlying layers. Sand is compacted in this way to sandstone.

(iii) Cementation: It is the bonding together of compacted sediments by natural materials such as calcium compounds, silica and iron, all of which have the properties of bonding on the loose materials.

Classification on the Basis of Formation

(i) Mechanically formed rocks: These contain fragments from breaking up of other rocks. These sediments are also called *Clastic Sediments*. The breaking up of older rocks takes place through denudation by agents like running water, moving glaciers and wind. Mechanically formed rocks include *shale, sandstone, clay, conglomerates* and *loess*. In this process, the sediments are gradually squeezed by the weight of overlying sediments and the lower layers harden to form rocks. Since such rocks are formed in layers, they are known as *Stratified Rocks*. For example, sand becomes sandstone.

(ii) Chemically formed rocks: These are formed by the direct precipitation of mineral matter from solution. The accumulation takes place in lakes and lagoons. They are compacted through evaporation. For example, gypsum and rock salt and potash. Rock salt is found in Dead Sea, Aral Sea as well as in Sambhar Lake in Rajasthan.

(iii) Organically formed rocks: These rocks contain remains of dead plants and animals. Limestone (or calcareous rocks) is formed



Fig. 6.6. Cliffs of Normandy. These are made of limestone.

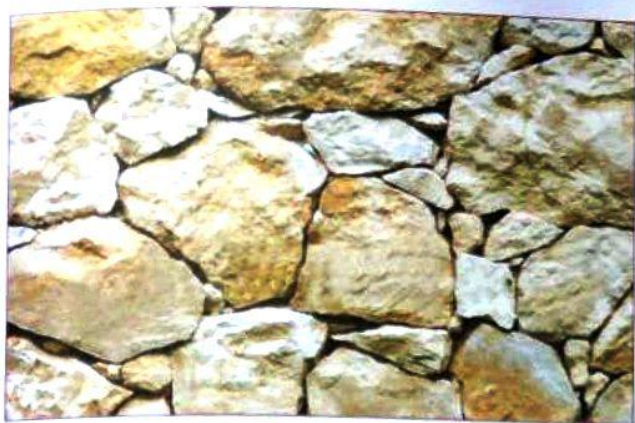


Fig. 6.7. Limestone

by skeletons, shells and animal remains. It contains large proportions of lime.

The rocks like peat, lignite, bituminous and anthracite are termed as *carbonaceous rocks*. Other types of organically formed rocks are *Siliceous Rocks*, formed due to dominance of silica contents. *Chalk* is a form of *carbonate rock*. It is formed due to precipitation of carbonate materials.

In the ancient past there were vast swamps of forest regions that got buried and underwent changes to yield fossil fuels.

The vegetable matter undergoes changes after being submerged by underground water. Formation into rocks proceeds in stages—peat, lignite and coal. The products of the first phase are *peat*. It is used as fuel. *Lignite* is a more decomposed rock of organic matter. It is also used as fuel. Several new products have been obtained from these rocks in recent years including wax and resins. In *coal*, percentage of carbon is very high. Two types of coal, *bituminous* and *anthracite* are sources of fuel for power generation. The remains of animals and plants which have become hard and turned into sedimentary rocks/fuels such as coal or petroleum are known as fossil fuels.

Classification on the Basis of Agents Formation

(i) **Riverine Rocks** are formed by the alluvial deposits brought by the flowing water of streams.

(ii) **Lacustrine Rocks** are found on the bed of a lake corresponding to successive periods of deposition.

(iii) **Glacial Rocks** are formed by the glacial deposits in the form of debris or tills. The glaciers erode the surface and the sides of a valley and transport the eroded material further. When the glacier melts due to heat, the debris brought by it is left behind in the form of moraines, which form glacial rocks. The glacial rocks, include boulders, gravels, sand, etc.

(iv) **Aeolian Rocks** rocks are formed with sand particles brought by winds. The deposition of sand particles, one over the other, makes them hard and form sedimentary aeolian rocks. Such rocks are found in deserts. Loess is an important Aeolian deposit.

(v) **Marine Rocks:** These are formed at the ocean floor. These rocks are of two types:

(a) **Calcareous Sedimentary Marine Rocks:** These rocks are formed by the deposition of shells and skeletons of sea organisms—corals, clams and oysters, etc. They live on ocean floor and extract calcium carbonate from ocean water. Chalk and limestone are the examples of such rocks.

(b) **Carbonaceous Sedimentary Rocks:** These rocks are formed by the sea plants which remain buried for a very long period. These long preserved remains are known as fossils. They are converted into the form of coal, lignite and peat due to pressure of overlying rocks on them.

Classification of sedimentary rocks is also done in other ways like transportation

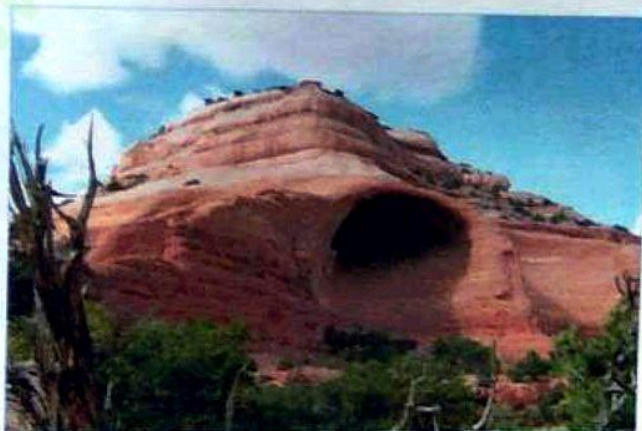


Fig. 6.8. Alcove in the Navajo Sandstone.



Fig. 6.9. Quarrying

agents. Their basic characteristics however remain the same.

METAMORPHIC ROCKS

Formation: The word *Metamorphic* is derived from 'metamorphose' which means change in form. *Metamorphism* refers to the alteration of the composition or structure of a rock by heat, pressure or other natural agency. The rocks were once igneous or sedimentary which underwent change through physical or chemical processes.

The factors that take part in changing the form of rocks are temperature and pressure, or both. Since rocks are composed of minerals, these may change their composition and texture under great pressure and temperature.

Characteristics of Metamorphic Rocks

1. They are harder and more compact than their original form. For example marble made from limestone is harder than limestone.
2. Most of them are impermeable — they do not allow water to percolate through them.
3. They do not have fossils as fossils in sedimentary rocks are destroyed during the formation of metamorphic rocks.
4. Metamorphic rocks are formed due to change in texture and composition of the pre-existing rocks.
5. New minerals are formed during the process of metamorphism.

Thermal Metamorphism

Thermal Metamorphism occurs when the transformation of the original rock takes place due to the influence of high temperature. For



Fig. 6.10. Metamorphic Rocks

example slate is formed from clay; and graphite from coal. The heat may be from hot magma or from friction of moving rock layers.

Dynamic Metamorphism

Dynamic Metamorphism occurs when the transformation takes place mainly because of pressure at a great depth within the earth's crust. Chemically active hot gases while passing through the rocks change their chemical composition. Under conditions of this change, minerals get arranged in a series of bands known as *foliation*. Important metamorphic rocks and the original rocks are given in Table 6.2.

The rocks used in the Taj Mahal at Agra are marbles metamorphised from Dolomites. Dilwara Temple at Mount Abu is also built of similar marbles.

Regional Metamorphism

Due to mountain building process, igneous and sedimentary rocks are buried deep inside the crust. The pressure of overlying rocks and the intense heat caused by large-scale earth movements change such rocks. Such a process is known as the *regional metamorphism*.

When a small area is affected by such a change this is known as *local or contact metamorphism*. This happens when hot magma affects cracks or the layers of rocks and these areas are transformed into metamorphic rocks.

Many metallic minerals such as gold and silver are found in metamorphic rocks.

Table 6.2

Original Rock	undergoes changes to form	Metamorphic Rock
Limestone		Marble
Sandstone		Quartzite
Shale		Slate
Coal		Graphite
Basalt		Schist
Granite		Gneiss
Dolomite/Chalk		Marble

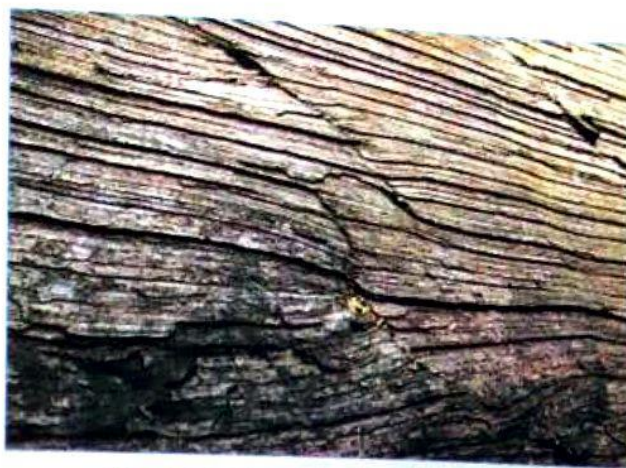


Fig. 6.11. Slate is formed from Shale.

ECONOMIC SIGNIFICANCE OF ROCKS

- Like minerals, rocks are of great resource value, some directly and some as constituents of minerals.
- Soils are derived from weathering of rocks.
- Almost all types of building materials used for paving roads, floors or building walls of houses or various other structures including bridges come from rocks.
- A Rocks are a source of precious metals like gold, silver, platinum, etc.
- Apart from minerals and fossil fuels, even rock wastes have now been used in manufacturing various articles.

ROCK CYCLE

The earth is said to be 4.5 billion years old. Obviously rocks undergo cyclic transformation. This continuous process of transformation of old rocks into new ones is known as *rock cycle*. The cycle may also pass through the process of formation of sedimentary, metamorphic and igneous rocks.

1. The igneous rocks are the primary source of all other rocks. Igneous rocks are formed on the outer surface of the earth due to volcanic activities. On the earth's surface, rocks are disintegrated and eroded by climatic factors. The disintegrated material is removed and transported to lower levels or to the sea by the forces of running water, winds, glaciers and ocean currents. In the basins, lakes or ocean beds the sediments accumulate.

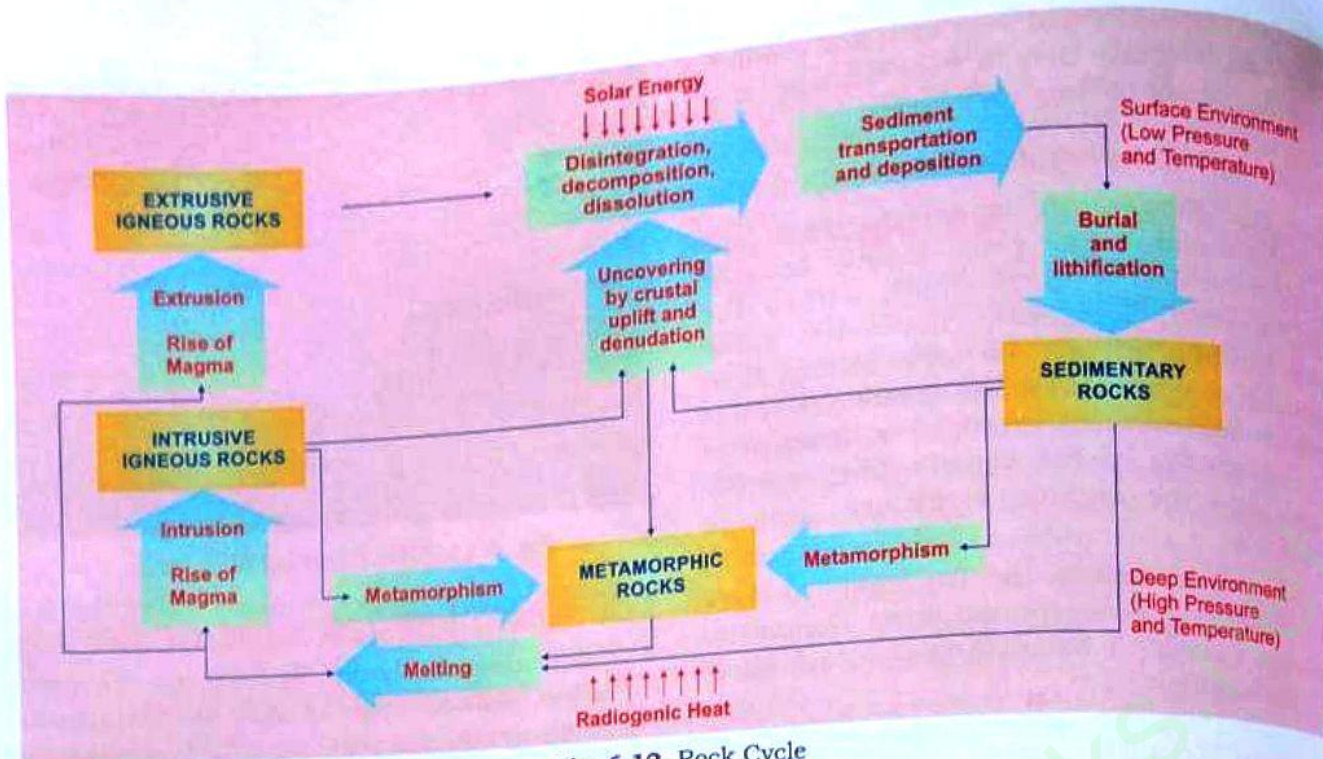


Fig. 6.12. Rock Cycle

- The accumulations undergo lithification through the processes of evaporation, compaction and cementation as discussed earlier.
- Once the loose sediment is transformed into sedimentary rock, it is then carried in depressions or on the sea floor further down under the earth. The sedimentary rock may further undergo disintegration and be again recrystallised into igneous rock and then transformed into metamorphic rock. It should be remembered that in the course of metamorphism, rock changes its form by intense heat and pressure.
- In case the rock melts it may again result in formation of igneous rock. The disintegrated material may again form sedimentary rock. In completing any of these changes hundreds and thousands of years are involved. In the operation of the rock cycle, the earth is kept young and movements of adjustments specially through horizontal flow or convection currents maintain the balance between various elements of the earth like oceans and continents.

Terms to Remember

Lithification	: The process that turns loose sediments into rock.
Igneous rocks	: Rocks formed by cooling and solidification of magma on or below the surface of the earth.
Sedimentary rocks	: Rocks formed in layers from sediments brought by rivers, glaciers and wind. They may also contain dead remains of plants and animals.
Metamorphic rocks	: Rocks formed by the change in the form of igneous or sedimentary rocks under the earth's crust by temperature and pressure.
Gypsum	: A rock formed after evaporation of water. A soft white or grey mineral is left behind. It is used in the construction industry and to make plaster of Paris.

I. Short Answer Questions

1. State two points of distinction between rocks and minerals.
2. Name any three elements of the earth's crust.
3. Name three types of rocks.
4. Give two differences between Extrusive Igneous and Intrusive Igneous rocks.
5. Name any two characteristics of Igneous Rocks.
6. State two characteristics of Basic Igneous Rocks.
7. Name two important landforms made by Igneous Rocks.
8. What are Sills? Give an example.
9. Which rocks are associated with ores of metals and which rocks are associated with fossil fuels?
10. Mention any two characteristics of Sedimentary Rocks.
11. Name the rocks which are most widespread on the earth. Give two examples of Sedimentary Rocks.
12. Name the three stages of lithification of Sedimentary rocks.
13. Name the types of Sedimentary rocks based on agents of formation.
14. Which agents are responsible for deposition of sediments?
15. What are known as metamorphic rocks? Give two examples.
16. Briefly define Mechanical Metamorphism.

II. Explain these terms associated with rocks.

1. Extrusive Igneous Rocks.
2. Laccoliths and Batholiths.
3. Fossil fuels.
4. Lithification of Rocks.
5. Metamorphism.

III. Distinguish between each of the following:

1. Plutonic and Volcanic rocks.
2. Thermal and Dynamic Metamorphism.
3. Sills and Dykes.
4. Calcareous and Carbonaceous rocks.
5. Acid Igneous Rocks and Basic Igneous Rocks.

IV. State the type of rocks for the formation of which the following processes are involved:

1. Solidification of magma on the surface of the earth.
2. Formation of large crystals, coarse texture and slow cooling and compaction.

3. Accumulation takes place over long periods of time in seas, lakes and streams.
4. Decomposition of organic matter at different stages and over different periods of time.

V. Structured Questions

1. (a) Distinguish between rocks and minerals.
(b) Describe how igneous rocks are formed. State their main characteristics.
(c) Give a reason for each of the following:
 - (i) Igneous rocks also called the primary rocks.
 - (ii) Igneous rocks are used by builders and sculptors.
 - (iii) Sedimentary rocks are called secondary rocks.
- (d) Define different types of igneous rocks on the basis of their chemical composition.
2. (a) How are sedimentary rocks formed?
(b) Explain the formation of sedimentary rocks on the basis of agents of formation.
(c) Give a reason for each of the following:
 - (i) Mechanically formed sedimentary rocks are also termed as stratified rocks.
 - (ii) Rocks like peat, lignite and anthracite are called carbonaceous rocks.
 - (iii) Fossils are present in sedimentary rocks.
- (d) What is metamorphism? What are its causes? Give an example of rocks formed by heat and pressure.
3. (a) State the chief characteristics of metamorphic rocks.
(b) State the economic significance of rocks.
(c) What is Rock Cycle? How does it keep the earth young?
(d) Draw a well labelled diagram of Rock Cycle.

VI. Project/Activity

1. Rock collection is a great hobby. Collect rock samples from different places and name them.
2. Go around your area and survey the rocks. Write down your observations.

