The Rock Cycle

Igneous rocks are produced when molten rock cools and solidifies . When exposed at the earth's surface, the rock is broken down into tiny particles of sediment by weathering and erosion. This weathered material is carried by water or wind to form sedimentary deposit . The sediment is gradually buried by more sediment and **subjected to higher pressure** and temperature. It eventually hardens into sedimentary rock (lithifies) . If burial continues, the increasing pressure and temperature at depth recrystallizes the sedimentary rock into a metamorphic rock. The rock cycle is completed when the metamorphic rock becomes so hot that it melts and forms a magma again. Igneous and sedimentary rocks can become metamorphic rocks if they are **buried deeply enough** or are affected by plate tectonic processes . Metamorphic rocks exposed at the surface will also weather to form sedimentary deposits.

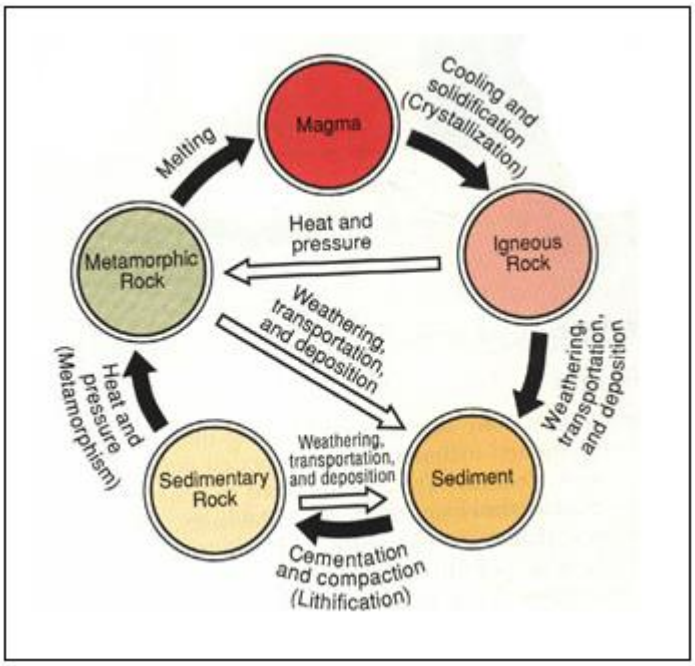

Figure 4.1 The rock cycle.

1.Igneous Rocks

Magma is molten rock, usually rich in silica and containing dissolved gases. (**Lava** is magma on the Earth's surface.) Igneous rocks may be either **extrusive** if they form at the Earth's surface (e.g., basalt) or **intrusive** if magma solidifies underground.

• Mineralogically and chemically, intrusive rocks are essentially identical to volcanic rocks.

• Volcanic rocks are fine-grained (or glass) due to their rapid solidification; intrusive rocks are generally coarse-grained, which is inferred to mean that the magma crystallized slowly underground.

Igneous Rock Textures

Texture refers to a rock's appearance with respect to the size, shape, and arrangement of its grains or other constituents.

The most significant aspect of texture in igneous rocks is grain (or crystal) size. Extrusive rocks typically are **fine-grained rocks,** in which most of the grains are smaller than 1 millimeter.

Igneous rocks that formed at considerable depth usually more than several kilometers are called **plutonic rocks**.

Characteristically, these rocks are coarse-grained, reflecting the slow cooling and solidification of magma. For our purposes, **coarse-grained rocks** are defined as those in which most of the grains are larger than 1 millimeter.

Some rocks are **porphyritic;** that is, large crystals are enclosed in a groundmass of finer-grained crystals or glass. An analogy for porphyritic texture is a milk chocolate bar containing whole almonds. If the groundmass is fine-grained, extrusive rock names are used. For instance.

Chemistry Of Igneous Rocks

Chemical analyses of rocks are reported as weight percentages of oxides (e.g., SiO_2, MgO, Na_2O, etc.) rather than as separate elements (e.g., Si, O, Mg, Na), For virtually all igneous rocks, SiO_2 (silica) is the most abundant component. The amount of SiO_2 varies from about 45% to 75% of the total weight of common volcanic rocks.

Mafic Rocks

Rocks with a silica content close to 50% (by weight) are considered silica-deficient, even though SiO_2 is, by far, the most abundant constituent. Chemical analyses show that the remainder is composed mostly of the oxides of aluminum (Al_2O_3), calcium (CaO), magnesium (MgO), and iron (FeO and Fe_2O_3).

Silicic (Felsic) Rocks

At the other extreme, the silica-rich (65% or more SiO_2) rocks tend to have only very small amounts of the oxides of calcium, magnesium, and iron. The remaining 25% to 35% of these rocks is mostly aluminum oxide (Al_2O_3) and oxides of sodium (Na_2O) and potassium (K_2O).

Intermediate Rocks

Rocks with a chemical content between that of felsic and mafic are classified as intermediate rocks.

Ultramafic Rocks

These rocks contain less than 45% silica. Ultramafic extrusive rocks are mostly restricted to the very early history of the Earth.

2.Sedimentary Rocks

Sedimentary rocks make up only about 5 percent of the Earth's crust.. As a result, sedimentary rocks cover about 75 percent of continents.

Many sedimentary rocks have high economic value. Oil and gas form in certain sedimentary rocks.

Types of Sedimentary Rocks

Sedimentary rocks are broadly divided into four categories:

1. Clastic sedimentary rocks are composed of fragments of weathered rocks, called clasts, that have been transported, deposited, and cemented together. Clastic rocks make up more than 85 percent of all sedimentary rocks (Fig. 4–1). This category includes sandstone, siltstone, mud shale.
2. Organic sedimentary rocks consist of the remains of plants or animals. Coal is an organic sedimentary rock made up of decomposed and compacted plant remains.
3. Chemical sedimentary rocks form by direct precipitation of minerals from solution. Rock salt, for example, forms when salt precipitates from evaporating seawater or saline lake water.
4. Bioclastic sedimentary rocks. Most limestone is composed of broken shell fragments. The fragments are clastic, but they form from organic material. As a result, limestone formed in this way is called a bioclastic rock.

Naming Sedimentary Rocks Units

A body of rock is commonly given a formal name and referred to as a formation. A formation can consist of a single rock type or several different rock types. To qualify as a formation, a body of rock should be easily recognizable in the field and be thick and laterally extensive enough to show up well on a geologic map. Although sedimentary rocks are most commonly designated as formations, bodies of igneous and metamorphic rock that meet these qualifications also are named and are called formations. Formations are

often named for the geographic locality where they are well exposed and were first defined.

A contact is the surface between two rocks of different types or ages. Contacts separate formations and separate different rock types or layers within a single formation. In sedimentary rocks, contacts are usually bedding planes.

For convenience, geologists sometimes lump two or more formations together into a group or subdivide a formation into members.

Sedimentary Structures

I. **Cross-bedding** consists of small beds lying at an angle to the main sedimentary layering. Cross-bedding forms in many environments where wind or water transports and deposits sediment. For example, wind heaps sand into parallel ridges called dunes, and flowing water forms similar features called sand waves.

II. **Ripple marks** are small, nearly parallel sand ridges and troughs that are also formed by moving water or wind. They are like dunes and sand waves, but smaller. If the water or wind flows in a single direction, the ripple marks become asymmetrical, like miniature dunes. In other cases, waves move back and forth in shallow water, forming symmetrical ripple marks in bottom sand.

III. **Graded bedding**, the largest grains collect at the bottom of a layer and the grain size decreases toward the top. The larger grains settle rapidly and concentrate at the base of the bed. Finer particles settle more slowly and accumulate in the upper parts of the bed.

IV. **Mud cracks** are polygonal cracks that form when mud shrinks as it dries. They indicate that the mud accumulated in shallow water that periodically dried up. For example, mud cracks are common on intertidal mud flats where sediment is flooded by water at high tide and exposed at low tide. The cracks often fill with sediment carried in by the next high tide and are commonly well preserved in rocks.

3.Metamorphic rocks

A metamorphic rock owes its characteristic texture and particular mineral content to several factors, the most important being

(1) The composition of the parent rock before metamorphism.
(2) Temperature and pressure during metamorphism.
(3) The effects of tectonic forces.
(4) The effects of fluids, such as water.

Classification of metamorphic rock

I. Nonfoliated Rocks

If the rock is nonfoliated, it is named on the basis of its composition. The two most common nonfoliated rocks are marble and quartzite, composed, respectively, of calcite and quartz.

II. Foliated Rocks

If the rock is foliated, you need to determine the type of foliation to name the rock. For example, a schistose rock is called a schist. But this name tells us nothing about what minerals are in this rock, so we add adjectives to describe the composition for example, garnet-mica schist. The following are the most common foliated rocks progressing from lower grade (they usually form at lower temperatures) to higher grade:

Types of Metamorphism

The two most common types of metamorphism are contact metamorphism and regional metamorphism. Hydrothermal processes, in which hot water plays a major role during metamorphism, are discussed later in this chapter.

I. Contact Metamorphism

Contact metamorphism (also known as thermal metamorphism) is metamorphism in which high temperature is the dominant factor. This is because contact metamorphism mostly takes place not too far beneath Earth's surface (less than 10 kilometers).

II. Regional Metamorphism

The great majority of the metamorphic rocks found on Earth's surface are products of regional metamorphism, which is metamorphism that takes place at considerable depth underground (generally greater than 5 kilometers). (regional metamorphism is sometimes referred to as dynamothermal metamorphism).