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WINNING AND WORKING

IGNEOUS ROCKS

A rock that has solidified from molten lava or magma is called an igneous rock. However, rocks formed by the consolidation of molten magma are said to be primary rocks. These rocks are formed when volcanic lava solidifies, Generally, igneous rocks are massive in form. It is supposed that these rocks are the oldest ones formed on the earth's crust.

Examples: Granite, gabbro, dunite are formed by the consolidation of magma. Basalt and trachyte are formed due to the solidification of lava.

Magma and Lava

Both these refer to melts of rocks which are compositionally silicate rich. The term magma is applied when the melt is underground. The same, when it reaches the earth's surface and flows over it, is called lava. Thus, based on the mode of occurrence, the melt of rocks is described either as magma or lava.

Magma is the parent material of igneous rocks. Anywhere on the earth, the temperature increases proportionately with the depth. The rate of increase of temperature of this kind, however, varies place-wise and depth-wise. So, it is natural to expect that at very great depths, the prevailing temperatures must be capable of melting the rocks, thereby producing magma. This is one of the reasons for the formation of magma.

Extrusives

Extrusive rocks are of a wide variety, depending on the nature and amount of erupted material and its association with the country rock.

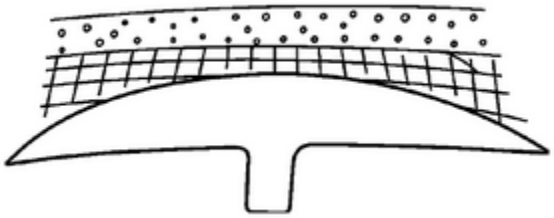
A volcano is considered as a conduit between the earth's surface and the body of magma, the crust beneath it. During volcanic eruption, lava is extruded from the volcanic vent and gases contained in the lava are ejected through it. Depending on the type of eruption, lava flows are divided into two groups: (a) fissure eruption (b) central eruption.

Intrusives (Minor)

Sills

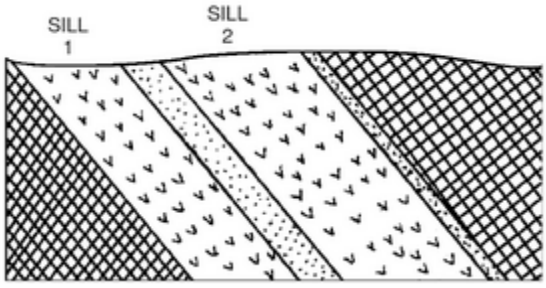
Sills are relatively thin tabular bodies of magma which essentially penetrate parallel to the bedding pianos of foliations of the country rocks. Sills are typically thin and shallow and are mainly located on unfolded country rocks. They are mostly basaltic in composition. A high

degree of fluidity is essential to produce a sheet-like form. Sills are grouped into two types based on their ejection. Simple sills are those which are formed due to a single ejection.



Simple sill

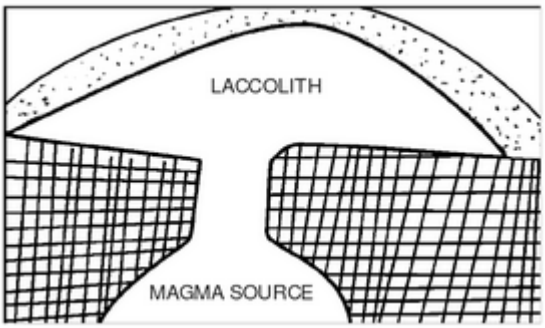
Multiple sills are formed as a result of more than one ejection.



Multiple sill

Laccoliths

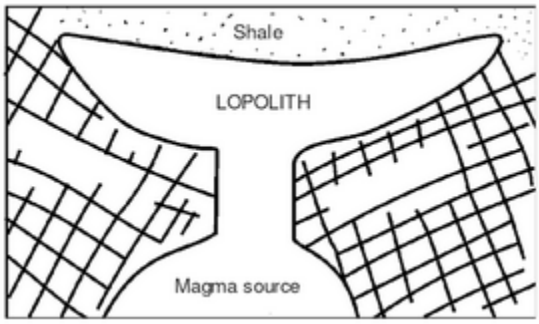
A laccolith is an intrusion with a flat floor and domed roof, the roof having been arched by the pressure from magma. High viscosity magma does not spread over but tends to form a bun shape (see figure).



Laccolith

Lopoliths

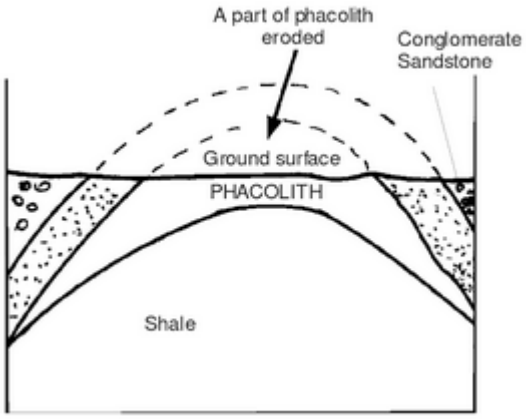
According to Grout's description, a lopolith consists of a large, lenticular, centrally sunken, concordant basin or tunnel -shaped intrusive mass (see figure).



Lopolith

Phacoliths

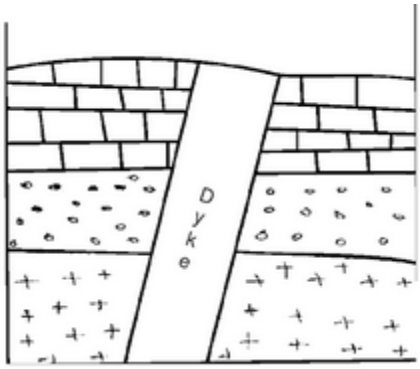
Phacoliths are intrusive concordant bodies mainly associated with folded rocks (see figure).



When they occur in a syncline, they are doubly convex downwards; when occurring within an anticline they are doubly convex upwards.

Dykes

Dykes are the intrusion of magma into vertical fissures which tut across the bedding of the country rock see figure).



Many dykes are more resistant than the surrounding rocks. Dykes vary in size from a few metres to a few hundred metres and extend from a few metres to a few hundred kilometres. However, the majority of dykes are only several metres in thickness.

DESCRIPTION OF SOME IMPORTANT IGNEOUS ROCKS

Granite

Granite is a plutonic igneous rock because it is formed due to solidification of magma at great depths. It is a holocrystalline and leucocratic rock because it is completely crystalline and a light coloured rock. It is an acidic and oversaturated rock because it is very rich in silica content (nearly 72%) and has free quartz.

- Granite is massive, unstratified and dense (specific gravity 2.6-2.8; density = 2500 to 2650 kg/cm^3); therefore it is very strong and competent (compressive strength = 1000 to 2500 kg/sq. cm).
- Granite has an interlocking texture, which keeps minerals firmly held, and this cohesion contributes greatly to the strength of the rock.
- Granite is either equigranular (with a few dark minerals) or has a porphyritic texture. These factors enable granite, on polishing, to take or a mosaic appearance or a mottled appearance respectively.
- Since granite is massive and formed from melt it is neither porous (porosity is < 1 %) nor permeable (absorption 0.5 to 1.2%). So no saturation or percolation by water is possible. Therefore, the rock will not become weak in the presence of water and also it remains durable.
- Granite is very rich in silica; therefore it is very much resistant to decay, i.e., weathering.
- The constituent minerals of granite are very hard. This makes the rock tough and resistant to abrasion. (Hardness coefficient = 18.)
- Presence of mural joints facilitates easy quarrying.
- Presence of rift and grain permit easy dressing, i.e., easily workable.
- Being the most abundant plutonic rock, it is found in plenty and is easily available in many places.
- As its essential minerals are pale coloured, it often has pleasing colours of pink and grey in various shades.
- Granites offer reasonable//re and frost resistance, because minerals are not many and these rocks are free from fractures.

Gabbro

Gabbro is a plutonic rock. These rocks are useful in various civil engineering constructions. **Mineral composition**. Essential minerals are plagioclase (generally laboradorite) and monocline pyroxenes (augite). Accessory minerals such as hornblende, biotite, hypcrsthene and olivine occur in some varieties like nepheline apatite and magnetite.

Texture: (Grain size, coarse. Some varieties show a porphyritic texture.

Dolerite

The term dolerite refers to a dark, heavy, fine grained igneous rock. This is the most commonly found hypabyssal rock. It is intermediate in composition and characteristically melanocratic. Mineralogically and chemically it is similar to gabbro and basalt. It is fine grained compared to gabbro but coarse grained compared to basalt.

Dolerite has all the merits and virtues possessed by granite (see under granite) except its colour. Of course, pure black colour has great demand. Since dolerites are more fine grained, they are stronger and more competent than granites.

Basalt

Basalt is a simple mixture of labradorite, augite (essential) and iron oxides. It is similar to dolerite in mineral content. Vesicular and amygdaloidal structures are the most common in basalts.

Basalts are the most abundant among volcanic rocks. Their quantity is five times greater than all other volcanic rocks put together. The basalts, as Deccan traps, are extensive in peninsular India and occupy an area of more than two lakh square miles. They are spread over Maharashtra, parts of Gujarat, Madhya Pradesh, Karnataka and Andhra Pradesh.

Massive basalts are highly durable and the strongest (having the highest load-bearing capacity or crushing strength). This is because not only are they compact, hard and tough but also more fine grained than dolerite. For this reason basalts are used fairly extensively as building stones in the areas in which they occur.

SEDIMENTARY ROCKS

Sedimentary rocks are formed by the consolidation of loose sediments or chemical precipitation from the solution at or near the earth's surface.

Sedimentary rocks are also called *layered rocks* because weathered sediments are transported and deposited on the oceanic floor in the form of layers. During the geological process, these layers are made compact, consolidated and uplifted to form layered rocks. These nicks show

sedimentary features, such as ripple marks, stratification, cross-bedding, fossils (in some rocks), etc.

Examples: Sandstones, limestones, shales.

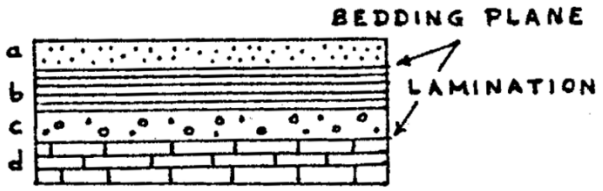
The branch of petrology which deals with the Study of sedimentary rocks and their equivalents is termed **sedimentary petrology**. Common sediments, such as sandstone, shale and limestone, form 95 per cent or more of all sediments.

Mineral fuels of sedimentary origin such as natural gas, petroleum and coal are available in sedimentary rocks.

Various terms are adopted by sedimentary petrologists.

Coarse	Gravel
Medium	Sand
Fine	Clay

All sedimentary rocks are, in general, characterized by stratification. Deposition of sediments into layers or beds is called the "stratification"- The planes dividing different beds are called the "bedding planes" (see figure).



The thickness of a bed may vary from a few centimetres to many meters.

Classification of Sedimentary Rocks

Sedimentary rocks are broadly classified on the basis of the size and origin of sediment. Five groups are recognised:

- Rudaceous
- Arenaceous
- Argillaceous
- Calcareous
- Carbonaceous deposits

Rudaceous Deposits

Rocks consisting mainly of gravel, pebbles, cobbles or boulders and cemented materials of conglomerate and breccia belong to this group.

Arenaceous Deposits

Rocks mainly consisting of sandy material belong to this group. Most of the sands are composed of quartz and other loose sediments.

Argillaceous Deposits

Shale sediments are the most abundant in nature. Argillaceous deposits, clay and shales in particular, are used tor bricks, building and roofing tiles, etc.

Calcareous Deposits

Limestone is a very common sedimentary rock. It has been estimated that limestone and dolomite form one-fifth to one-fourth of the stratigraphic records.

Carbonaceous Deposits

Deposits which are formed by the accumulation of organic materials are included in this group. These are coal, peat, lignite, anthracite and cannel coal. All these rocks consist of plant debris in various stages of alteration.

- **Peat:** It is derived from compressed mosses and plants. It has a high ash content and smoke when burnt. Peat is not completely transformed coal. However, it is considered the first stage of coal formation.
- **Lignite:** Also called brown coal, it is a low rank coal. Lignite generally retains the structure of the original wood from which it is converted.
- **Bituminous Coal:** Bituminous coal is a higher rank of coal which is used in industries. The average bituminous coal contains 80-85 percent carbon a\~\6 shows a calorific value of 14 x 10^6 to 16 x 10^6 Joules. The semi-bituminous coals are transitional between coal and anthracite.
- Most of the coal deposits in Gondwana are found in the Damodar system. Important coalfields are situated in Godavari valley, Wardha Valley, Satpura Sone Valley and Chhattisgarh, Mahanadi Valley, Palaman, Damodar Valley, Hazaribagh, Deogarh and Kajmahal.
- **Anthracite:** This is a high rank coal which consists of 90-95 per cent carbon and low oxygen and hydrogen; calorific value 15 x 10^6 J. This type of coal is *not available* in India.

METAMORPHIC ROCKS

Metamorphic rocks are pre-existing rocks formed by mineralogical, chemical or structural changes especially in the solid state, in response to marked changes in temperature, pressure

and chemical environment at depths in the earth's crust, that is below the zones of weathering and cementation.

The rocks subjected to metamorphism lose their original characteristics and new features are added. For instance, granite, an igneous rock is metamorphosed to form gneiss, whereas, a sedimentary rock, limestone, is metamorphosed to form marble. In weathering conditions, these metamorphic rocks again form sedimentary rocks.

Classification of metamorphic structures into five groups: cataclastic, maeulose, schistose, granulose and gneissose.

Metamorphic Rock Types

Slate

Nature. Slates are dark coloured exceedingly fine grained low grade metamorphic rocks. They have a remarkable properly called slaty cleavage which permits them to be split into thin broad sheets. Their colour is commonly gray to black but may be green, yellow, brown and red.

Phyllite

Nature. A phyllite is a fine grained, foliated lustrous rock.

Mineral Composition. It consists of chlorite, muscovite and quartz. The grains of this rocks are so fine that individual minerals can not be recognized by unaided eye.

Schist

Nature, Schists are coarse grained metamorphic rocks which show well developed foliation or schistosity along which the rock may be easily broken. Their colour varies according to mineral composition. Mica-schists are the most common metamorphic rocks.

Mineral Composition. Mica-schists consist essentially of quartz and mica, usually muscovite or biotite. Mica is the major mineral which occurs in irregular leaves and foliated masses.

Gneiss

Nature. A gneiss is a coarse grained, irregularly banded metamorphic rock having poor schistosity. A gneiss has usually a light colour, although this is not necessarily so.

Mineral Composition. Quartz and felspar occur together in light coloured bands which alternate with dark bands of flaky ferromagnesian minerals, such as biotite or hornblende. Generally quartz and felspars predominate over micaceous minerals.

Quartzite

Nature. A quartzite is a hard, dense, siliceous metamorphic rock hiving .granular texture. It is distinguished from a sandstone by noting the fracture which in a quartzite passes through the grains but in a sandstone passes around them.

Mineral Composition. Quartzites are composed essentially of quartz with small amounts of mica, tourmaline, graphite or iron minerals. They are usually light in colour.

Marble

Nature. A marble is a crystalline calcareous metamorphic rock having granular texture. Marbles are generally while but various impurities may create a wide range of colour such as pink, yellow, grey, green and black.

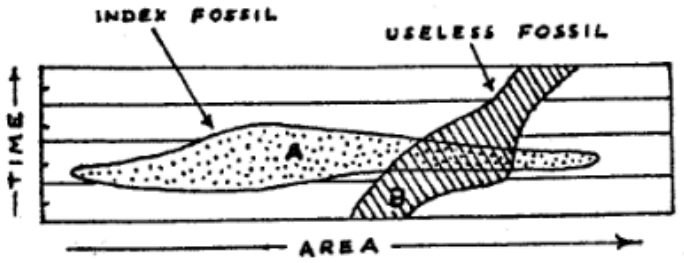
Mineral Composition. A marble is composed of grains of calcite or more rarely dolomite.

STRATIGRAPHY

"**Stratigraphy**" is the science of description, correlation and classification of strata in *sedimentary* rocks. It also includes the interpretation of the dispositional environments of the strata.

Facies. A set of lithological and paleontological characteristics of a sedimentary rock which indicate its particular environment of deposition, are called "facies".

Index fossils. Those fossil forms which have short time ranges of their existence and wide geographical distribution, are called "index fossils". In following figure the fossils 'A' have wide distribution and short duration, and therefore they are the index fossils.



The fossils 'B' are not index fossils because they have long time ranges and limited distribution. The index fossils are an excellent tool for correlating the fossiliferous rock formations of the same age.

FOSSILS

"Fossils" are remains or impressions of ancient animals and plants which have been preserved within the sedimentary rocks.

Uses of Fossils

- The fossils are commonly used for correlating the strata and determining their relative ages.
- Fossils indicate whether the rock is a fresh water deposit or a marine deposit.
- Fossils give information about the climate of the times in which they lived.

- The fossils have helped in understanding the evolution of plants and animals.

LITHOSTRATIGRAPHIC CLASSIFICATION

In regions having different kinds of geological history, the boundaries of the Geological Time Scale do not coincide with the actual stratigraphic boundaries. In many areas, though the major stratigraphic divisions are identified, the demarcation of smaller divisions, such as series and stages become very difficult. In case of unfossiliferous strata, it is not possible to identify the divisions corresponding to those of the standard time scale. In order to avoid these difficulties the "Lithostratigraphic classification" has been devised. In this classification the reformations are divided chiefly on the basis of lithological criteria.

Group

The major divisions of rock formations are called "Group." Each Group includes a thick succession of rocks which extends over a large area. The bigger unconformities separate one Group from another. A "Supergroup" is formed when two or more Groups join together;

Formation

It is the basic unit used for naming the rocks in stratigraphy. It may be defined as a set of rocks which have some distinctive feature of lithology and are large enough to be mapped.

Bed

A bed is the smallest lithological unit. It may be defined as a single sedimentary rock unit which has a distinct set of mineralogical or fossil characteristics which help to distinguish it from beds above and below.

MINERALOGY

The science of mineralogy is the study of the physics and chemistry of natural, solid, crystalline materials. A mineral is a naturally-occurring, homogeneous solid with a definite, but generally not fixed, chemical composition and an ordered atomic arrangement. It is usually formed by inorganic processes.

CLASSIFICATION OF ORE DEPOSITS

The ore deposits are formed in many different ways. Depending upon the process that may operate to produce them, the ore deposits may be classified as follows.

- Magmatic ore deposits.
- Sublimation ore deposits.
- Pegmatitic ore deposits.