# ENVIRONMENTAL GEOSCIENCES

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**Lecture-27**

## Description of Common Igneous Rocks

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. We are discussing the module 5. In the module five, we have already discussed about the concept of rocks, the different types of the rocks, and the magma, its composition and constitution. Today, we will discuss the description of the common igneous rocks. In this lecture, the important concepts we will cover like what is igneous rock, what is the formation of igneous rocks, classification of igneous rocks, texture of igneous rocks and description of common igneous rocks.

So what we have seen in the previous lectures that rocks are primarily of three different types that is igneous, sedimentary and metamorphic rocks and the magma which is just consolidating and forming the rocks are generally the igneous rocks. Igneous rocks are very hard and compact rocks. So we can see here the name igneous itself derived from the word ignis which means fire in Latin. Approximately 90 % of the earth crust is composed of igneous rocks. So we have seen in the interior of the earth also that earth's interior is having the three important layers that is the crust, mantle and core.

And the crust was constituting the heterogeneous types of rocks. So here you can see approximately 90 % of the Earth's crust is composed of igneous rocks. But their great abundance is hidden on the Earth's surface by a relatively thin layer of sedimentary and metamorphic rocks. So these we have already discussed in the structure of the Earth also. Igneous rocks are formed by cooling and solidification of molten magma so in the chapter magma we have discussed that magma is the hot molten material so when magma gets cooled and solidified it is just forming the rocks that is the igneous rocks so magma is a hot viscous siliceous melt containing water vapour and gases.

It comes from great depth below the earth's surface. It is composed mainly of, you can see here, oxygen, silicon, aluminium, Fe, calcium, magnesium, sodium and potassium.

When a magma comes out upon the earth's surface, it looses its gases And such type of magma is then called as lava. So such type of magma is generally called as lava.

Some of the examples of igneous rocks are granite, syenite, rhyolite, basalt, andesite, etc. So this is the general view of the igneous rocks. Since we have seen that igneous rocks are forming by the consolidation of the molten magma, so it is divided into two important groups. First is the intrusive bodies and second is the extrusive bodies. So intrusive bodies means which are formed underneath the earth's surface.

So the igneous rocks which are just forming underneath the earth's surface is generally called as intrusive igneous rock. On the basis of depth of formation, again intrusive rocks are further divided into two types. The first is the plutonic rocks which are formed at very great depths and second is the hypabyssal rock which are formed at the shallower depths. Now the exctrusive igneous rock or exctrusive bodies. These are due to the consolidation of magma above the surface of the earth.

These are also known as volcanic rocks. So when lava is consolidating and forming the igneous rock, such type of rock is known as volcanic rocks. Now what are the important features of igneous rocks. Generally igneous rocks are remaining hard, massive, compact with the interlocking grains. Igneous rocks are having entirely absence of fossils.

It is in it absence of bedding planes remains. Enclosing rocks are remaining in baked conditions. Usually this type of rock contain much feldspar mineral. So this is about the characteristics or features of the igneous rocks. Now formation of igneous rocks.

How the igneous rocks are forming? One by one we will learn the steps. So first is the magma formation. Igneous rocks originate from magma which is molten rock beneath the earth's surface. Magma forms due to high temperature, pressure or addition of volatiles in the earth's mantle or crust.

Magma movement, is the next point. Magma rises towards the earth's surface because it is less dense than the surrounding solid rock. Then cooling and solidification takes place. In it, cooling and solidification. Intrusive igneous rocks.

Form when magma cools and solidifies slowly beneath the earth's surface and example is granite. The slow cooling allows large crystals to form. So in it we can see the crystals are in larger in structure. In the extrusive igneous rocks it is forming when magma reaches the earth's surface as lava and then lava is cooling rapidly forming a rock named

as basalt and this rapid cooling results in the formation of glassy texture or fine-grained structure in the earth. So this is about the stages of the formation of igneous rocks.

Next is the crystallization. As magma cools, minerals crystallize at different temperature based on their composition and following the Bowen reaction series, what we have discussed earlier. Solid igneous rock formation. Once the magma or lava fully solidify, it becomes an igneous rock, either intrusive or extrusive based on its cooling locations. So this is about the formation of the igneous rocks.

Next is the classification of igneous rocks. Igneous rocks show great variation both in chemical and mineralogical composition as well as textural characteristics. Different classification have been proposed on the basis of mineralogical composition, on the basis of chemical composition, on the basis of textural characteristics. So one by one we will understand these thing. On the basis of mineralogical composition,

Since the relative amounts of various minerals in a rock can be measured or estimated with a fair degree of accuracy, this criteria is given more emphasis for the classification of igneous rocks. The minerals commonly occurring in igneous rocks may be broadly classified into two varieties. First is the felsic variety and second is the mafic varieties. Felsic is a term derived from feldspar, feldspathoid and silica. Felsic minerals are light in colour, low melting point, low specific gravity, comparatively of late crystallization.

Felsic minerals are leucocratic that is light coloured minerals are remaining. Next is the mafic. Mafic is similarly derived from ferromagnesian minerals, like biotite, pyroxene, amphiboles, etc. Mafic minerals are dark coloured, higher specific gravity, higher melting point and are early crystallized minerals. Mafic minerals are melanocratic that is dark coloured minerals.

So what we have understood that felsic minerals consist of light coloured minerals whereas mafic minerals consist of dark coloured minerals. One is felsic is leucocratic whereas mafic is melanocratic. Now on the basis of chemical composition. In their chemical composition the igneous rocks vary between wide limits. The rocks like granite may contain about 70 to 80 % of silica and very little quantity of iron, magnesia and lime.

While at the other extreme end, there are rocks like peridotite, dunite etc. which often contain about 35 to 40 % of silica and larger quantities of iron, magnesia and lime. Therefore, the igneous rocks may be classified as acid igneous rocks, that is felsic rocks. These rocks have more than 65 % of the silica content and example of the igneous rock is

granite, granodiorite. Second is the intermediate rocks these are having 55 to 65 % of silica content. An example of the igneous rock is the syenite and diorites. Then basic rock or mafic rocks here the silica content is between 44 % to 55 % and the example is basalt and next is the ultra basic rocks in this case silica content is less than 44 % and the example is the anorthosite. So, these are about on the basis of chemical composition.

Now, Shands and Holmes classified the igneous rocks as oversaturated rocks, saturated rocks and undersaturated rocks. So, what are these? Oversaturated rocks are those rocks which crystallize from melts containing higher amount of silica. They contain abundant quartz and alkali feldspars. Whereas saturated rocks, these rocks are formed when the amount of silica present in the melt is just sufficient to form the silicate minerals.

Saturated igneous rocks do not contain quartz. And under saturated rocks, these rocks crystallize from a melt which is deficient in silica and high in alkalies and aluminium oxide. Such rocks contain silica-poor minerals such as felspathoids and lack quartz. So, these are the classification based on Shands and Holmes. Now, on the basis of texture, it is mostly based on the cooling history of the magma and the modes of occurrence of these rocks.

So, therefore, the igneous rocks may be classified as plutonic rocks. These rocks are formed under deep-seated conditions where the temperature and pressures are remaining high and the rate of cooling is very, very slow. Hence, their texture is holocrystalline and coarse-grained. You can see in the diagram also, plutonic rock, hypabyssal masses and volcanic rocks. Now next is the hypabyssal rocks.

The hypabyssal includes the rocks of dykes, sills and small laccoliths etc. which occupies intermediate positions in the crust between the plutonic and volcanic rocks. Their texture is usually merocrystalline. Their texture is remaining merocrystalline. So B is the hypabyssal masses. Here B, this portion, is the hypabyssal masses.

Now next is the volcanic rocks. The volcanic rocks, on the other hand, are formed on the surface of the earth. And due to rapid rate of cooling, their texture becomes holohyaline and fine grained. Holohyaline and fine grained. So, C is the example of volcanic rocks.

So, in this way, we have seen the three important types of rocks, that is, plutonic rocks, hypabyssal and volcanic rocks. Now, texture of igneous rocks. We have already discussed the formation of igneous rocks and the classification of igneous rocks. Now, we will discuss the texture of igneous rocks. Texture of igneous rocks describe the actual

relation between crystals or that between the crystal glassy material present within the igneous rocks.

Rocks have been formed under diverse physicochemical environment and textural studies indicate the cooling history of the magma. Texture of igneous rocks is a function of three important factors. First is the degree of crystallization, that is crystallinity. Second is the size of the grains, that is the crystals, that is granularity. And third is the fabric, which includes shape of crystals, shape of crystals and mutual relation of grains of crystals and glassy matter.

So, this texture depends on three important factors. Now, first is the crystallinity. So on the basis of crystallinity, the different type of texture has been recognized in the igneous rock. The first is the hollow crystalline, when an igneous rock is made up of mineral grains only. Second is the hemicrystalline, when a rock contains both crystalline as well as glassy matter in variable proportions.

Here you can see, this is the example of hemicrystalline. Now, holohyaline, when the igneous rock consists of wholly of glass. This one is the example of holohyaline. Therefore, the degree of crystallization depends on the following factors. Rate of cooling, then viscosity of magma, that is composition of the magma and the presence of volatile components.

Third is the depth of cooling and fourth is the volume of the magma. Next is the granularity. It refers to the grain size, grain size of the crystals present in the igneous rocks. These are of generally two types. First is the Phaneric and second is the Aphanitic.

So what is Phaneric? When individual crystals are visible to the naked eye and are coarse grain or medium grain or fine grain. So such type of grain size are coming under the Phaneric. So coarse grain means when the grain size is 5 mm or above. Medium grain size is 1 mm to 5 mm and fine grains are smaller than 1 mm.

Then the condition will be of Phaneric type. Second is the affinity. When individual grains cannot be distinguished with unaided vision, And these are remaining of different types. First is the microcrystalline, when individual crystals are distinguishable only under the microscope.

Merocrystalline, intermediate in range. Cryptocrystalline, when individual crystals are too small to be separately distinguished even under the microscope. And glassy, when there is no crystallization at all. So, it is the example of aphanitic type. Next is the fabric.

Here the shape of the grains are very important. It refers to the degree of development of crystals faces, and are generally remaining of different types. First is the euhedral. When the mineral grains are found to have perfect crystal outline, then these are known as euhedral. These are also known as idiomorphic or automorphic crystals.

Second is the sub-hedral when the crystal outlines have partially developed. These are also known as hypidiomorphic or hypautomorphic crystals. And anhedral when the crystal faces are remaining absent. So here are the examples of euhedral grain, then subhedral grain and the anhedral grain. Mutual relationships.

It refers to the relative size, shape and dimension of crystals and their relation to one another. It may be equigranular or inequigranular. In the case of equigranular, the grain size is relatively uniform with little or no marked difference between the individual grains. In the case of inequigranular, the grain size shows a marked difference from grain to grain. So this is about the equigranular and inequigranular.

Now structure of igneous rocks. The structures of igneous rocks are large scale features which are dependent on several factors like composition of magma, viscosity of magma, then temperature and pressure at which cooling and consolidation take place and the presence of gases and other volatiles. Next is the forms of igneous rocks. The form that is the size, shape of the igneous bodies depend mostly on the following factors. First is the mode of formation, second is the viscosity, third is the temperature, fourth is the composition of the magma and fifth is the relation with the surrounding country rocks.

Now common igneous rocks. Important characters of a few of the common igneous rocks will be described in this lecture. Some of the common igneous rocks are granites, diorites, andesites, syenites, gabbro, dolerites, basalts, etc. Now the first is the granite. Granites are defined as plutonic, light coloured and acidic igneous rocks.

They are the commonest type of igneous rocks. The word granite is derived from Latin word granum meaning a grain and obviously refers to the texture of the common rock. Now composition. The most common mineralogical constituents of granites are quartz and feldspars. Feldspars which make up greater part of granite are generally of two types.

The first is the potash feldspar, commonly orthoclase and second is the soda bearing feldspars like albite and oligoclase. Feldspar microcline may also occur in some varieties of granites. Other minerals, the most important are micas, both muscovite and biotite, amphiboles, commonly hornblende, and rarely pyroxenes like augite and hypersthene.

Similarly, accessory minerals like oxides of iron, chiefly magnetite, apatite, garnet, and tourmaline may appear in some granites. Textures

Granites are generally coarse-grained granite texture. Granites are generally coarse to medium grain, holocrystalline and even grained rocks. Granitic, graphic and porphyritic and inter-growth textures are the most common types made with in the granite. Now types of granites. Many types of granites are distinguished on the basis of relative abundance of some accessory minerals and special textural features.

A granite with good amount of white mica or muscovite may be named as muscovite granite and that with a black mica may be named as biotite or biotite granite. Sometimes it may become necessary to indicate the presence of more than one accessory mineral. The type name then becomes a bit complex. Thus we may have hornblende biotite granite, or muscovite biotite granite, etc. The common types of granites include muscovite granite, biotite granite, hornblende granite, augite granite, hypersthene granite, and tourmaline granite.

Types defined on the basis of special textures include graphic granite and porphyritic granite. Occurrence, Granites are most widely distributed type of igneous rocks They occur chiefly as deep-seated intrusions like sills, bosses, stocks, and batholiths. Megascopic Identification, Granites can be identified in hand specimen by their coarse to medium grain texture. Mineralogical constituents, especially the abundance of feldspars in association with quartz, and these are light-colored leucocratic appearance.

Granites find extensive use in architectural works. These have been used extensively in monuments and memorials, as columns and steps in buildings, and also as concrete aggregate after crushing. The origin of granite is one of the most controversial problems in petrology. Most minor granitic bodies appear to be clearly intrusive character and as such their formation from a magnetic source is easily accepted. Variations, as we pass from granite to diorite through granodiorites following variations appear in the composition of the rocks.

The relative proportion of quartz falls gradually so that in diorites it is reduced to subordinate amount. Feldspar orthoclase which is dominating type of feldspar in the granites is overcome in proportion by felspar plagioclase in granodiorites and in diorite where plagioclase constitutes the bulk of the rocks. A number of rock types evolved because of this variation. Some of them have been given special names like adamelite

which is a variety of granodiorite that contains feldspar orthoclase and plagioclase in equal proportions. Next igneous rock is the Diorite.

It is an intermediate igneous rock of plutonic origin with a silica percentage generally lying between 52 to 66. Diorites are typically rich in plagioclase feldspar of sodic group that is albite. Besides plagioclase and alkali feldspar, diorites also contain accessory minerals like hornblende, biotites and some pyroxenes. Quartzs is also present in some diorites. Example is quartz diorites.

Texture. In texture, diorites show quite close resemblance to granites and other plutonic rocks. They are coarse to medium grained. Occurrences, diorites are commonly occur in the form of small dikes, sills, stocks and other such intrusive bodies and also as rocks formed on the margins of bigger granite masses. Hypabyssal and volcanic equivalents, rocks known as aplites. and granophytes are hypabyssal equivalents and rhyolites the volcanic equivalents of granites.

There is not much difference in the chemical and meteorological composition of granites and its hypabyssal or volcanic equivalents. The distinction lies only in textural and structural characters and also in the mode of occurrence. Whereas granite is generally medium to coarse-grained, its volcanic equivalent rhyolite is invariably fine-grained in texture. Volcanic equivalents of diorites are termed andesites. Now andesite.

These are volcanic rocks in which plagioclase feldspars, sodic and subcalcic varieties like albite, andesine, labradorite, etc. are the predominant constituents, making the potash feldspars only a subordinate member. Composition. Besides plagioclase and potash feldspars, andesites may contain small amounts of quartz as well as biotite, hornblende, augite, olivine, and hypersthene from among the dark minerals. Occurrence, andesites are known to be the most abundant volcanic rocks, next only to basalts, and form flows of huge dimensions. Petrologists are sharply divided over the origin of andesites. Some believe them to be the products of normal crystallization of magma, whereas others, in view of the presence of some foreign materials in them, think that some andesites may be the product of mixed magmas or magmas enriched with the fragments of wall rocks.

Next type of igneous rock is the syenites. These are defined as igneous, plutonic, even-grained rocks in which alkali feldspars including orthoclase and albite are the chief constituent minerals. They may contain besides these essential constituents dark minerals like biotite, hornblende, augite and some accessories. Textures, syenites show textural types, almost similar to that of granites, they are also close to medium grain,

holocrystalline in nature, exhibiting graphic intergrowth or porphyritic relations among the other constituents. Types, a number of types of syenite rocks have been distinguished on the basis of presence of accessory and dark minerals.

Some of the important ones are nordmarkites, a syenite with some quartz, Then monzonite, in which plagioclase feldspar become approximately equal in proportion to alkali feldspars. Larvikite, sometimes known as blue granite, is actually a syenitic rock in which feldspar, labradorite, a plagioclase is prominent constituents. Nepheline, alkali syenites are those syenite rocks in which nepheline, a felspathoid, becomes an important component. Quartz is typically absent in such syenites.

Theralite is a special type of nepheline syenite in which feldspar labradorite is present. This is known as teschenites if instead of nepheline, analcite is the felspathic mineral. Teschenites and theralites are of limited occurrence. Composition, syenites contain chiefly feldspar of which many types occur simultaneously or in different rocks. The most common feldspars of the syenite are orthoclase and albite, although microcline, oligoclase and anorthite are also present in many of them.

Few syenites are sometimes termed as alkali rocks because of higher proportion of alkali feldspars in them. Common accessory minerals are apatite, zircon and sphene. Quartz, so common in granite, is either altogether absent or is only a minor accessory in syenite rocks. In some syenite, the felspathoids, nepheline, leucite, make their appearance. Volcanic equivalent of syenite is the trachyte.

Trachyte is the name given to the volcanic equivalent of syenite. The rock is fine-grained and shows trachytic texture. It contains alkali feldspars as chief constituents. Then Phonolite. Phonolite is a volcanic equivalent of Nepheline syenite.

So these are about the syenites. Next is the Gabbro. These are coarse-grained, dark-colored, plutonic igneous rocks of basic character. Plagioclase feldspars of lime-soda composition, i.e. labradorite and anorthite, are the chief constituents. Besides these, the mafic minerals like augite, hornblende, olivine, biotite, and iron oxides are most common.

Texture, variable generally medium to coarse grain. Reaction rims are frequently observed. Occurrence, gabboric rocks occur in sills and dykes and also as plugs, stocks and lopoliths. Types of gabbro, chief types are norite containing orthorhombic pyroxenes like hypersthene, enstatite in addition to labradorite. Gabbro type rock, it contains monoclinic pyroxenes most commonly augite as the dominant mafic minerals.

Anorthosite, it is a monomineralic rock containing generally feldspar, labradorite. Eucrite, rock in which feldspar, bytownite or anorthite dominates, pyroxenes are also abundant in it. Essexite, it is characterized by the presence of some nepheline in addition to feldspars and the mafic minerals. Troctolite, it is that gabbroic rock which contains mainly feldspars and olivines, the pyroxenes being absent. Dunite, it is characterized by the absence of feldspars and domination of olivine and pyroxenes.

Next is the dolerite. These are igneous rocks of typical hypabyssal origin, having formed as shallow sills and dykes. They may be regarded as roughly equivalent to gabbros of plutonic origin on the one hand and basalts of volcanic origin on the other. The term diabase is also used by many for rocks doleritic in composition. Composition of dolerite, dolerites are predominated by calcic plagioclases i.e. anorthite, labradorite and sufficient quantity of dark minerals like augite, olivine and iron oxides.

Texture, dolerites are mostly fine to medium grained rocks. Ophitic and porphyritic textures are typically common in most of them. Next is the basalts. Basalts are roughly the volcanic equivalents of gabbros. They are most widespread of the volcanic rocks and are characterized by amygdaloidal or compact structures and a variety of textures, for example porphyritic, but are invariably fine-grained.

The composition of basalt is They are chiefly composed of calcic, plagioclage, feldspar, and ferromagnesian minerals like augite, hornblende, hypersthene, olivine, biotite, iron oxides. Many types of basalt are distinguished on the basis of domination of particular minerals. A few of these are spilite, spilite, so in pillow structure, tepherite, olivine-free type, basanite, olivine-rich type, and tachylyte, a glassy basalt. The olivine-free basalts are often called tholeites.

Occurrences. Basaltic rocks form extensive lava flows on the continents, the plateau basalts, and on the ocean floor. Engineering Importance Many of the igneous rocks, especially granites and related varieties are extensively used wherever it is available for engineering construction. Granites, syenites and dolerites are characterized by very high crushing strengths and can be easily trusted in most construction works. Basalts and other dark-colored igneous rocks are preferred only as roadstones. The igneous rocks, being mostly crystalline, compact and generally of impervious character, are always safe as foundation rocks, abutments in dams and reservoirs or wall and roof rocks in tunnels.

They are however generally the most unsuitable rocks for holding groundwater reserves. Some of them like pegmatites and peridotites are of special economic importance as they

may contain valuable ore minerals. Now let us summarize the chapter we have discussed about the igneous rocks. We have seen that these are the rocks formed by the cooling and solidification of magma or lava either underneath the surface of the earth or above the surface of the earth. Some of the examples are granite, syenite, rhyolite, basalt, andesite etc.

Then we have discussed about the classification of igneous rocks. We have seen different classification were there and these have been proposed on the basis of mineralogical composition, chemical composition and textural characteristics. Thirdly, we have discussed about the texture of the igneous rocks in which we have seen texture of igneous rock is a function of three important factors. Degree of crystallization that is crystallinity, size of the grains that is granularity and third is the fabric. And lastly, we have discussed about some of the common igneous rocks in which we have discussed the important rocks like granites, diorites, andesites, syenites, gabbro, dolorites, basalts, etc.

Thank you very much to all.