Engineering Geology

Lecture-5

Megascopic

- Perceptible through unaided vision; visible without the use of a powerful magnifying instrument, or with only the assistance of a pocket-lens: used in contrast to *microscopic*, with reference to objects or investigations in regard to which the use of a microscope is not required: as, the *megascopic* constituents of a rock; Also called as *macroscopic, macroscopical.*

  The larger structural features and components of rocks which do not require the use of the microscope to be perceived. Opposed to microscopic.

- Identification of rocks by megascopic studies.
- Identification of subordinate constituents in rock samples

MEGASCOPIC STUDY OF COMMON:

SEDIMENTARY

1. Colour
2. Compactness
3. Mineral Composition:
   - Framework grains
   - Matrix
   - Cement
4. Texture:
   - Grain Size
   - Roundness
   - Sorting
   - Structure and fossil (if any)
5. Inference/Name
6. Origin

METAMORPHIC

1. Colour
2. Grain Size
3. Hardness
4. Texture/Structure
   - Foliation
   - Cleavage
   - Structure
5. Mineral Composition
   - Essential
   - Accessory
6. Metamorphic Facies
7. Inference/Name
8. Parent Rock

IGNEOUS

1. Colour Index
2. Mineral Composition
   - Essential
   - Accessory
3. Texture
   - Crystallinity
   - Granularity
   - Shape of grains
   - Mutual relationship
   - Other textures
4. Diagnostic Characters
5. Inference/Name
6. Mode of Occurrence

Megascopic Features of Common Sedimentary Rocks

1. **Colour**: Sedimentary rocks exhibit colours of different depending on their mineralogical composition, matrix and cement. The red, brown or green sandstone is mainly due to the presence of iron oxides and iron bearing silicates. The black or dark gray coloured rocks such as shales contain iron sulfides or organic matter.

The color of the rock is documented based on the visualization by eyes

2. **Compactness**: It depends upon the mineralogical composition which includes composition of clasts, matrix, cement and texture of the rock. Some rocks like conglomerate and sandstone are hard and compact. Sandstone with siliceous cement is more compact than sandstone with calcareous cement. Limestone with more silica content is more compact. Shales are soft and may be fragile. Hardness or compactness depends upon the composition, cement and texture of the rock. Glass plate or knife blade may help to test this property. If the cement is calcareous or argillaceous (clayey) in sandstone then it will be scratched with a knife or blade. But, is if the cement is siliceous then you will not be able to scratch it.

3. **Mineral Composition**: Mineral composition is described under the three sub-heads: i) framework grains, ii) matrix, and iii) cement.

i) **Framework grains**: Framework or detrital grains of the clastic or siliciclastic rocks is made up of mineral grains and rock fragments. Amongst the mineral grains, quartz, feldspar, mica and clay minerals are the most common. These are identified with the help of hand lense.

Try to identify quartz, it will appear mostly colourless or in lighter shades. Feldspar (can be K-feldspar or plagioclase) will appear to be off-white in colour. Mica minerals are flaky in appearance. They are identified on the basis of colour. Muscovite and biotite show silvery white and shining black/brown shades respectively. Clay minerals present are identified by their soft and friable nature. They are crumbled when scratched by a knife blade. Apart from mineral grains, rock/lithic fragments are also present.

Generally igneous grains will be hard and compact; sedimentary show layering and metamorphic will show foliation. In conglomerates and breccias, the framework is formed by gravel size material, sand-sized material in sandstones, and silt and clay size material in shale and claystone. The rock may contain matrix, cement and void spaces between the grains.

ii) **Matrix**: The grains of clastic rocks are bound together by cement and /or matrix consisting of clay minerals and silt size quartz particles. Presence of high matrix percentage makes the rock more friable. The percentage of mineral components in a rock is variable and depends on the type of rock under examination.

iii) **Cement**: The cementing material in clastic rocks is usually secondary silica (arenaceous), calcium carbonate (calcareous), iron-oxides and hydroxides (ferruginous) and clayey (argillaceous). Siliceous cement commonly occurs as rim of quartz outgrowth over the pre-existing quartz rims Calcite and amorphous silica may occur as secondary cementing minerals. Cementation is the principal chemical process which makes a rock hard and compact. Cement is normally found in well-sorted sandstones.

4. **Texture**: Texture of a clastic rock is described in terms of size, shape, roundness and sorting of the clasts.

   i) **Grain Size**: Grain size is highly variable in the terrigenous sedimentary rocks and is broadly described as coarse, medium or fine. Write average grain size of the clasts in terms of gravel, sand, silt, or clay (Table 7.2, Fig. 7.1). Further subdivisions of these clasts or grains have been discussed using standard size scale.

Table 7.2: Grain size classes of sediments and sedimentary rocks.		
Grain Sizes (mm)	**Sediment Types**	**Nomenclature**
>2	Gravel	Conglomerate, breccia
2 – 0.5	Coarse sand	Coarse sandstone
0.5 – 0.25	Medium sand	Medium sandstone
0.25 – 0.0625	Fine sand	Fine sandstone
0.0625 – 0.004	Silt	Siltstone, mudstone and shale
< 0.004	Clay	Claystone

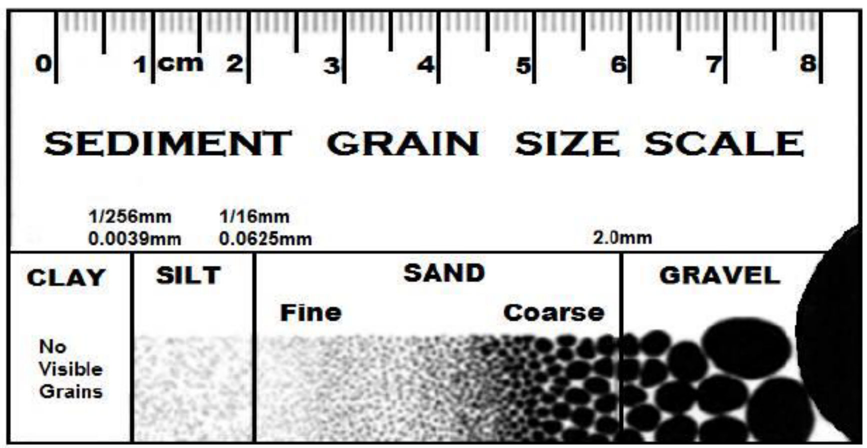
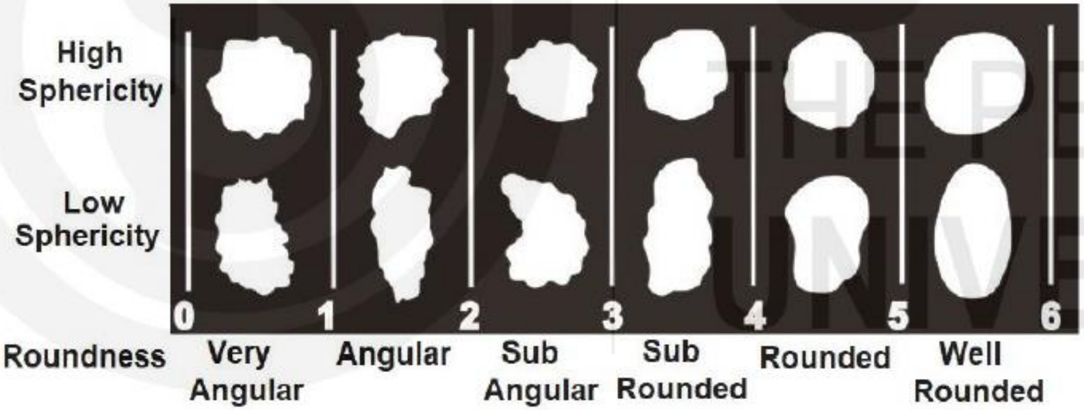


Fig. 7.1: **Sediment grain size scale.**

ii) **Roundness**: It is related to the nature of individual grain boundary, i.e. to the absence or presence of sharp corners and edges. Abrasion of clastic particles during the process of transportation causes reduction in size and rounding of sharp edges and corners of a grain. As a result, particles of different shapes and sizes are produced. A very much angular grain must have sharp and jagged corners, whereas a well-rounded grain must have completely rounded and smooth corners. Degree of roundness of a particle is directly related to the amount of time involved in the transportation of sediment. Describe the roundness/angularity of a clast in terms of well rounded, rounded, subrounded, subangular, or angular using the roundness scale (Fig.7.2). Sphericity can be defined as degree to which the particle attains the shape of a sphere. It is expressed as relationship amongst three axes (length, width and thickness) of a grain and defined in terms of morphology and geometric shape. The relation between the three axes (length, width, thickness) of a grain defines the morphology and geometric shape. You can use Figure 7.2 to identify the sphericity and roundness of the grains.

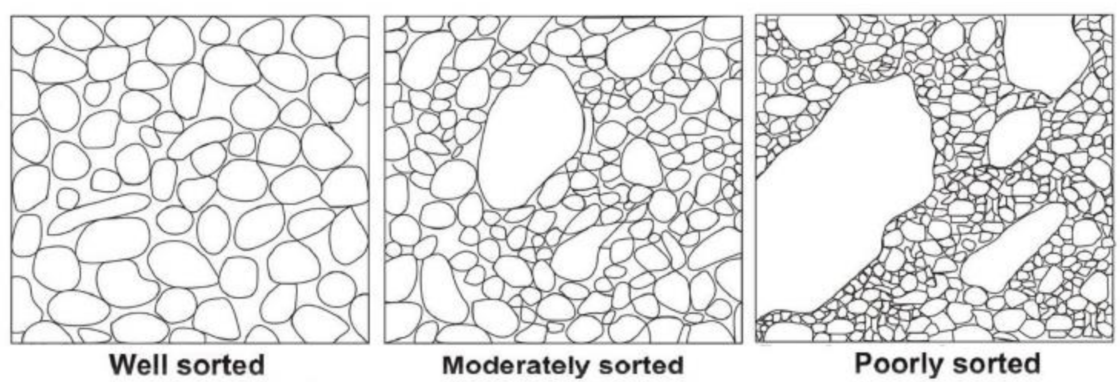
Fig. 7.2: Roundness scale and its relation to sphericity.



iii) **Sorting**: It reflects the process of transportation and deposition of sediments. Sorting is one of the most useful aspects as for as grain size distribution is concerned. It is a measure of range, or variation of a grain size particles present in the rock. Sorting basically reflects the action of wind and waves and post-depositional sedimentary processes. The rock is said to be well-sorted when the grains are more or less of a uniform shape and size. Poorly sorted rocks contain grains of different sizes. You will describe sorting in terms of well sorted, moderately sorted, or poorly sorted as given below (Fig. 7.3):

- **Well sorted**: All clasts are of more or less size in the rock. Dune and beach sands are well sorted.
- **Moderately sorted**: A significant variation in grain size such as river and tidal current flat deposits.
- **Poorly sorted:** Large spread in grain size distribution. Glacial till, debris flow and mudflow deposits are generally poorly sorted.

Fig. 7.3: Diagram showing sorting of grains.



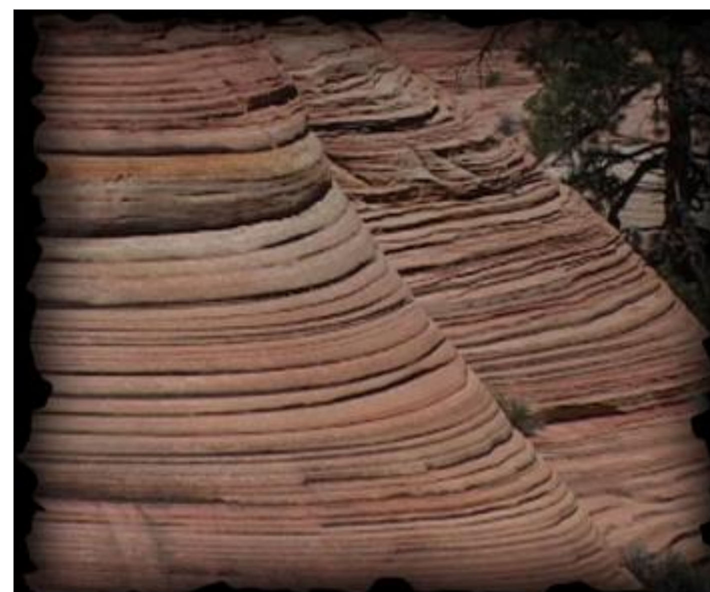
v) **Structure**: Hand specimens can show small scale structures such as parallel and cross lamination, graded bedding, rain−drop impressions, mud cracks, etc. These structures provide direct evidence of the processes of sediment transport and energy conditions of the depositional basin.

vi) **Fossil content**: Fossils of vertebrate and invertebrate animals, plant debris and the tracks, trails or burrows of animals may occur in sedimentary rocks. Occurrence of fossil is rare in older rocks; however younger rock may contain few fossils. Some limestones (coquina) are made up entirely of shell fragments. Fossils can help in finding the relative age of the sedimentary rock and give clues to the type of depositional environment in which the sediments were deposited.

5. **Inference/Name**: You have to mention name of the rock identified in hand specimen. The identification be carried out based on colour, compactness, mineralogical compositions, texture and structure of the rock specimen.

6. **Origin**: The study and analysis of the texture, structure and composition of the sediments and sedimentary rocks that enables sedimentologists to comprehend origin of the sedimentary rocks in order to deduce environment of deposition such as ancient shorelines, riverine flood plains, deserts, and swamps. Clastic sedimentary rocks formed mostly by the accumulation of silicate mineral fragments include most of the sandstones, mud rocks, conglomerates, and breccias. Biochemical sedimentary rocks consist of particle fragments produced by the precipitation of previously existed living organisms and include limestones and cherts. Chemical sedimentary rocks are formed by direct chemical precipitation from the water. Some limestones and cherts may also form in this manner.

Shale	Breccia	Coal	Limestone
			
Shale is very black and it breaks very easily. Shale is a clastic sedimentary rock. Shale can be found along beaches. Shale has a fine-grained texture, so it's NOT very bumpy and rough.	Breccia has variable colors. Breccia is a clastic sedimentary rock. Breccia has a fine-grained texture, so it's NOT very bumpy and rough.	Coal is a dark grayish-black. It can be found in mines. Coal is an organic sedimentary rock. Coal is a fine-grained, so it's NOT very bumpy and rough.	Limestone is a light gray color. It is an organic sedimentary rock. Limestone is a coarse grain, so that means that it is rough and bumpy.



Megascopic Features of Common Metamorphic Rocks

1. **Colour**: Metamorphic rocks exhibit different colours depending on their mineral composition. Brown or black colour is possibly due to the dominance of biotite. Presence of chlorite gives green colour to the rock. Dominance of calcite renders white or off-white colour to the rock. If the metamorphic rock is rich in muscovite, quartz and feldspar and its colour will be silvery off-white. You have to mention colour of the rock by observing its appearance in the light. Thus, the colour of rock in hand specimen will be documented as per visualization of your eyes.

2. **Grain size**: It reflects pressure and temperature conditions of metamorphism. Generally, high temperature and pressure conditions resulted in the formation of high-grade of metamorphic rocks, favouring formation of larger grains. Whereas, low pressure and temperature conditions favour smaller grains. You have to observe the grain size of the rock on the basis of the size of the majority of grains present in the rock.

The grain size is categorised as given below:

- fine-grained < 0.75 mm
- medium grained 0.75-1 mm
- coarse-grained 1-2 mm
- very coarse-grained > 2 mm

However, in hand specimen terms such as **fine**, **medium-**, **coarse-grained** are used for categorising all metamorphic rocks except slates and phyllites, where a fine grain size is implied by the name. You have to observe grain size for both matrix and porphyroblasts/porphyroclasts, if you find them in the hand specimen.

3. **Hardness**: Hardness is the measure of resistance to a smooth surface that offers to abrasion. In other words, it is the resistance offered by a rock on breaking when certain amount of force is applied. It is described in terms of hard, compact, brittle and soft.

4. **Texture and Structure**: It includes porphyroblasts/porphyroclasts, foliation and layering, small folds or wrinkles or kink folds, cumulates, equigranular, and inequigranular. Metamorphic rocks either bear foliated (layered) or non-foliated texture. Foliated texture is a pervasive layering caused by compositional layering or by the parallel orientation of platy (e.g., mica) or elongate (e.g., amphibole) mineral grains. Foliation is caused by recrystallisation under directed (compressional) stress. If rock lacks in the platy or elongated mineral grains and does not exhibit foliation even though

it recrystallized under great pressure then it is said to be non-foliated texture commonly found in rocks such as marble and quartzite. Foliated textures show a distinct planar character in which the mineral grains of the rock are aligned with each other in a definite direction. Non-foliated textures do not exhibit alignment of mineral grains. Non-foliated textures display random orientation of the mineral grains. Generally, the term foliation is used as non-genetic term for layering. **Foliation** refers to any layering in a metamorphic rock. This term is applied to surfaces possibly of relict bedding or to surfaces that are purely formed as a result of deformation and/or recrystallisation. There are several types of foliation:

Cleavage: It is an important feature of metamorphic rocks. It is the capacity of the rock to split along certain directions parallel or subparallel to the smooth surfaces. Cleavage refers to schistosity surfaces that are more or less planar. Cleavage is usually defined by aligned fine-grained mica or chlorite grains. It is therefore most common in aluminous, low-grade metamorphic rocks. Cleavage is of many types. But here discussion is restricted to slaty and crenulation cleavages. **Slaty cleavage** is a perfectly planar type of cleavage and defined by extremely fine-grained mica and/or chlorite in slates and phyllites. The slate exhibits slaty cleavage or excellent rock cleavage, i.e tendency to break into thin and flat slabs or sheets. **Crenulation cleavage** is a cleavage defined by alignment of mica and/or chlorite grains on the limbs of cm-to mm-scale periodic folds or crenulations.

On the basis of texture, **several structures** are present in the metamorphic

i) **Phyllitic structure** shows a strong parallel arrangement or foliation of fine-grained minerals. The phyllitic texture commonly exhibits wrinkles over the surfaces. The parallelism of fine-grained mica gives rise to silky lustre sheen also known as phyllitic lustre.

ii) **Slaty structure** has a strong parallelism in the foliation of fine-grained clay minerals and platy minerals (e.g. micas) which imparts a strong slaty cleavage (Fig. 9.2a).

iii) **Schistose structure** or schistosity is strongly foliated texture, produced by the growth of minerals. Schist has a foliation or mineral alignment of medium to coarse-grained minerals. Such type of texture is associated with the mica schist, chlorite schist and hornblende schist (Fig. 9.2b).

iv) **Gneissose structure** or gneissosity shows discontinuous banding of light-coloured medium to coarse-grained (such a quartz and feldspar) and dark-coloured minerals (e.g. pyroxene and hornblende) with granulose texture. The light and dark bands differ in composition and arranged alternately, thus produced by the segregation of minerals. This compositional layering or gneissic banding gives rise to gneiss with a striped appearance, e.g. gneiss (Fig. 9.2c).

v) **Granulose texture** is produced by an abundance of equidimensional minerals in the form of welded interlocking mosaic of crystals, e.g. quartzite and marble (Fig. 9.2d).

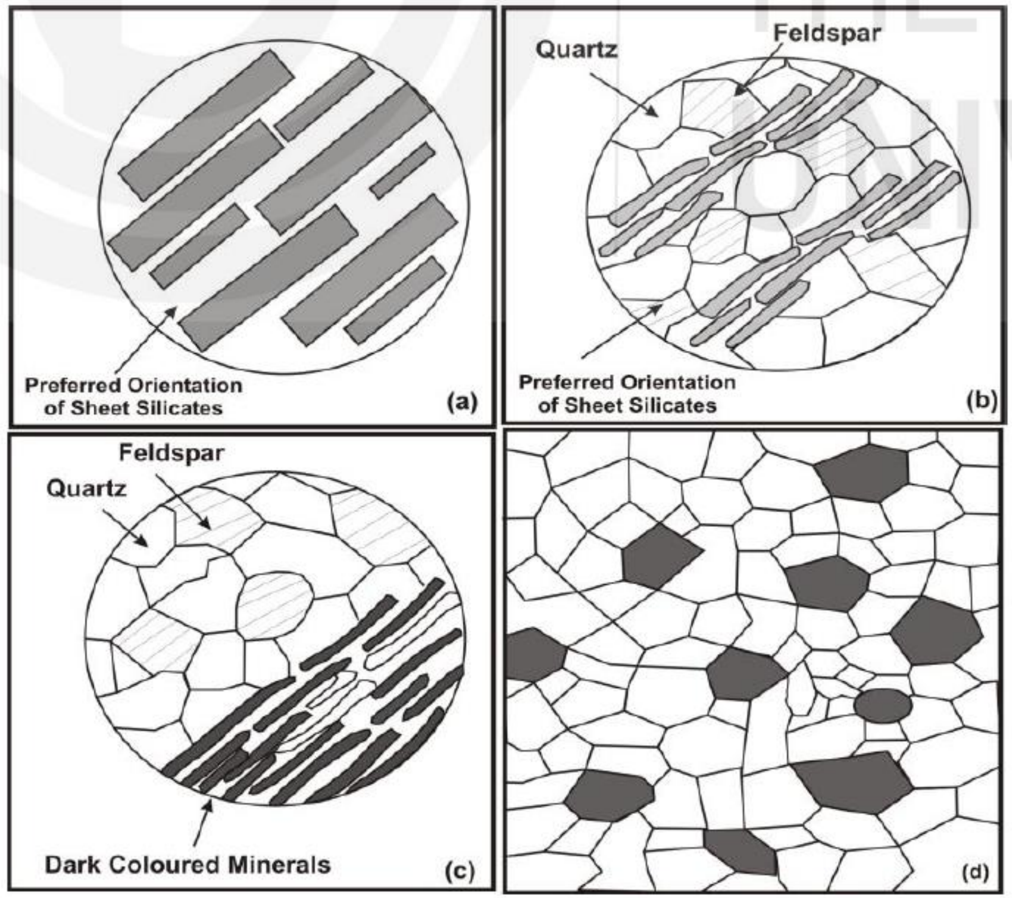


Fig. 9.2: Diagrams showing a) Slaty; b) Schistose; c) Gneissose; and d) Granulose structures.

5. **Mineral Composition**: Common minerals present in the metamorphic rocks include: quartz, feldspar, mica, calcite, and hornblende.

Index

minerals are those minerals in the metamorphic rocks which indicate the degree of metamorphism the original rock has suffered. I**ndex minerals** form at certain pressure and temperature conditions, therefore help in the identification of grade of metamorphism. Index minerals also provide important evidences about the nature of the protolith and the metamorphic conditions which have produced it.

Chlorite, muscovite, biotite, garnet, and staurolite are index minerals, representing a sequence with respect to low-to-high grade rocks.

properties of minerals are helpful in their identification. Each mineral displays a few physical properties that can be recognised megascopically. These minerals show some of the important physical properties that are useful in identification of rocks.

1. **Essential minerals** are those minerals whose presence are necessary and considered to be essential for naming or nomenclature of the particular rock. For example, quartz, orthoclase and plagioclase should be present for naming a rock as granite; minerals augite and labradorite are necessary for a rock to be named as basalt. Quartz and orthoclase minerals in granite; augite and labradorite in basalt are considered as essential minerals.

2. **Accessory minerals** are also formed at the time of primary crystallisation of magma but their presence is not necessary and not used in naming the particular rock, e.g. magnetite, apatite, zircon. They are present in small quantity. Some minerals are present in very small quantity but they can be used in naming the rock such as hornblende or biotite granite. Hornblende or biotite can be prefixed with granite and named as biotite granite or hornblende granite, depending on the mineral present.

6. **Metamorphic Facies**:

In general, metamorphic rocks do not drastically change chemical composition during metamorphism, except in the special case where metasomatism is involved. The changes in mineral assemblages are due to changes in the temperature and pressure conditions of metamorphism. Thus, the mineral assemblages that are observed must be an indication of the temperature and pressure environment that the rock was subjected to. This pressure and temperature environment is referred to as ***Metamorphic Facies.*** (This is similar to the concept of sedimentary facies, in that a sedimentary facies is also a set of environmental conditions present during deposition). The sequence of metamorphic facies observed in any metamorphic terrain, depends on the geothermal gradient that was present during metamorphism.

7. **Inference/Name**: On the basis of textural and mineral composition, you have to infer name of the rock identified in hand specimen.

8. **Parent Rock**: You have to mention about the parent rock or protolith

Gneiss	Quartzite	Slate	Marble
			
Gneiss is a mixture of light and dark colored layers. Gneiss is a foliated metamorphic rock. Gneiss has a coarse grained texture.	Quartzite is a whitish gray and sometimes a very light pink. Quartzite is a nonfoliated metamorphic rock. Quartzite has a coarse grained texture.	Slate is usually a light gray color but sometimes it can be a pinkish purple. Slate is a foliated metamorphic rock. Slate has a fine grained texture.	Marble can be white, blue-gray, green, blue-black, pinkish-orange. Marble is a nonfoliated metamorphic rock. Marble has a coarse grained texture.

Megascopic Features of Common Igneous Rocks

1. **Colour Index**:

This classification is based on the percentage volume of ferro-magnesium or dark coloured minerals present in the rock. The groups are:

- **Leucocratic**: ‘Leuco’ means light ‘cratic’ means coloured. When the rock is dominantly composed of light-coloured minerals and poor (<0.33%) in dark coloured minerals it is known as leucocratic.
- **Mesocratic**: ‘Meso’ means medium, when the dark coloured minerals vary between 33-67%. It represents intermediate colour, i.e. neither dark nor light in appearance.
- **Melanocratic**: ‘Melano’ means dark, when the dark coloured minerals are more than 67% in the rock.

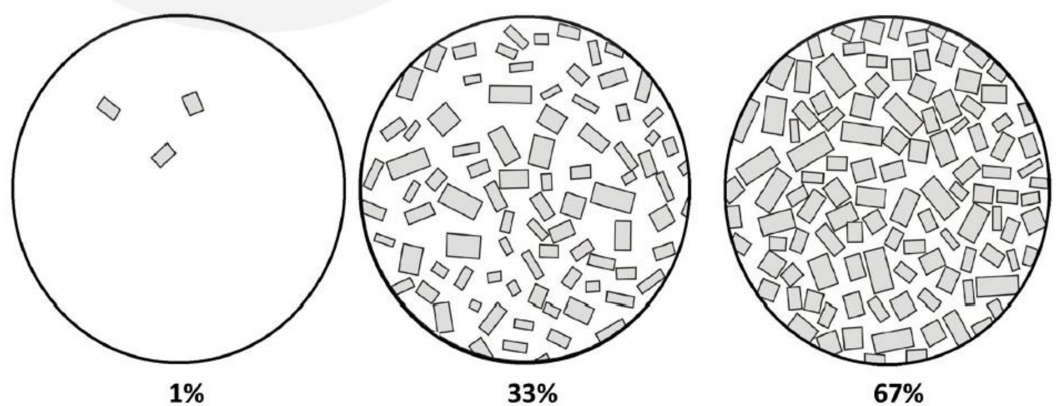


Fig. 1.1: Relative proportion of dark minerals visible in the hand specimen.

2. **Mineral Composition**: Let us discuss about mineralogical composition (Table 1.1). 'Rock is an aggregate of minerals'. In order to identify the rocks, we have to observe and study the mineral composition carefully. The identification of minerals in igneous rocks, includes essential and accessory minerals. You have read about the essential and accessory **Essential minerals** are those minerals whose presence are necessary and considered to be essential for naming or nomenclature of the particula rock. **Accessory minerals** are also formed at the time of primary crystallisation of magma, but their presence is not necessary and not used in naming the particular rock.

Shand and Holmes (1935) devised a method of classification on the basis of the silica content present in the rock. Igneous rocks can be classified into four subgroups (Fig. 1.2), such as:

a) **Felsic igneous rocks**: These rocks have more than 66% SiO_2 content. They are also called acidic or silicic rocks, e.g. granite, rhyolite.

b) **Intermediate igneous rocks**: These rocks have 52 to 66% of silica, e.g. granodiorite, syenite, phonolite, diorite and andesite.

c) **Mafic/basic igneous rocks**: The silica content in these rocks vary between 45 to 52%, e.g. gabbro and basalt.

d) **Ultramafic/ultrabasic igneous rocks**: In these rocks, silica content is less than 45%, but contain high Mg content, e.g. dunite, peridotite, pyroxenite.

The term texture is applied to megascopic (as observed in hand specimens with unaided eyes) as well as microscopic features (as observed in thin section under the microscope).

Here we will discuss about the megascopic characters.

A) Crystallinity / degree of crystallisation

B) Granularity/ grain size

C) Shape of the mineral grains

D) Mutual relationship amongst crystals and glass as well

A) **Crystallinity** or degree of crystallisation refers to degree or amount of crystals formed during the process of crystallisation/solidification of magma. The igneous rocks may be composed of crystals, partly crystals and partly glass or completely glass. On the basis of crystallinity or degree of crystallisation, textures of the igneous rocks are grouped as:

- **Holocrystalline texture**: If you observe that the constituent minerals present in the rock are entirely or wholly composed of crystals e.g. orthoclase in granite, augite in gabbro. Holocrystalline texture is seen in plutonic rocks.
- **Hemicrystalline/Microcrystalline texture**: When the rock comprises partly of crystalline and partly of glass, e.g. dolerite, basalt. This is mainly observed in the rocks which are crystallised near the surface or at a shallow depth from the surface.

- **Holohyaline texture**: The rocks exhibiting this texture are entirely made up of glass or crystallites and microlites. This texture is mostly seen in volcanic rocks, e.g. obsidian, pitchstone.

B) **Granularity** or grain size in igneous rocks shows wide variation. It varies from a meter size to a few centimeters (e.g. pegmatite) to even > 0.01 mm size of a microlite or sometimes even glassy as found in volcanic rocks. Generally, **phaneritic** and **aphanitic** (Fig. 1.3) terms are used to describe coarse and fine-grained rocks, respectively. Coarse grained crystals can be easily observed with unaided eyes and mineral grains are identified. Whereas, study of fine-grained minerals requires petrological microscope for their identification. In phaneritic rocks, the mineral grains are large enough to be visible with unaided eyes. Based on grain size, phaneritic texture (Fig. 1.4) is classified into following:

- fine grain (< 1mm)
- medium grain (1-5 mm)
- coarse grain (3 mm-5 cm)
- very coarse grained (>3 cm)

When magma undergoes rapid cooling under surface or near surface conditions, the fine grained, glassy rocks are formed and called as volcanic rocks. The cooling of magma at shallower depths results in a medium grained rock (1-5mm) as in case of hypabyssal rocks. When magma crystallises at a deeper level under high pressure and temperature conditions with a slow rate of cooling, very coarse rained igneous rocks are formed. Such rocks are called as plutonic rocks. **Aphanitic rocks** comprise fine grained and have too small lens. If the grains are visible only under the microscope, they are **microcrystalline**. In case, only a felty mass is seen and mineral grains are not recognisable under the microscope, then it is called **cryptocrystalline**. **Phyric** and **aphyric** are two terms used for describing rocks with phenocrysts and without phenocryst respectively. Phyric is sometimes used instead of porphyritic. Thus, on the basis of grain size, you can ascertain the rate of cooling and mode of occurrence.

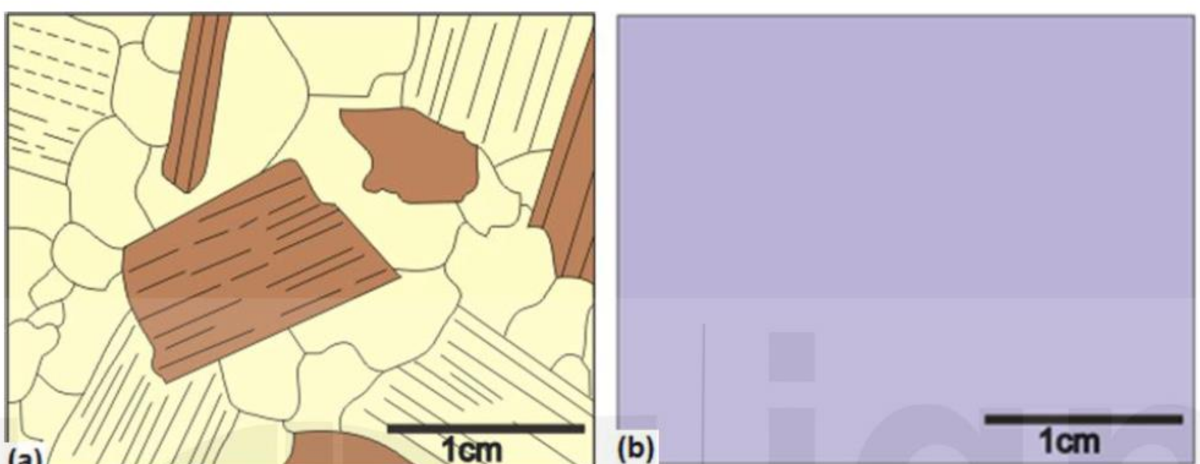


Fig. 1.3: a) Phaneritic, and b) Aphanitic texture.

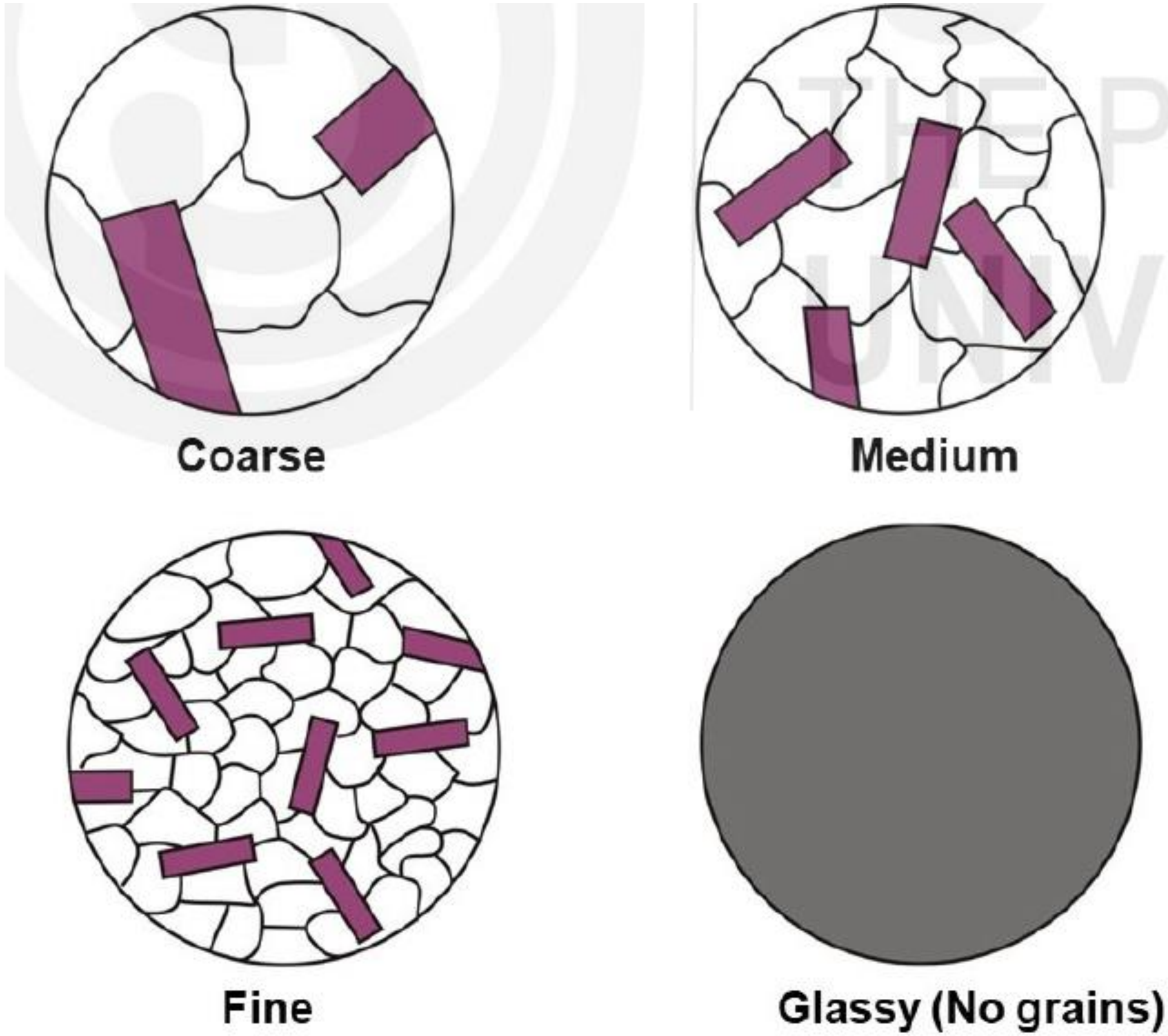


Fig. 1.4: Coarse, medium, fine and glassy texture (megascopic view).

C) **Shape of the Crystals** has been discussed using three important terms euhedral, subhedral and anhedral. These terms are based on the degree of the development of crystal faces. They are:

- **Euhedral** term is used for the mineral grains which possess fully developed crystal faces. The synonymous terms used are idiomorphic and automorphic.
- **Subhedral** refers to crystal forms with less or partly developed crystal faces or grain boundaries. It is called as hypidiomorphic or hypautomorphic.
- **Anhedral** term is used for mineral grains lacking crystal outlines called as allotriomorphic or xenomorphic.

D) **Mutual relationship between crystalline and non crystalline material** is very significant in understanding the texture of a rock. We have read that apart from describing the shape, fabric also includes mutual relationships of crystals and non-crystalline matrix/glass. It is has been discussed under two sub-groups:

- Equigranular texture
- Inequigranular texture

1) **Equigranular Textures**: When a majority of the grains in the rock or hand specimen are of equal size, it is said to have equigranular texture, e.g. granite

2) **Inequigranular Textures**: Igneous rock with marked difference in the grain size, in which one set of grains is distinctively larger than the associated another set of grains, forming groundmass. It becomes that one set of grains is distinctively larger and associated with another set which is much finer in size, then it is termed as **inequigranular**. But, in case variation of larger to smaller is systematic and gradual, then it is known as **seriate texture**.

Other type of textures include: intergrowth (like graphic), myrmekitic, corona, exsolution, directive/ flow, eutaxitic, devitrification, spherulitic and spinifex textures.

4. **Diagnostic Characters**: This includes typical or diagnostic character or structure present in the rock you have identified. For example flow banding in rhyolite or vesicles and amgdaloidal structure in basalt.

5. **Inference/Name**: You have to give name of the identified rock in hand specimen. The identification has to be based on colour index, form, mineralogical composition and texture.

6. **Mode of Occurrence**: Texture of a rock is used in recognition of the mode of occurrence of rocks i.e. plutonic, volcanic or hypabyssal.

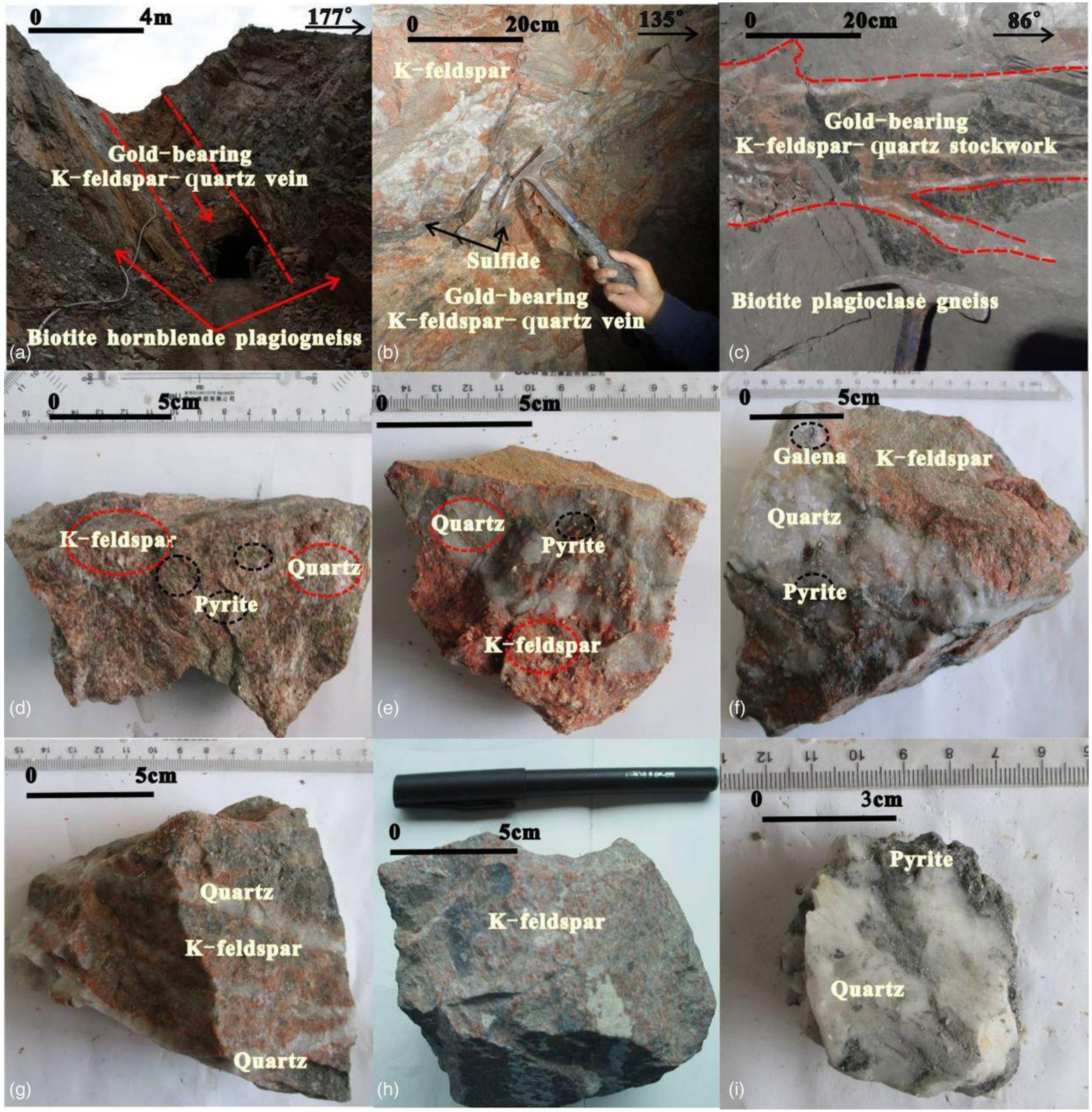
Plutonic (Intrusive) igneous rocks form when the magma cools and crystallises in the deeper part of the Earth under high pressure and temperature conditions with slow rate of cooling of the magma. When the cooling of magma takes place below the surface of the Earth it is very slow. It results in the formation of large crystals and gives rise to coarse grained rocks recognised by their interlocking crystals and hypidiomorphic or panidiomorphic texture, visible in the hand specimens, e.g. granite, granodiorite, gabbro, and diorite. The volcanic (extrusive) igneous rocks crystallise from hot or partly molten rock material known as lava that moves over the Earth's surface. The lava cools and crystallises rapidly (in the contact with air and water) giving rise to fine grained or glassy texture.

Hypabyssal rocks (such as dolerite) undergo cooling and consolidations at a shallow depth near the surface of the Earth. They are medium grained and mesocrystalline or hemicrystalline. They often occur as dykes or sills. Thus, with the help of the grain size and texture alone, you can mode of occurrence is ascertained, whether plutonic, volcanic or hypabyssal.

Gabbro	Pumice	Granite	Basalt
			
Gabbro is an intrusive rock, which means it grows inside of a volcano. Gabbro is a very dark colored rock. Gabbro is blackish-greyish and it has so speckles of white mixed in with it. Gabbro has a coarse grained texture.	Pumice is an extrusive rock, which means it grows on the outside of the volcano with the cooling lava. Pumice can be white, gray, light black, or green. Pumice has a glassy texture.	Granite is an intrusive rock, which means it grows inside of a volcano. Granite can be white, pink, or gray. Granite is a little rough. You can see little crystals.	Basalt is an extrusive rock, which means it grows outside of the volcano with the cooling lava. Basalt can come in black, dark grey, and greenish-black. The texture of basalt is rough. You can also see little crystals.

Identification of Subordinate Constituents in Rock Samples

- Constituents of rock
  - Dominant
  - Subordinate
- Subordinate constituents in rock sample such as seams or bands of other type of minerals, e.g., dolomitic limestone, calcareous sandstone, sandy limestone, mica schist


0 4m
177°
Gold-bearing
K-feldspar- quartz vein
Biotite hornblende plagiogneiss
(a)
0 20cm
135°
K-feldspar
Sulfide
Gold-bearing
K-feldspar- quartz vein
(b)
0 20cm
86°
Gold-bearing
K-feldspar- quartz stockwork
Biotite plagioclase gneiss
(c)
0 5cm
K-feldspar
Quartz
Pyrite
(d)
0 5cm
Quartz
Pyrite
K-feldspar
(e)
0 5cm
Galena
K-feldspar
Quartz
Pyrite
(f)
0 5cm
Quartz
K-feldspar
Quartz
(g)
0 5cm
K-feldspar
(h)
0 3cm
Pyrite
Quartz
(i)