EXPERIMENT 7

MEGASCOPIC STUDY OF COMMON SEDIMENTARY ROCKS

Outline of Experiment

7.1 INTRODUCTION

You have read about sedimentary rocks in Block 3 of BGYCT-135 course. Sedimentary rocks have been classified on the basis of their mineralogical composition, mode of formation, environment of deposition and textural features. On the basis of origin, the sedimentary rocks have been classified

into two major groups: (1) clastic and (2) non-clastic rocks. Sedimentary rocks have different compositions and textures, and they are the products of different kinds of source materials, mode and distance of transportation and depositional environments. On the basis of physical characters or megascopic properties, sedimentary rock samples are examined and identified in the field and laboratory with unaided eyes. In this experiment, you will study the megascopic characters of some important clastic rocks such as conglomerate, breccia, sandstone, siltstone, shale, and non-clastic rocks such as limestone, fossiliferous limestone, oolitic limestone and chert.

Expected Learning Skills

After performing this experiment, you should be able to:

- ❖ identify megascopic characters of common clastic rocks such as conglomerate, breccia, sandstone, siltstone and shale;
- ❖ identify non-clastic rocks such as limestone, fossiliferous limestone, oolitic limestone and chert; and
- ❖ learn about Indian occurrences and uses of sedimentary rocks.

7.2 REQUIREMENTS

You will require the following to perform this experiment successfully:

- Hand specimens of the clastic rocks such as conglomerate, breccia, sandstone, siltstone, shale, and non-clastic rocks such as limestone, fossiliferous limestone, oolitic limestone and chert
- Hand lens
- Laboratory file, scale, pen/ pencil and eraser
- Dilute hydrochloric acid (HCl)

Note:

- **Do not use pen/pencil/marker pen to mark the hand rock specimens.**
- **Please do not attempt to cleave rocks in the laboratory. Many of the specimens you examine cannot be readily replaced.**
- **Do not break the rock in order to see if the rock contains fossils such as corals, mollusks, foraminifera etc.**

***Instructions*: You are required to study Block 3 of BGYCT-135 course (Petrology) before performing this experiment. Bring this practical**

manual along with the Block-3 of BGYCT-133 course while attending the Practical Counselling session.

Instructions to perform the experiments and document in your laboratory file:

In the laboratory, you will make observations and identify the given hand specimens. Describe the megascopic characters as given in Table 7.1.

- Take the rock specimen in your hand and observe it carefully.
- Identify the megascopic characters of rock as mentioned in Table 7.1.
- Examine the minerals in the rock with the help of a magnifying lens and to determine its texture and mineralogical composition.
- Identify whether the rock is a clastic or non-clastic (chemical or biogenic) sedimentary rock.
- If the rock is a clastic sedimentary rock, determine its grain size, roundness and sorting as per the norms discussed in the next section.
- In case of chemical sedimentary rocks, describe whether the rock is crystalline, microcrystalline or clastic/bioclastic.
- Name the given rock specimen on the basis of texture and mineral composition.
- Write uses and occurrences in India.
- **You are instructed to draw the sketch of the hand specimen with important characters observed in the laboratory given by your instructor.**

Remember!! Descriptions of the hand specimens in the tables and the sketch given in this experiment are generalised. You have to document your own observations and draw the sketches of the hand specimen in the laboratory file.

Table 7.1: Megascopic Characters of ……

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** :
7. **Important Uses** :
8. **Indian Occurrences** :

7.3 BASIC CONCEPTS

You have read about the formation of sedimentary rocks in Unit 8 of BGYCT-135 course. The particles that form a sedimentary rock are called sediments, and may be composed of geological detritus/minerals or biological detritus/organic matter. Thus, sedimentary particles or sediments are building blocks of sedimentary rocks. The sedimentary particles are of three types:

1. **Terrigenous particles**: They are the fragments of the pre-existing rocks that have been worn down into small pieces such as gravel, sand, silt and clay by weathering, mass-wasting events by geological agents such as wind, water or ice and volcanoes. They form basic component of clastic rocks such as sandstone and shale.
2. **Chemical precipitates**: These materials are transported in solution as dissolved load, but later they grow as solids in the depositional basin as a result of chemical precipitation. Carbonate rocks (limestone) and evaporites are examples of chemical precipitates.
3. **Organic materials**: They are the plant and skeletal remains or imprints of the organisms**;** examples are coal deposit, coquina/fossiliferous limestone.

Depending on the origin and nature of the sedimentary particles, sedimentary rocks can be classified as clastic and non-clastic rocks.

i) **Clastic Rocks**: Sediments of the clastic rocks are derived from disintegration of pre-existing rocks by physical, chemical and biological processes. The clasts or detrital fragments are transported by gravity, running water, wind and glaciers and are laid down in various depositional basins e.g., marine, fluvial, aeolian, lacustrine. This type of sedimentary deposition is referred to as clastic sedimentation. Grain size of the clastic rocks that ranges from clay, silt and sand to pebble, cobble and boulder size materials. Occurrences of rocks formed by the deposition of clastic materials are conglomerate, breccia, sandstone, and shale. The

mineralogical composition of hand specimens of clastic rock will be discussed under three sub-heads: (1) framework grains, (2) matrix, and (3) cement. Similarly, you will document the texture of clastic sedimentary rock in hand specimen as 1) grain size, 2) shape, and 3) sorting.

ii) **Non-Clastic Rocks**: They exhibit crystalline texture. Non-clastic rocks are formed by chemical or biochemical precipitates from fluids. Chemical sedimentary rocks such as limestone, dolomite, rock salt and gypsum show such textures. Grains show an interlocking mosaic of crystals. These sedimentary rocks are made up of fragments of interlocking minerals formed by chemical processes such as evaporation, precipitation, recrystallisation etc. or biochemical processes i.e. accumulation of the remains of the hard parts of organisms. Thus, non-clastic sedimentary rocks may be further subdivided into: chemical and biochemical / organic sedimentary rocks. The dissolved mineral products that are removed from the weathering site are transported in solution and deposited in a basin by chemical precipitation. Such chemically precipitated rocks are known as **chemical sedimentary rocks** e.g. limestone and dolomite. Carbonaceous materials plants and skeletal remains of organisms/microorganism (algae, fungi, bacterial etc.) form the major components of **organic/biogenic sedimentary rocks**. Occurrences of rocks formed by the accumulation of plant debris in swamp or bogs are coal deposits.

Let us discuss about all the points covered in the megascopic description of Table 7.1 one by one.

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. Write appropriate colour of the rock by observing its appearance in the light. Thus, the colour of rock in hand specimens will be documented in your laboratory file as per visualization of your eyes. You are advised to take help from the Munsell colour system/chart for recognition of colour accurately and describe with appropriate terms.

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**: You will identify and describe mineral composition under the three sub-heads: i) framework grains, ii) matrix, and iii) cement. You have read about these in Unit 9 of BGYCT-135 course. Let us discuss them one by one:
   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. Rock fragments include fine grained igneous, metamorphic and sedimentary rock clasts. You will have to identify these framework grains with the help of hand lens provided to you in the study centre. 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. Now, how will you identify them? 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. Clastic sedimentary rocks also contain a very small amount of heavy minerals such as zircon, tourmaline, rutile, etc.
   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. Chemical sedimentary rocks are mostly a single mineral or mineraloid. Limestone, for example, is made

up of predominantly of crystalline or cryptocrystalline grains of calcite formed by chemical precipitation.

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

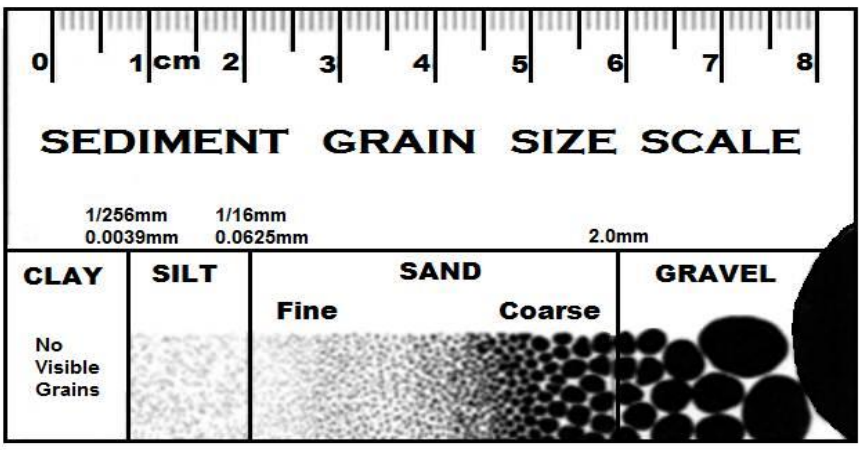

Fig. 7.1: **Sediment grain size scale.**

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.

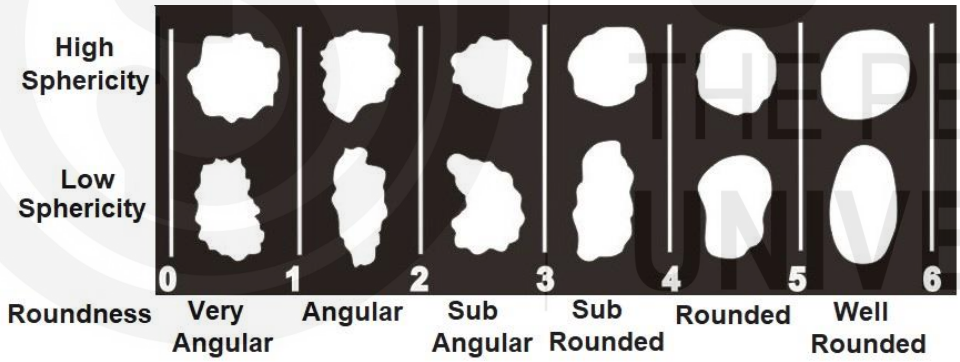

Fig. 7.2: Roundness scale and its relation to sphericity.

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.

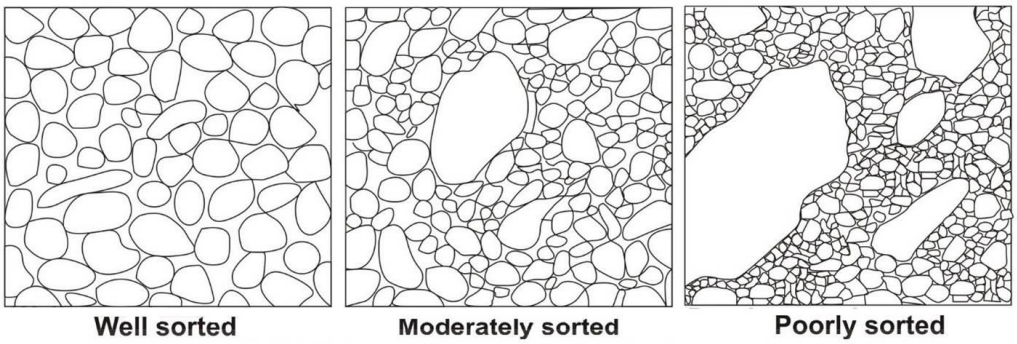

Fig. 7.3: Diagram showing sorting of grains.

iv) **Texture of non-clastic rocks**: Chemical (non-clastic) texture is common in rocks such as limestone, dolomite, rock salt, etc. It is formed by chemical or biochemical precipitation of dissolved minerals or mineraloids in the solution. The grains show an interlocking mosaic of crystals. The non-clastic texture may be crystalline or microcrystalline (micritic). Some rock such as fossiliferous limestone /coquina and calcarenite exhibit bioclastic and clastic textures since the time of formation by the accumulation of shell debris and carbonate clasts. Carbonate rocks are dominantly composed of two minerals: calcite ($CaCO_3$), and dolomite ($CaMg(CO_3)_2$). The principal constituents of limestones are the well-organized grains made up of calcium carbonate known as allochemical component, micrite and sparite. **Allochemical components** are abbreviated to allochems, and are organized aggregates of carbonate, formed within the depositional basin. They include ooids, bioclasts, peloids and intraclasts. **Ooids** are spherical or ellipsoidal grains up to 2 mm in diameter contain regular fine-grained concentric laminae of carbonates developed around a nucleus. **Peloids** composed of fine-grained carbonate recognisable internal structure.

Intraclasts composed of sediments once deposited on the floor of the depositional basin and later eroded and reworked to form new grains within depositional basin. **Bioclasts** are the remains either complete or fragmented of hard parts of the carbonate-secreting organisms.

The term micrite is used microcrystalline calcite and refers to carbonate sediments with a > 5 μm crystal size. It forms in the depositional basin either as a direct precipitate from seawater or from disintegration of calcium carbonate secretions associated with the organisms such as algae. The crystal size of a micrite is much less than the thickness of a normal thin section and so it is not possible to recognise individual crystal under the microscope. Micrite often appears medium to dark grey in colour. The outer parts of ooids, peloids and intraclasts are commonly made of micrite. The term **sparite** is used for sparry calcite and refers to crystals of 5 μm or > 5 μm in diameter. Sparite crystals are generally coarse with crystals typically tens to hundreds of microns in size.

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.

Evaporite deposits are common and consist of halite, gypsum, and other salts.

7. **Important Uses**: List important uses of the rock observed.
8. **Indian Occurrences**: Give important Indian occurrences of the listed rock types identified by you.

Let us discuss megascopic characters of clastic rocks.

7.4 CLASTIC ROCKS

You will identify conglomerate, breccia, sandstone and shale in hand specimens.

7.4.1 Conglomerate

Conglomerate is a coarse-grained siliciclastic rock that contains rounded, smooth gravel to boulder size clasts. However, in a hand specimen, you will get fine clasts of a gravel size. The space between the gravel to pebble size clast is commonly filled-up with the matrix or cement that binds clasts together. The matrix consists of sand, silt and clay size grains. The cementing material is generally chemically precipitated calcite, silica or iron oxide. The colour and hardness of the rock is very much variable and depend upon the nature of the clasts or detrital components and strength of the cement or matrix present in it. As the clasts are rounded, it may not be feasible to identify the clasts easily. It is possibly; you may be confused with quartz and quartzite clast.

The rounded conglomerate clasts indicate that they have either experienced or endured a long distance of transportation by water or they had undergone to and fro motion by high energy wave action in a tidal flat environment for a long time.

Based on ratio of clasts and matrix, you can divide the conglomerate is divided into two broad classes:

- **Clast supported**: The clasts are in contact with each other and the matrix fills the void spaces (Fig. 7.5a).
- **Matrix supported**: The clasts are not in contact with each other and the matrix surrounds every clast (Fig. 7.5b).

Clasts are generally > 2.0 mm size and easily visible by unaided eyes. Normally in a hand specimen, you identify clasts of a granule (2-4 mm), and pebble (4-64 mm) sizes. Sorting of conglomerate is determined based on the size of the clast assemblage. A mixture of variable size clast is poorly sorted conglomerate, while clast of almost same size is well sorted.

You are advised to identify conglomerate in the hand specimen provided to you at your study centre with the help of megascopic characters are given in the Table 7.3 and photographs and sketches of the hand specimens given in Figure 7.4 and 7.5. You have to identify whether hand specimens of conglomerate are a clast supported or matrix supported and draw sketches of hand specimen in laboratory file.

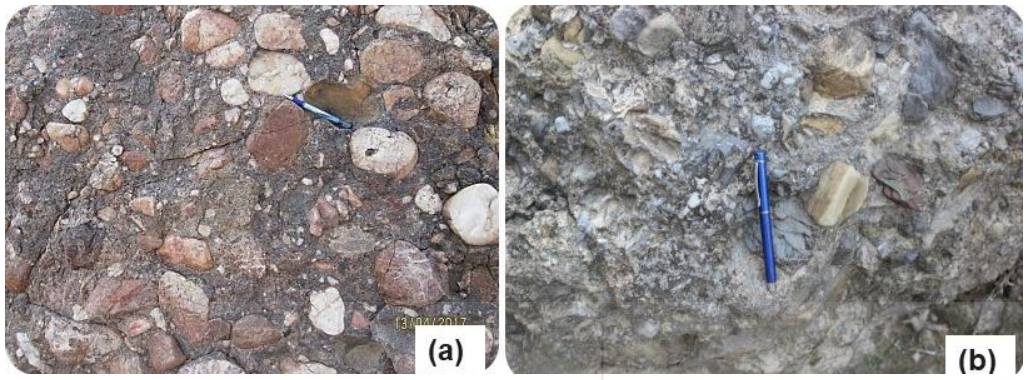

Fig.7.4: Hand specimens of conglomerate: a) Clast supported; and b) Matrix-supported.

Table 7.3: Megascopic Characters of Conglomerate.

1.	**Colour**	:	Varies from tan brown, greyish, buff. Colour depends on clasts, matrix and cement.
2.	**Compactness**	:	Moderate to hard.
3.	**Mineral Composition**:		
	• **Framework grains**	:	Quartz (hard, vitreous luster, cleavage absent, conchoidal fracture).
			Feldspar (subvitreous luster, 2 sets of cleavages, conchoidal fracture.
			Rock fragments may include fine grained igneous, metamorphic and sedimentary rock clasts.
			Igneous-interlocking texture.
			Sedimentary-clastic/non-clastic texture and layering observed.
			Metamorphic-foliation is common.
			Rock fragments can be of jasper, chert, quartzite, limestone, basalt, granite or granodiorite.
	• **Matrix**	:	Sand, silt and clay size grains.
	• **Cement**	:	Commonly consists of chemically precipitated calcite, silica or iron oxide.
4.	**Texture**:		
	• **Grain Size**	:	Coarse-grained (2-64 mm), granule to pebble

			size clasts.
	• **Roundness**	:	Rounded to subrounded.
	• **Sorting**	:	Poorly sorted. Conglomerate clasts may be of more than one type of rock, then it is termed as **polymictic.** Clast of single type of rock is **oligomictic.**
5.	**Inference/Name**	:	**CONGLOMERATE**
6.	**Origin**	:	Deposited near alluvial fans, braided rivers, where the debris brought from the mountain peaks are rounded in the streams and sorting starts to take place. Usually, large pebbles are left behind while smaller debris is carried further downstream.
7.	**Important Uses**	:	Conglomerate is used as aggregate, for decoration of walls and floors and in construction of road. It is also host of many economic minerals.
8.	**Indian Occurrences**	:	Lower Vindhyans of Son Valley. Upper Siwalik, Sub-Himalaya, Jurassic rocks of Kachchh basin, Gujarat, Cuddapah basin, Andhra Pradesh.

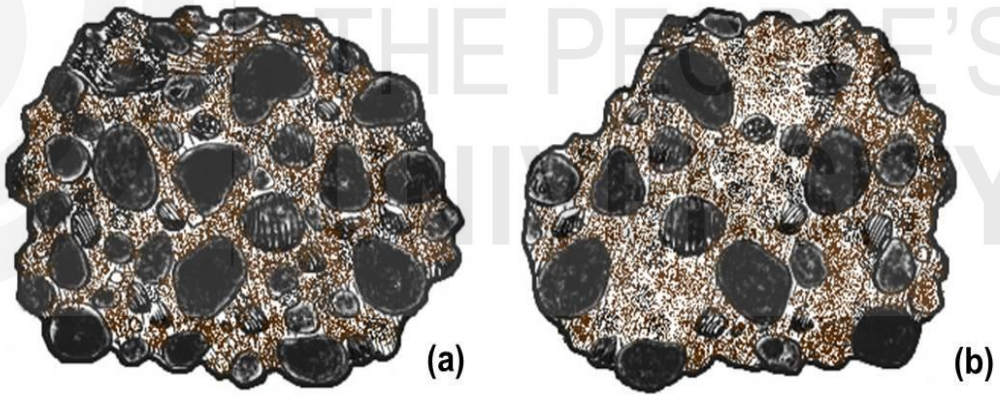

Fig. 7.5: Sketches of conglomerate: a) Clast supported; and b) Matrix supported.

7.4.2 Breccia

Sedimentary breccia is a clastic rock composed of angular fragments (> 2.0 mm in diameter) of rocks or minerals cemented together by a sandy-silty matrix or by calcite, silica or iron oxide cement. It is generally variable in colour. It is moderately hard, poorly sorted and immature rock. The angular shape of the clasts in breccia indicates that they have not been transported far away from their source rock. Breccias are generally formed near fault scarps. Common occurrences of the breccias are chert and collapse breccias. **Chert-**

breccia is commonly autoclastic breccias, where both clastic fragments and matrix consists of microcrystalline quartz. The **collapse-breccia** is formed as a result of dissolution of underlying soluble bedrock, such as limestone or dolomite, thereby allowing the overlying rock to settle and become fragmented. With the help of megascopic characters (given in the Table 7.4) and photograph and sketch of the hand specimen (given in Figure 7.6), you are advised to identify breccia in the hand specimen provided to you in your study centre.

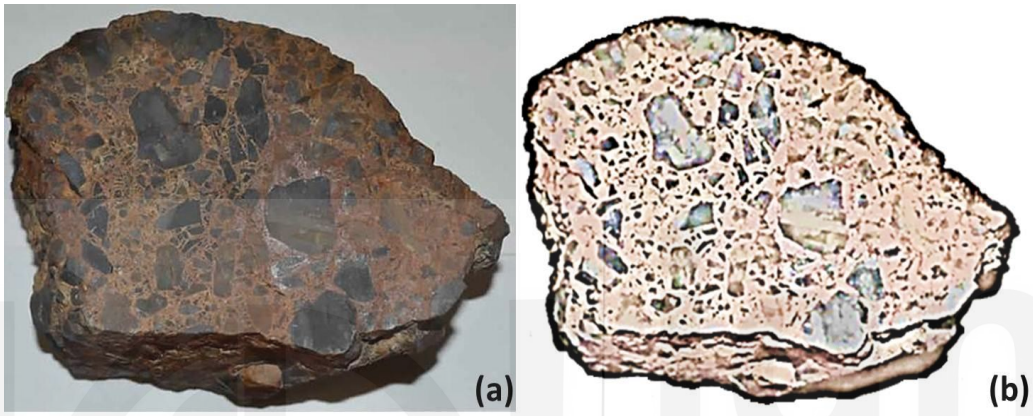

Fig. 7.6: Breccia: (a) Hand specimen; and (b) Sketch.

The important physical characters observed for the breccia are described below:

Table 7.4: Megascopic Characters of Breccia.

1.	**Colour**	:	Commonly light.
2.	**Compactness**	:	Moderately hard.
3.	**Mineral Composition**:		
	• **Framework grains**	:	Quartz (hard, vitreous luster, cleavage absent, conchoidal fracture). Feldspar (subvitreous luster, 2 sets of cleavage, conchoidal fracture. Rock fragments chiefly of fine grained igneous, metamorphic and sedimentary clasts. Igneous-interlocking texture. Sedimentary- clastic/non-clastic texture and layering observed. Metamorphic-foliation common. Rock fragments are of jasper, chert, quartzite, limestone, basalt, granite or granodiorite.
	• **Matrix**	:	Fine grained sandy-silty and clayey.
	• **Cement**	:	Calcareous, siliceous and ferruginous. You may identify it with the help of Munsell colour index.

			Calcareous- gives buff, off-white colour to a rock, if you pour 2-3 ml dilute HCl on it, you will find effervescences. Siliceous-off-white or white colour to a rock, very hard if scratched with knife. Ferruginous-gives reddish brownish colour to the rock. Clayey-off-white, buff colour to rock, scratched with knife.
4.	**Texture**:		
	• **Grain Size**	:	Coarse- to medium grained (> 2.0 mm in diameter).
	• **Roundness**	:	Angular to sub-angular fragments.
	• **Sorting**	:	Poorly sorted. Polymictic- if the clasts represent more than one rock types. Oligomictic- if clasts are from one rock type.
5.	**Inference/Name**	:	**BRECCIA**
6.	**Origin**	:	Form near mountains, where landslides occur. The landslide pile up vast amount of debris that contains large and small angular rock fragments. The large angular fragments often cemented in a rock. In other case the debris is carried away in the downstream side.
7.	**Important Uses**	:	Breccia is used as sculptural and architectural material. It is an ornamental or facing material in walls and columns. It is also used as an aggregate and in the construction of road.
8.	**Indian Occurrences**	:	Upper Vindhyans of the Son Valley. Chert breccia occurs in Subathu Formation, NW Himalaya.

7.4.3 Sandstone

Sandstone belongs to arenaceous group. The name sandstone is assigned to a rock predominantly composed of coarse grained or sand size detrital grains. The sandstones form in a variety of environments and often contain significant clues related to sorting of particles of a particular size, shape, composition and about their origin. Sandstone is a coarse to fine-grained (2.0 mm to 0.0625 mm) clastic sedimentary rock. The grains are bound together by fine grained matrix and /cement. Colour of the sandstone varies from white, buff, gray, pink, red, black to brown. Ferruginous (iron oxide) cement gives brown to red colour in the sandstone. Silica and calcite cemented together in sandstone is white and buff in colour.

Compactness varies from moderate to hard in the sandstone. Generally, siliceous, ferruginous and calcareous cement gives compactness to the

sandstones, while feldspathic sandstones with silty-clayey matrix are less compact.

Types of Sandstone: Sandstones have been classified by various sedimentologists, but the classification proposed by Dott (1964). It uses relative abundance of framework grains such as quartz, feldspar, and rock fragments and abundance of matrix between the grains. Broad subdivisions of the sandstones are described below:

- **Quartz sandstone**: Quartz sandstone contain >90% quartz grains and little or no clayey matrix. When it contains >95% quartz, it is known as **Quartz arenite** (Fig.7.8a). Grains are commonly cemented with silica, but calcite and iron oxide cement may also be present. Arenites are usually white or buff coloured, well sorted, well rounded and texturally and mineralogically super mature. They often represent ancient dune, beach, or shallow marine deposits
- **Feldspathic sandstone**: Feldspathic sandstones have <90% quartz grains, more feldspar grains than lithic grain and little clayey matrix. A rock consisting of >25% feldspar is called **arkose** (Fig.7.8b). They are usually pink to reddish in colour, immature and poorly sorted and type of arkosic sandstones are commonly deposited in alluvial fans or fluvial aprons of the depositional basin.
- **Lithic sandstone**: Lithic sandstones contain <90% quartz grains. It contains more lithic fragments than the feldspar grains. A rock containing heterogeneous mixture of rock fragments, feldspar, and quartz together with the appreciable amounts (>15%) of clayey matrix is known as **wacke or greywacke** (Fig.7.8c). They are deposited in fore-arc and back-arc basins etc. undergoing uplift at faster rate and thus the sediments do not get enough time for maturing.

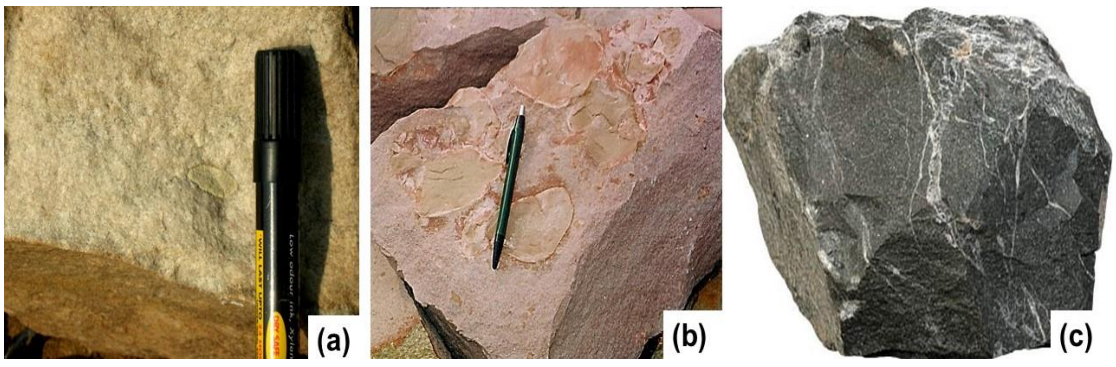

Fig. 7.8: a) Quartz arenite; b) feldspathic sandstone (arkose); and c) lithic sandstone (greywacke). (Source: https://flexiblelearning.auckland.ac.nz/rocks_minerals/rocks/greywacke.html, for (c); Photo credit for (a) and (b) Prof. Meenal Mishra)

Now, you have learnt about three varieties of sandstones. You have to identify sandstone on the basis of above criteria. Megascopic characters are given in Table 7.5. You have to write your observations based on the samples under observation. Ask your academic counsellor in case of any doubts. With the help of megascopic characters given in the Table 7.5 and photographs and sketches of the hand specimens given in Figure 7.7 and 7.8, you are instructed to identify different type of sandstones in the hand specimens provided to you at your study centre.

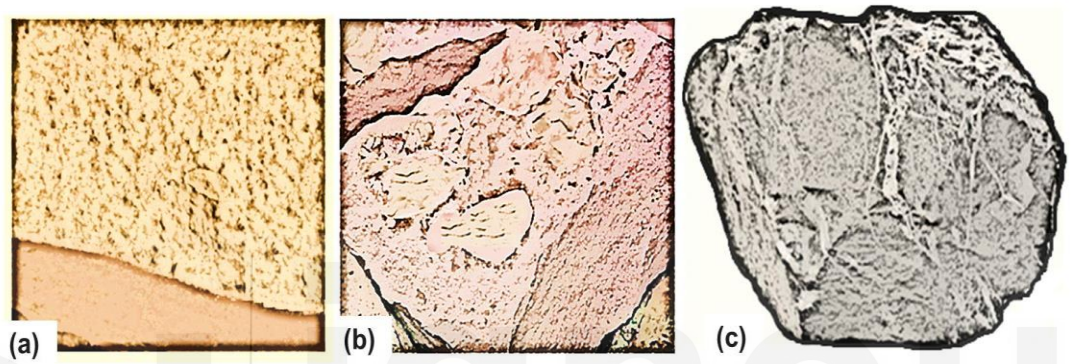

Fig. 7.7: Sketches of: a) Quartz arenite; b) Feldspathic sandstone (arkose); and c) Lithic sandstone (greywacke).

Table 7.5: Megascopic Characters of Sandstone.

1.	**Colour**	:	Varies from white, buff, gray, pink, red, black to brown. It also depends framework grains and cement. Sandstone with iron oxide cement is brown to red in colour. Silica and calcite cemented sandstone is off-white and buff coloured.
2.	**Compactness**	:	Varies from moderate (in case of lithic sandstone) to hard (quartz arenite).
3.	**Mineral Composition**:		
	• **Framework grains**	:	Quartz (smooth vitreous surface, hard, colourless, transparent and translucent grains). Feldspars (off-white or grey in colour, subvitreous luster). Micaceous minerals may be present. Black flaky mineral is biotite and shinning silvery mineral is muscovite. Rock fragments may include fine grained clasts of igneous, metamorphic and sedimentary rock. Igneous-interlocking texture. Sedimentary-layering seen. Metamorphic foliation. Rock fragments of jasper, chert, quartzite, limestone, basalt rarely granite or granodiorite may or may not be present. Accessory minerals such as zircon, tourmaline,

rutile may be present and can be identified under the high-power hand lens (if sandstone is coarse grained).

- **Matrix** : Fine silt size quartz and clay minerals.
- **Cement** : May be siliceous, calcareous, ferruginous and clayey.
  Matrix is identified with the help of colour.
  Calcareous- gives buff, off-white colour to the rock, if you pour 2-3 ml of dilute HCl, it will show effervescences.
  Siliceous-off-white or white colour to the rock, very hard if scratched with the knife.
  Ferruginous-gives rise to reddish brown colour to the outcrop.
  Clayey-off-white, gives rise to buff colour to the rock, scratched with the knife.

4. **Texture**:
   - **Grain Size** : Coarse to fine grained (2.0 mm to 0.0625 mm size). Clasts visible unaided eyes, often identifiable.
   - **Roundness** : Generally mature sandstones such as quartz sandstones/arenite are well-rounded, whereas in immature sandstones, e.g. lithic sandstone/ greywacke the grains are subrounded to angular.
   - **Sorting** : Varies from well sorted in case of quartz arenite to poorly sorted in greywacke.
5. **Inference/Name** : **SANDSTONE**
   Remember! Here you have to mention whether the sandstone is quartz arenite, feldspathic sandstone or greywacke hand specimen.
6. **Origin** : Quartz arenite often represents ancient dunes, beaches, or shallow marine deposits. Arkosic sandstones commonly deposited in alluvial fans or fluvial aprons of the depositional basin. Greywackes deposited in deep sea water by turbidity currents.
7. **Important Uses** : Sandstones are used as dimension stone for buildings as paving material. It is used in the construction of roads and buildings. Most of ancient times the temple, tomb, castle, gate and fort in India built-up of Vindhyan Red Sandstones. It is also used as an aggregate and filling material, etc.
8. **Indian Occurrences** : Popular sandstones occur in Vindhyan, Siwalik, Gondwana Supergroup of rocks and many other basins.

7.4.4 Siltstone

In siltstone, the grains are not visible by unaided eyes, but when rubbed with fingers it gives a gritty feel. Siltstone contains >50% silt size (0.004-0.063 mm) particles. Siltstone represents the transition from fine-grained sandstone to mud and clay rocks. Siltstone may also contain s substantial amount of carbonates, mainly of calcite and forms cement or fine-grained carbonate detritus (carbonate mud deposited along with the silt size grains), and such type of rock is called as calcareous siltstone. Siltstones are generally massive, thickly to layered, strongly lithified, homogeneous and horizontally or obliquely laminated. With the help of megascopic characters given (Table 7.6) and photograph and sketch (Fig. 7.9) of the hand specimen, you are instructed to identify hand specimens of siltstone provided to you at your study centre.

Table 7.6: Megascopic Characters of Siltstone.

1.	**Colour**	:	Variable, such as grey, buff, red, green, brown or black.
2.	**Compactness**	:	Varies from moderately hard to soft.
3.	**Mineral Composition**:		
	• **Framework grains**	:	Angular quartz grains significantly associated with the tiny feldspar grains and mica flakes.
	• **Matrix**	:	Very fine clay present as matrix.
	• **Cement**	:	Cement mainly composed of calcite or fine-grained carbonate detritus (carbonate mud deposited along with the grains).
4.	**Texture:**		
	• **Grain Size**	:	Silt size ranges from 0.004 to 0.063 mm.
	• **Roundness**	:	Angular to subangular grains common.
	• **Sorting**	:	Well sorted.
5.	**Inference/Name**	:	**SILTSTONE**
6.	**Origin**	:	Deposited along the river banks, flood plain, and natural levee. Continental shelf, beyond the formation of the sandstone, but before the shale in the open ocean.
7.	**Important Uses**	:	The pore spaces of the siltstone can serve as good aquifer. But it is rarely porous enough or extensive enough to serve as an oil or gas reservoir. Its main use is as a low-quality fill when better materials are not available locally.
8.	**Indian Occurrences**	:	In nearly all the depositional basins.

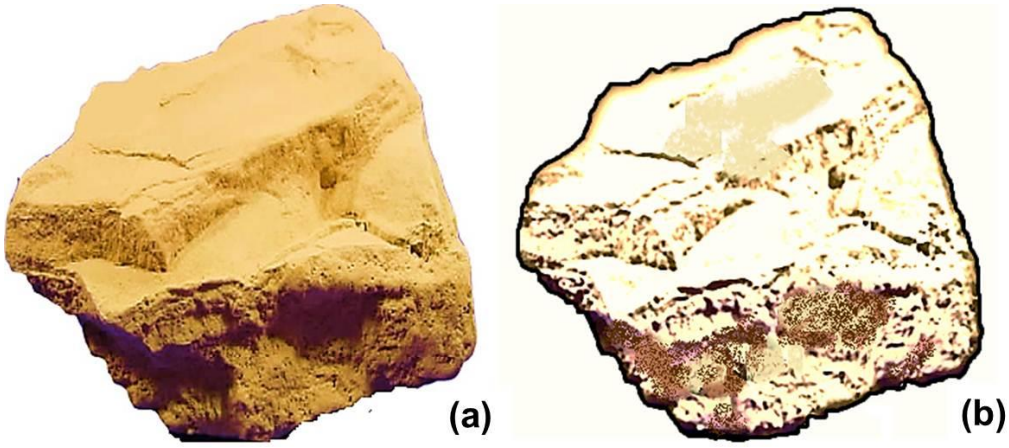

Fig. 7.9: (a) Hand specimen; and (b) Sketch of a siltstone. (Source: http://www.dinojim.com)

7.4.5 Shale

Shale is a common fine-grained clastic rock composed mostly of clay-and silt-sized particles. Shale when rubbed with hand gives a smooth feel. When you pour water in the field or laboratory on shale it gives odour of wet mud due to presence of clays. Colour of the shale that varies from various shades of grey, yellow, buff, red, brown to black. It depends upon the colour of the minerals present. Various colours of red, brown and yellow indicate presence of iron oxide or iron hydroxide such as hematite, goethite, or limonite. It commonly shows fine lamination and fissile nature due to the presence of mica-like clay minerals aligned parallel to **a** and **b** axes. Sole marks and fossils are commonly found in shale. Shales are well sorted and exhibit high porosity and very low permeability. They are generally found at the bottom of the lakes and oceans, river deltas and flood plains. **Black Shale** is a variety of shale enriched in organic matter (>5%) that gives black colour of the rock. Shales rich in organic matter as kerogen are known as **oil shale** yields hydrocarbon on distillation.

With the help of megascopic characters (Table 7.7) and photograph and sketch of the hand specimen (Figs. 7.10 and 7.11), you are instructed to identify hand specimens of shale provided to you at your study centre.

Table 7.7: Megascopic Characters of Shale.

1.	**Colour**	:	Variable, such as grey, red, green, brown or black.
2.	**Compactness**	:	Varies from moderately hard to soft.
3.	**Mineral Composition**:		
	• **Framework grains**	:	Composed primarily of clay minerals such as kaolinite, smectite, montmorillonite, illite

and silt size quartz particles. Other minerals include feldspars, calcite, iron oxide and a few heavy minerals. Pyrite is a common diagenetic mineral in shale. Grain size is too small to be identified by unaided eyes.

- **Matrix** : Very fine clay present as matrix.
- **Cement** : Mainly composed of calcite or fine-grained carbonate detritus (carbonate mud deposited along with the grains).

4. **Texture**:
   - **Grain Size** : Grain size is <0.0625 mm.
   - **Roundness** : Well-rounded to angular.
   - **Sorting** : Very well sorted.
   - **Structure** : Ripple marks may be present.
5. **Inference/Name** : **SHALE**
6. **Origin** : Marine and other environments that include lakes, river, floodplains, lagoons, and portions of the deep-ocean basins.
7. **Important Uses** : Shale acts as a cap rocks for oil and gas. They are rich in pyrite and various metals such Cu, V, U, and Ni. Oil shales are mined as fossil fuel.
8. **Indian Occurrences** : Vindhyan, Cuddapah, Siwalik and Gondwana sequences contain shale deposits. Black shales are also reported from the Vindhyans Supergroup and Tal Formation of Lesser Himalaya.

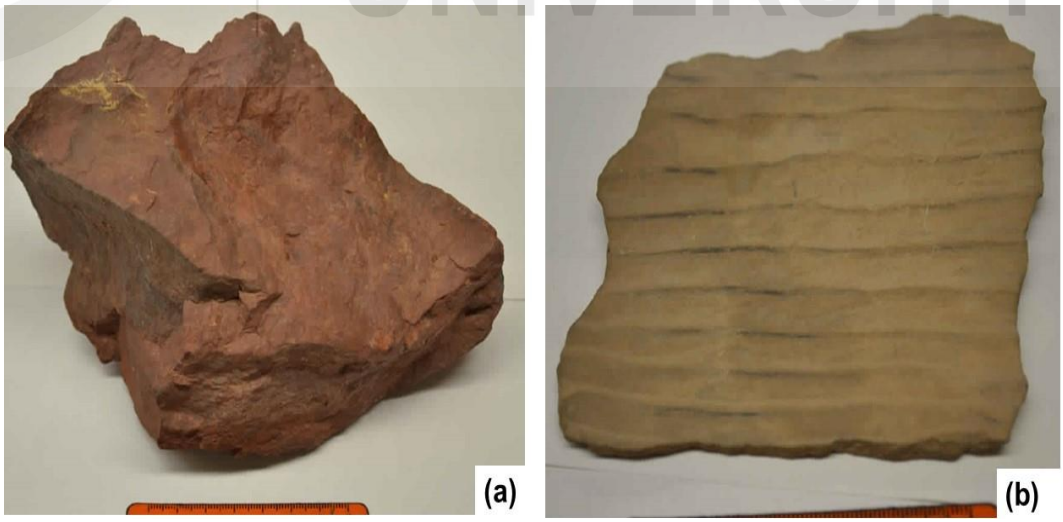

Fig. 7.10: **Shale in hand specimens showing: a) Red coloured and massive; and b) Buff coloured showing ripple marks.** (Source: http://www.dinojim.com)

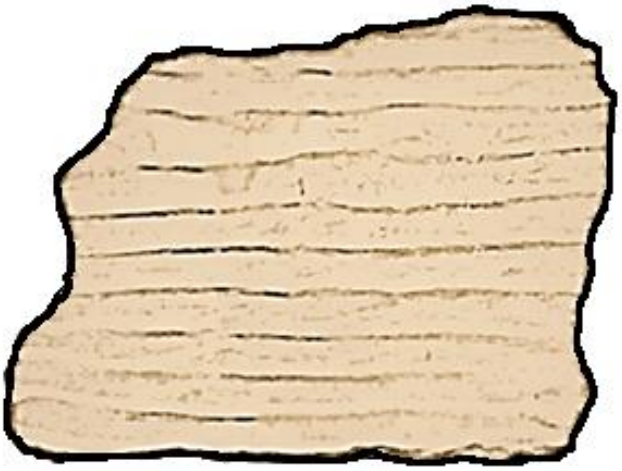

Fig. 7.11: Sketch of a shale.

7.5 NON-CLASTIC ROCKS

You will identify limestone, fossiliferous limestone, oolitic limestone and chert.

7.5.1 Limestone

You have read in Unit 8 of BGYCT-135 course that limestone is the most abundant chemical sedimentary rock formed by both chemical and biochemical processes due to the precipitation of calcite from lake or ocean waters. They dominate at shallower depths and in warm near-shore waters. Limestones can be described only in a limited manner in the field. Detailed studies require studies through the thin-sections and peels. Three components make up majority of the limestones. They are allochemical components, micrite (micro-crystalline calcite) and sparite. Allochemical components, refers to allochems which includes bioclasts (skeletal grains/fossils), ooids, peloids and intraclasts. The main group of organisms contribute to the skeletal material the molluscs (bivalves and gastropods), brachiopods, corals, echinoderms (especially the crinoids), bryozoans, calcareous algae, stromatoporoids and foraminifers. Limestone colour varies from light grey to dark grey, yellow and brown. It is compact massive and readily reacts with a few drops of dilute HCl.

Based on the megascopic characters, texture and composition, the limestone can be named as:

- Fossiliferous limestone
- Crystalline limestone
- Oolitic limestone
- Stromatolitic limestone

With the help of megascopic characters (Table 7.8) and photographs and sketch (Figs. 7.12 and 7.13) of the hand specimens, you are instructed to identify the hand specimen of limestone provided to you at your study centre. Try to identify above mentioned limestone types and document observations in your laboratory file.

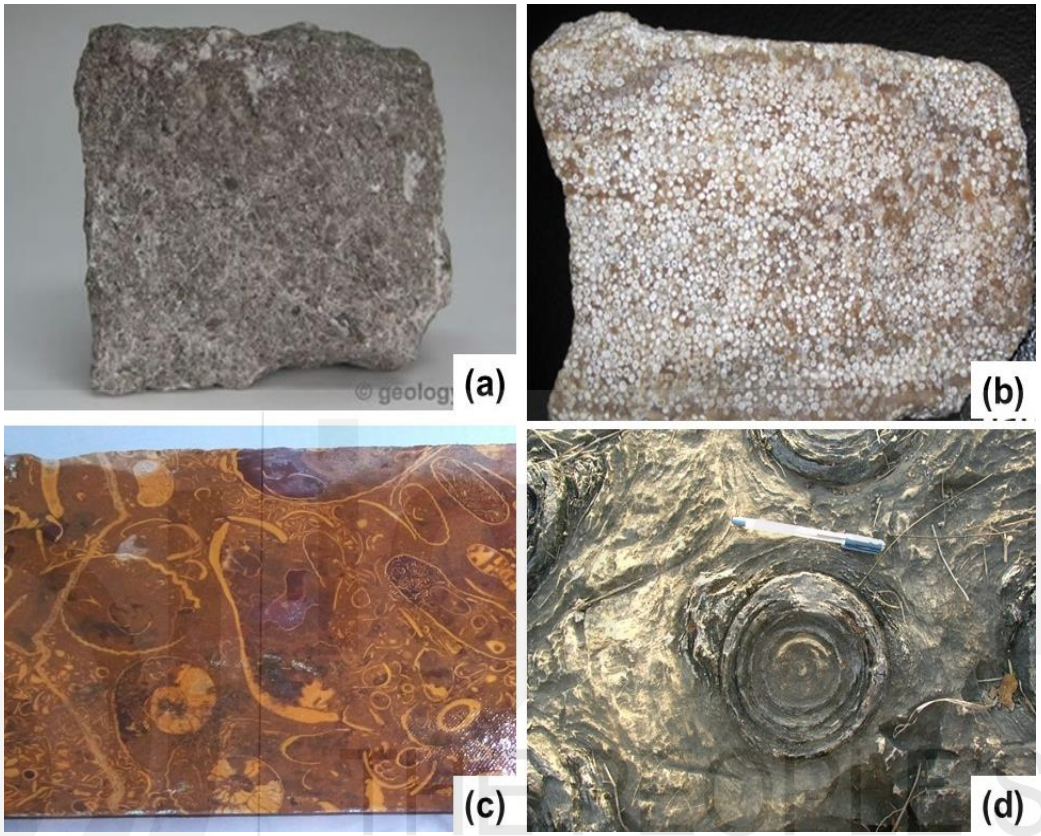

Fig. 7.12: a) Crystalline limestone (Source: www.geology.com)**; b) Oolitic limestone** (Source: https://upload.wikimedia.org/wikipedia/commons)**; c) Fossiliferous limestone; and d) Stromatolitic limestone.** (Photo credit for (c) and (d): Prof. Meenal Mishra)

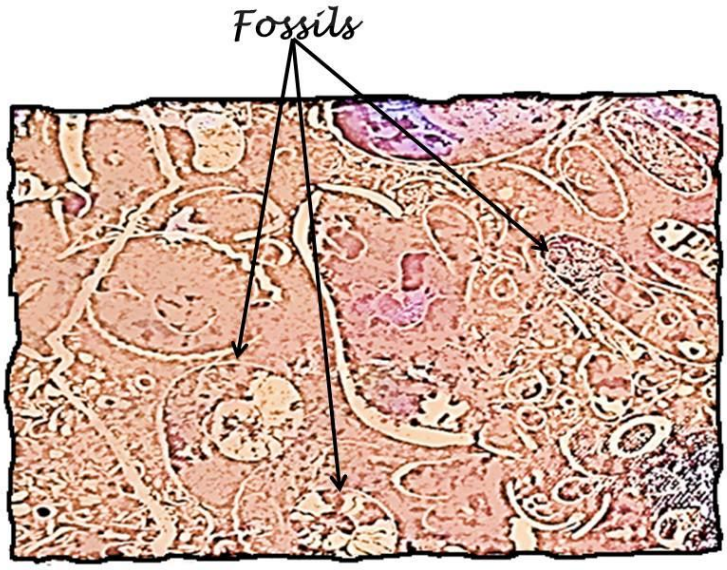

Fig. 7.13: Sketch of fossiliferous limestone.

Table 7.8: Megascopic Characters of Limestone.

1. **Colour** : Varies from light grey to dark grey, yellow and brown shades.
2. **Compactness** : Compact and hard.
3. **Mineral Composition** : Composed mainly of > 50% calcite. Often contains minor amount of dolomite, clay, silica, iron oxides, phosphorus and sulphur.
   - Matrix : Micritic (carbonate mud).
   - Cement : Sparite (sparry calcite, calcite spar) equant cement precipitated in the pore spaces between the grains and in large cavities. Fibrous calcite is also a cement that coats grains, fossils and lining cavities.
4. **Texture:**
   - Grain Size : May be microcrystalline (micrite) or coarse grained sparite. Chemically precipitated limestone is usually fine grained and is usually not visible with the unaided eyes. Grains and fossil/shell fragments are visible in bioclastic limestones. Size of grain that varies and depends upon the type of organism and their calcareous skeletons present in the rock.
   - Other Textures : Limestone may show clastic/bioclastic texture. The types of limestone textures are:
     i) **Non-clastic Texture:** It is formed when mineral constituents in solution become supersaturated and undergoes precipitation. It may be:
     Crystalline: It shows a crystalline mosaic of precipitated carbonate grains. Crystals are visible and form an interlocking network (Fig. 7.12a).
     Microcrystalline: It is composed of interlocking mosaic of microscopic crystals, but crystals are not visible with unaided eyes. Such limestones are dense, nonporous and breaks-up with conchoidal fracture.
     ii) **Clastic Texture**: Limestone composed predominantly of detrital carbonate grains compacted and cemented together exhibit clastic texture, for example, calcarenite. The appearance of calcarenite is very much similar to the sandstone.
     iii) **Bioclastic Texture**: It is similar to clastic texture except the clasts or grains are fossilised shell fragments (Fig.7.12c). Matrix

			may be composed either crystalline, microcrystalline or fine clastics. Limestone containing abundant fossils which show s bioclastic texture, e.g. Coquina.
5.	**Inference/Name**	:	**LIMESTONE**
6.	**Origin**	:	Limestone deposits exist in all the geological sequences right from the Precambrian to Recent except for the Gondwanas.
7.	**Important Uses**	:	Limestone is used in the production of cement, paper, fertilizer, petrochemicals, glass, pesticide, etc. It is used as a building material and in the manufacture of lime and carbon dioxide. It is also used as white pigment or filler in the products such as toothpaste or paints.
8.	**Indian Occurrences**	:	Almost all the Indian states produce some quantity of limestone. Important limestone producing states are Madhya Pradesh, Uttar Pradesh, Rajasthan, Andhra Pradesh, Gujarat, Chhattisgarh and Tamil Nadu.

7.5.2 Chert

Cherts are tough, compact rocks with low porosity and mainly composed of microcrystalline quartz and silica gel with varying amounts of impurities. Quartz occurs as randomly interlocked, microscopic quartz grains (microquartz) or fibrous chalcedony. Chert is a dense, hard siliceous-rock with low porosity. Chert present in the Banded Iron Ore Formations was formed primarily from the chemically precipitated silica. Often, they are bright and coloured and precipitated from the iron minerals. Many cherts appear to have been formed by silicification of volcaniclastic sediments and other rock types. Nodules, irregular bodies and discontinuous layers of the chert are frequently associated with the marine calcareous sediments. The term "chert" is occasionally used for massive rocks made primarily of microcrystalline quartz deposited around submarine volcanic hydrothermal vents. The diagnostic features of chert are: the waxy luster, conchoidal (shell-shaped) fracture, a hardness of seven (on the Mohs scale) and smooth (non-clastic) sedimentary texture. With the help of megascopic characters (Table 7.9) and photograph of a hand specimen (Figure 7.14), you are instructed to identify the hand specimen of the chert provided to you at your study centre. with the help of megascopic characters given in the Table 7.9 and photograph of the hand specimen given in Figure 7.14.

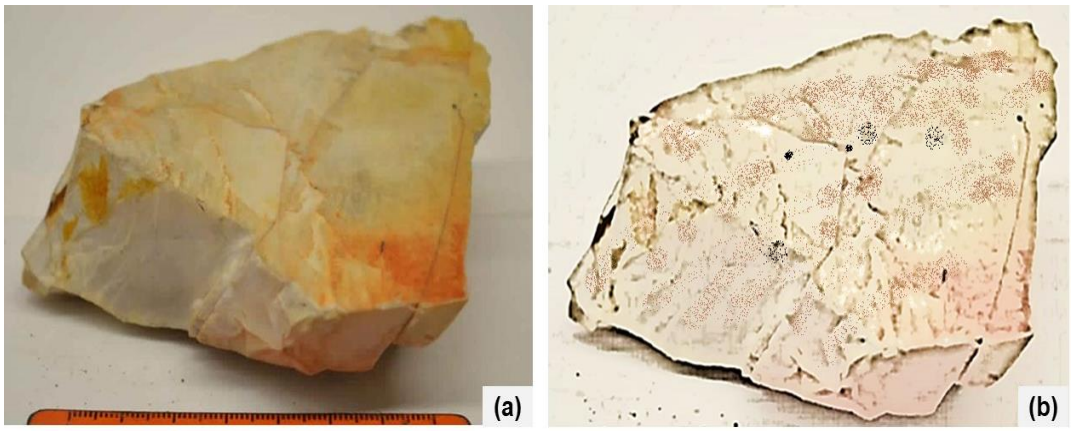

Fig. 7.14: a) Hand specimen; (Source: http://www.dinojim.com) **and (b) Sketch of chert.**

Table 7.9: Megascopic Characters of Chert.

1.	**Colour**	:	Varies from light to dark colours. Green, yellow, orange, and red cherts are also occur commonly. The dark colour is due to inclusions of mineral matter and organic matter. Abundant iron oxides in the chert produce red color. The name "jasper" is frequently used for the reddish cherts.
2.	**Compactness**	:	Very hard and compact.
3.	**Mineral Composition**:		
	• Minerals	:	Composed of microcrystalline and cryptocrystalline quartz (SiO_2) and gel silica.
4.	**Texture**	:	Chert displays irregular, sub-parallel, wavy to crenulated laminations on a sub-millimeter to centimeter scale, consisting of variable thicknesses of stacked chert laminae.
	• Other Textures	:	Chert be massive, bedded, nodular, massive, lenticular and brecciated.
5.	**Inference/Name**	:	**CHERT**
6.	**Origin**	:	Typically form during early digenesis by the precipitation of silica mobilised from biogenic sources like radiolarian tests or sponge spicules. Formed by hydrothermal activities.
7.	**Important Uses**	:	Excellent tool for starting fires. Used in various types of fire-starting tools (such as tinderbox), throughout the history of the man. In some areas, it is ubiquitous as stream gravel and fieldstone. It is currently used as construction material and road surfacing.
8.	**Indian Occurrences**	:	Andhra Pradesh, Uttarakhand, Assam, Karnataka, Odisha, Jharkhand.

7.6 LABORATORY EXERCISES

Study the megascopic characters of the rock samples such as conglomerate, breccia, sandstones, siltstone, shale and limestone given to you by your counselor. Follow the instructions given below:

1. Get a hand lens, knife, streak plate, coin, hardness-box, broken glass piece and rock specimen from your academic counsellor.
2. Study the megascopic characters of the rock by taking rock specimens in the hand and observe its properties with the help of the devices provided by your academic counsellor.
3. Write down megascopic characters of the rock specimens in the laboratory file.
4. Examine the rock with the help of a magnifying lens to determine its texture and composition.
5. Identify whether the rock is a clastic or a chemical sedimentary rock. If the rock is a clastic sedimentary rock, determine its grain size, roundness and sorting as per norms given in the textural classification (refer Figs. 7.1 and 7.2). In case of chemical sedimentary rocks, describe whether the rock is crystalline,
   microcrystalline or clastic/bioclastic.
6. Name the given rock on the basis of texture and mineral composition as given in the classification of sedimentary rocks, such as: arkose, limestone, etc. (refer Unit 11 of BGYCT-135).
7. Write down origin and uses from the knowledge you have gained while studying theory and practical courses BGYCT-135 and BGYCL-136.
8. Finally, draw neat sketch of the hand specimen observed in the laboratory given by your instructor.
9. If you find any problem during the study of the rock specimens, do not hesitate to ask your counsellor.
10. Handle rock specimens and all the devices provided to you with great care and do not damage them.

Exercise 1: Identify all the rocks in hand specimens given at the study centre. Study its megascopic characters and write down them in your laboratory file. Also draw the sketches of the hand specimen observed in the laboratory given by your instructor.

Write megascopic characters of the rock samples in the manner as listed below. Also mention the diagnostic properties used by you for the identification of particular rock type.

Table 7.10: Megascopic Characters of Sedimentary Rock.

1.	**Colour**	:
2.	**Compactness**	:
3.	**Mineral Composition**:	
	• Framework grains	:
	• Matrix	:
	• Cement	:
4.	**Texture:**	
	• Grain Size	:
	• Roundness	:
	• Sorting	:
	• Sedimentary structure and fossil (if present)	:
6.	**Inferences/Name**	:
7.	**Origin**	:
8.	**Important Uses**	:
9.	**Indian Occurrences**	:

Exercise 2: How would you distinguish between conglomerate and breccia.

Exercise 3: How would you distinguish arkose, arkosic sandstone and greywacke

Exercise 3: Write origin and uses of conglomerate, breccia, shale, and limestone.

Exercise 4: Identify field photographs of rocks and write their megascopic and diagnostic characters and name the rock given in Fig. 7.15(a-d).

Fig.7.15: (a-d) Various Sedimentary rocks. (Source: www.gsi.gov.in)

7.7 REFERENCES

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- www.geology.com
- www.gsi.gov.in

(Websites accessed on 1st April to 28th April 2020)

7.8 LEARNING RESOURCES

- Clastic and non-clastic rocks
  Link: https://www.youtube.com/watch?v=ELU2aXKjJF4
- Sedimentary rocks
  Link: https://www.youtube.com/watch?v=NwAVv7WZCfA
- What is limestone?
  Link: https://study.com/academy/lesson/what-is-limestone-properties-types-uses.html
- https://www.britannica.com/science/sedimentary-rock