The textural relation of granite, biotite granite, hornblende bearing granite, granite gneisses and high grade metamorphic rocks have been described in this chapter. The geochronological study of crystallization and deformation is mainly based on relation between the time and fabrics of rocks i.e. external foliation (se) and the internal foliation (Si) with the porphyroblast. The time relation between the phases of deformation and episodes of metamorphic/crystallinization, the rocks of the area displays textural evidences of metamorphic reaction involved in the formation of diverse minerals paragenesises. The field relationship and geochronological studies suggest that rocks of Bundelkhand have been subjected to polyphase deformations and metamorphism in the Archean time. The detail petrographic studies have been discussed under the following heads (a) Bundelkhand gneisses complex (b) granitoids (c) dolerites and mafic dykes (e) quartz reefs and (f) mylonites.

3.1 BUNDLEKHAND GNEISSES COMPLEX (BnGC):

The BnGC rocks comprise of gneisses, TTG, migmatites, granite gneisses, sillimanite gneisses, amphibolites, hornblende-biotite gneisses. These rocks are exposed in low land topography, generally showing NW-SE and E-W foliation and are well exposed at Nathupura, Lodhapahar, Jankhera ridge (Fig-2.6). The small xenoliths of BnGC were also found at several places as enclave within the granitoids. They are light to dark grey coloured bands of tolanites-trondhjemite gneisses (TTG), biotite gneisses granite, sillimanite gneisses and granite gneisses. The gneisses of Lodha pahar and Nathupura are mainly composed of biotite gneisses, where altered chlorite minerals and ferromagnesian minerals are aligned to the foliation of the rocks. The accessory minerals in biotite- gneisses include euhedral crystal of the Fe-Ti oxides, large crystal of apatite and zircon minerals.

The amphibolites and biotite-rich amphibolites (biotite-hornblende gneisses) are also found to be associated with the above mentioned rock types. These rocks are exposed in the small lensoidal bodies in the gneisses. Some places sulphide
mineralized shear zone has been observed in the gneissic rocks. Highly deformed and altered peridotites and mafic schistose rocks were also present at few places which is intrusive in the trondhjemitic gneisses. The BnGC rocks have been lithologically divided into three suits (1) gneiss TTG, migmatites granite gneisses (2) amphibolites and hornblende- biotite gneisses (3) schist and quartzites.

3.1.1 Biotite gneisses, TTG and Granite gneisses:

In study area, pelitic gneisses contain general trend of NW-SE to WNW-ESE and steeply dip towards north direction. At one place, they contain the deformational event in the gneisses indicate that N-S compression, which folded the whole sequence into tight isoclinal to open fold of various generations. The presence of complex folds in the gneisses indicates that gneisses had experienced polyphase deformation. Megascopically, these rocks are light grey to dark gray in colour, medium to fine grained but some places coarse grained variety are also observed with pink colour bands. Some places the thickness of melanocratic bands is greater than leucocratic bands. In gneisses melanosomes are set in dominant leucosomes. The leucosome are largely of quartz-feldspathic with minor amount of biotite. The melanosomes are granodiorite to diorite with biotite and minor amphiboles. The waxing and wining pattern are occurred in leucocratic and melanocratic bands at several places. Partial melting signatures as aggregates of granites melt are recorded from the gneisses. A sharp intrusive relationship between grey granite and gneisses has been observed. The leucocratic bands are rich in quartz and k-feldspar while melanocratic bands are rich in quartz, plagioclase and biotite minerals. The S-C fabrics in gneisses and the (local) micro faults in the gneissic rocks have been also noted. The small euhedral crystals of Fe-Ti oxides, feldspar, quartz, scricite, silliminite, apatite, epidote, zircon, opaque etc. are found in gneisses.

Feldspar

Orthoclase, microcline and perthite feldspar are the major minerals found in the BnGC rocks. Microcline is medium to fine grained containing cross hatched twinning. Sericite orthoclase shows the twinning to the untwining nature and some places shows the Carlsbad twinning. Sericitized feldspars incurred in the granite
gneisses and deformed gneisses. Coarse size orthoclase crystals with albite lamellae represented the lamellar twining (Plate-1b) have been identified from many places. The albite lamelles are very thick but some places thin (Plate-1c, 2b). Plagioclase minerals are subhedral, medium to coarse grained in gneisses rocks. They exhibits the prismatic forms plagioclase are colourless to grey (first order interference colour mineral). The characteristic feature of plagioclase is polysynthetic twinning (Plate 2c). Plagioclase contains the inclusions of biotite, apatite and K feldspar crystals. At some places myrmekite intergrowth characterized by vermicular texture obtained from granitic melts of gneisses.

**Quartz**

The quartz crystals are colourless to first order grey interference colour. They exhibit euhedral to anhedral in shapes medium to fine grained minerals. It shows and close extension due to polyphase deformation and crystallization. At many thin section quartz crystals are surrounded by biotite minerals.

**Biotite**

Biotite is dominant mineral constituent of this rock unit. Biotite are subhedral in shape. Two variety of biotites occur in this rock unit. (I) brown coloured biotites, most common, strongly pleochroic and (II) green coloured biotite.moderately pleochroic, rarely found. Some places both are found together and characterized by the one set cleavage. The brown colour variety of biotite contains the pleochroic haloes and some times coarse crystal of zircon with in the pleochroic haloes (Plate-5c). The magnetite crystal are formed along the cleavages of biotite minerals (Plate-1b). The biotite minerals are medium to coarse grained, tabular form, subhedral in shape (Plate-1a). The green biotite mineral show the one set of cleavage and are mainly associated with the retrograded and mylinitised granite- gneisses (Plate-2a). At many places magnetite crystals occur around the biotite crystals (Plate-2b). Medium to fine grained crystal of biotite are also oriented to foliation direction of the gneisses.

**Sillimanite**

Sillimanite usually occurs in small often minute crystals in the thin section. Prismatic, needle like crystals along the cleavages of biotite crystals are rare.
Sillimanite is usually found around the magnetite crystals (Plate-3a and 2b). It is colourless, high relief crystal and length slow. The textural study indicates that biotite is become unstable at higher temperature and responsible for the development of sillimanite. Rarely needle like crystal found as aggregates of very fine fibers at the cleavages of biotite. They are colourless, birefringence, parallel extinction fibrous habits minerals (Plate-3b).

**Muscovite**

Medium to fine grained they occurs in thin tabular crystals or scaly aggregates as retrograde product. Infew section characterized by second order interference colour. One set of cleavage are reported in muscovites thin section.

**Garnet**

Garnet is colourless, high relief, non pleochroic mineral medium to fine grained crystals. Garnet is distinguished from other mineral on the basis of high relief. Garnets are medium to fine grained colourless in thick section (Plate-6c ). They does not show any cleavage and inclusion.

**Zircon**

They are mostly associated with biotite gneisses, coarse crystals of zircon are also observed in few sections. Small crystals are associated with pleochroic haloes (Plate-6a). Zircon is usually small prismatic crystal in thin section, characterized by high relief.

**Apatite**

Apatite is medium to fine grained crystals. They are well developed in sillimanite gneisses. Apatite is euhedral in shape, colourless mineral. It show the moderate to high relief, first order interference grey in colour (Plate-6a, 7c and 8a) colourless birefringence.

**Sericite**

Sericite is alteration product of the K-feldspar. The development of sericite has been observed in many thin sections. This is randomly oriented, flaky in nature.
Sericitised orthoclase are observed in same thin section of granite, gneisses (Plate-1c). Sericites are secondary minerals formed by the hydrothermal alteration of the K feldspar in gneisses.

**Magnetite**

Magnetite minerals are usually euhedral to anhedral in shape (Plate-1a, 2a an 2c). Magnetite mineral are medium to fine grained. They are arranged in the cleavages of biotite minerals. They are embedded in the biotite, quartz crystals.

**Chlorite**

It generally occurs as secondary product due altered of biotite. Some times occurs in patchy masses, but some places it observed as subhedral-elongated crystal. Chlorite is characterized by light green to dark green pleochroism and low interference colour.

**Rutile**

Medium to coarse grained crystals of rutile are deep red brown in thin section. Rutile crystals in most of the thin section are euhedral in shape. The characteristic feature of the rutile minerals are simple contact twinning (Plate-4c).

**3.1.2 Amphibolites and hornblende- biotite gneisses :**

Amphibolites are mostly exposed at Lodha pahar, Kabrai area. They are medium to fine grained in nature & dark in colour. All the amphibolites are hard and compact in nature. The amphibolites of Lodhapahar also contain sulphide mineralization. The hornblende, biotite, plagioclase, magnetite, quartz, orthoclase, are the common mineral that occur in different proportion in the amphibolites. On the basis of mineral paragenesseses, the amphibolites has been classified into two types (1) hornblende- biotite gneisses (2) hornblende-plagioclase gneisses.

**Hornblende**

Prismatic crystals of hornblende minerals are medium to coarse- grained in nature, subhedral in shape. Light green to dirty olive green colour is the characteristic features of the hornblende in the gneisses. Two set cleavages are presents in many thin sections (Plate-7b). The extinction angle for prismatic section of hornblende
crystals ranges $10^0$ to $20^0$, characterized by second order interference colour. At many places hornblende crystal are altered to chlorite crystals (Plate-8c). Inclusions of biotite, magnetite, quartz, plagioclase are common in hornblende-biotite gneisses (Plate-9b and 9c). Hornblende crystals are associated with pyroxene crystals (Plate-11a). Hornblende is inclusion in biotite found in many section. Replacement texture is common.

**Plagioclase**

The plagioclases are medium to fine grained subhedral in shape and is characterized by colourless prismatic crystal first order grey colour mineral. (Plate-9a)

**Quartz**

Medium to fine grained subhedral to anhedral and the undulose extinction due to the strain effect. Quartz crystal contains the inclusion of hornblende and biotite crystal (Plate-11b and 11c).

**Biotite**

It is observed as medium to fine grained crystals, brown in colour, pleochroic mineral (pleochroism are light brown to dark brown). All the biotite crystals are aliened in the schistocity plane. Some time biotite crystal shows the replacement texture with amphibole and pyroxene crystals (Plate-11a and 11c). In many thin sections, biotite crystals are oxidized form. The inclusion of the quartz magnetite and hornblende crystals are common in the coarse grained crystals of biotite minerals (Plate-10a, 11a).

**Chlorite**

It is an alteration product of primary crystallizing mineral of biotite and hornblende. It is present in patch masses around the biotite and hornblende crystals. Chlorite pale green in colour but feebly pleochroic (pale green to darker green). In this section chlorite is present in small irregular flakes and laths.

**Pyroxene**

It is medium to coarse grained euhedral, mineral. Pyroxene is distinguished other minerals on the basis of high relief (Plate 17b) and cleavage angle associated with hornblende.
Actinolite

Colourless to pale green in thin section (Plate-9a). Pleochroism usually observed from yellow to green. Typical amphibole cleavage, 56° to 124°, two set cleavage texture are present in actinolite minerals. It is altered product of hornblende.

Magnetite

It is present in subhedral to anhedral in shape, medium to fine grained. They are present as accessory minerals of this rock. Magnetite minerals are black in colour, some places present in form of solid inclusion in biotite, hornblende crystals.

Calcite

Calcite euohedral in shape, fine to coarse grain aggregates. The calcite crystals are colourless to grey in thin section. The twinning is common in the calcite crystals. It altered product in amphibolites.

Epidote

In the thin section, the epidote minerals are present in the form of vein. It is also found as granular aggregates. They are high relief, colourless usually the secondary alteration product (Plate-14a) of plagioclase.

3.2 GRANITOIDS :

On the basis of field relationship, mineral compositions, textural and structural studies following type of granitoids have been obtained in the study area viz. (1) biotite granite (2) hornblende granite (3) grey granite (4) leuco granite (5) fine grain granite

Megascopically, the granite of the investigated area varying in grain size from coarse to fine grained. The porphyries of feldspar are very frequent in fine grained leucogranite rock. The leucogranite contains feldspar, quartz, biotite and rarely amount of hornblende. At some places, of granite rock contain perfect two sets of jointing and fractures. The deformed granite bands contain quartz feldspathic masses and show preferred orientation where alternate of ferromagnesium mineral band in biotite rich variety. At places, bands of mica are contain wearing and waxing pattern
along the foliation planes of quartzofeldspathic masses. Leucogranite rocks are coarse to fine grained. They are holocrystalline, equigranular hypidomorphic in texture. In many thin sections leuco granite shows porphyritic texture. The minerals constituents of granitoids are as follows

(1) predominant: quartz, feldspar minerals

(2) accessory minerals: biotite (rare), hornblende, zircon, allanite and sphene, magnetite

(3) secondary minerals: epidotes, chlorites, sericite

3.2.1 Biotite Granite:

Orthoclase

It is one of the predominant mineral of biotite-granite rock. Orthoclase minerals are medium to coarse grained in thin section. They are euhedral to anhedral in shape. It shows the intergrowth of microcline (hair like) crystal. The core of orthoclase formed perthite texture that is followed by plagioclases crystal. The orthoclase are usually found to alter in sericite minerals. The phenocrysts of fresh and unaltered characters of feldspar (Orthoclase) are also observed in few sections, they show Carlsbad twinning, low relief.

Microcline

Microcline is fine gained, euhedral to anhedral in shape. Cross hatched twinning are well developed in microcline crystals but some places of microcline crystals alteration shape from orthoclase through microcline crystals are formed. At some places microcline-perthite is also recorded. In plane polarized light cross hatched twinning are common feature of microcline minerals.

Quartz

Quartz is also one of the predominant minerals constituent of granite. It occurs as coarse to fine grained in shape, anhedral crystals. Quartz is characterized by low relief, undulose extinction but less altered minerals. The undulose extinction due to the strain effect is noted in few sections.
Biotite

It is coarse to medium grained, tabular crystals, perfect one set of cleavage are present in biotite crystals (plate-12a). Two types of biotite crystals are present in thin section. The biotite are brown in colour but some places they are green in colour. Pleochroic holoes was absent in biotite of this granite. The biotite is alloay than hornblende.

Hornblende

In thin section hornblende crystals are occurs rare or nearly absent. Hornblendes are medium to fine grained by euhedral prismatic crystals. They are light green in thin section. They shows the light green to dark green pleochroism and second order interference colour. In many of the thin section hornblende crystals of two set perfect cleavages are present.

Zircon

Zircon crystals are present in the form of inclusion in biotite granite. It is usually small prismatic crystals. They distinguished other on the basis of high relief, parallel extinction and absence of cleavages.

3.2.2 Leuco granite :

Megascopically, the granites of the investigated area are fine to coarse grained. The leucogranite are grayish to grayish pink rock. These rocks are hard and compact in nature. The large amount of phenocryst of feldspars is very frequent in the coarse grained leuco granite. The feldspar, quartz, biotite, magnetite are assececeory minerals and visible in the handspecimen. The hornblende crystals are rarely observed in leucogranite. Microscopically all these rocks are characterized by coarse to medium grained in texture. They are halocrystaline, equigranular, hypidiomorphic to allotriomorphic in texture.

Biotite

Biotite is medium to fine grained, light brown in colour, but the few crystals of biotite show the pleochroic holoes. Some time biotite also contains magnetite zircon.
Plagioclase

Plagioclase crystals are medium to coarse grained. They are subhedral in shape. It gives the lamellar twinning. Plagioclase feldspars are rare. At many places antiperthite texture are developed the contact of orthoclase crystals. At one places I have seen plagioclase feldspar. Some places orthoclase feldspars are altered to form the albite. The twin lamellae of albite are observed.

Quartz

Medium to coarse grained grains are euhedral in shape, colourless in thin section. Quartz is characterized by low relief, sharp extinction and less alteration. At places quartz show undulose extinction due to strain effect. It also observed as inclusion in feldspar, biotite, magnetite.

Hornblende

The hornblende shows light green in colour. Medium to fine grained texture. The hornblende shows the characteristic pleochroism of greenish brown to light green in colour.

Zircon

It is occasionally found as inclusion in the biotite and hornblende crystals. It is present in the form of pleochroic holoes in biotite and hornblende. Zircon is look like minute small prismatic crystal. They are low relief, and gives parallel extinction, no cleavages are present in the biotite crystals.

Magnetite

Magnetite is euhedral to anhedral in shape. They are low relief, non pleochroic, dark black in colour, no cleavage are present in the magnetite crystals. At many thin section of leucogranite rock magnetite are included in the biotite, hornblendes and quartz crystals.

3.2.3 Grey granite:

Grey granite is of dark grey coloured rock with massive fabrics. The pegmatite veins are present in grey granite rock. The weathered surface of granites forms thick alternate bands of light and dark coloured minerals. Chlorite is also present at the margin of biotite at its contact with plagioclase in the deform granite.
The granite is characterized by K feldspar, quartz, biotite, hornblende, magnetite with small amount of apatite and retrograded chlorite. The granites are dominated by minerals hornblende, zircon, chlorites, biotite, quartz, and plagioclase. Small amount of rutile, magnetite, actinolite and epidote are present.

Biotite

It is observed as coarse to fine, subhedral crystals. Coarse grained flakes of biotite show pleochroism from dark pale greenish, yellow to brown, dark brownish yellow. The parallel orientation of biotite defines the schistocity of foliation. Biotites are crystalised in two generations. The biotite of the first generation is characterized by xenoblasts. The biotite of first generation is characterized by brown to dark brown pleochroism while the biotite of later generation is light yellowish green to dark greenish brown and occurs as subidioblastic crystals. Inclusion of hornblende and quartz are present. pleochroic haloes are present in biotite crystals.

K-feldspar

Medium to coarse grained quartz crystals. At many places orthoclase is altered and form sericite minerals. Orthoclase is present in hair like structure and developed the irregular stringers of sodium rich feldspar and potassium rich feldspar. Minning of these feldspar developed the microperthite texture (Plate-12c). The subhedral to enhedral crystals of orthoclase contain the inclusion of hornblende and magnetite.

Microcline

Medium to fine grained crystals of microcline are present in grey granite rock. They are least predominant mineral constituent of this granitic rock. They are differentiated on the basis of cross hatched twinning (Plate-12c). Microcline mineral are euhedral to anhedral in shape crystals but at some alteration from orthoclase through microcliniation is also recorded (Plate-12a).

Magnetite

Medium to fine grained crystals of megnatite are present in euhedral shape. Magnetite are included in the hornblende and orthoclase crystals.
Hornblende

Hornblende crystals are coarse grained, strongly pleochroic (paleogreen to straw yellow or greenish below in colour). Magnetite crystals are present in the form of inclusion. Two set of cleavage are present in the hornblende crystals (Plate-9c). The hornblende minerals are present as one accessory minerals of which is usually present as xenoblastic form and associated with biotite and magnetite in the matrix of quartz.

Quartz

Medium to fine grained crystals of quartz are present in the grey granite. The coarse grained crystals of quartz are arranged to the foliation plane. It shows the wave extention. Magnetite crystals are included in quartz crystal.

3.2.4 Pink granite :

A coarse grained pink granite is one most dominant rock type in the study area. Pink granite is usually compact and massive in nature. The pink granite rock contains pink colour of feldspar crystals and grey colours of plagioclase crystals. NE-SW trending pegmatite veins have been found intrusive in the pink granite, which are devoid of muscovites but contains the biotite coarse grained (20cm x 15cm size), feldspar crystal, quartz (10cmx5.5cm size). The deformed pink granite rock comprises epidote as vein. Medium to coarse grained pink granite at places contains porphyroblast of hornblende and feldspar. The pink granite is also characterized by perthite texture, mymekte texture. Sphere is very common mineral and is present in large amount. Magnetite crystals are found to develop along the cleavages of hornblende crystal (Plate-10B). The pink granite consists of potash feldspar, perthite, quartz, hornblende, magnetite, sphere, rutile, hercynite, zircon, allenite, chlorite, epidote and apatite. The biotite mineral is not common in pink granite of Mahoba. The hornblende is always find greater than biotite. The microcline is greater than orthoclase.

Hornblende

The coarse grained hornblende shows strong pleochroism (pale green to strong yellow or greenish blue in colour). The medium grained hornblende contains more
magnetite crystals. The core part of the hornblende contains small granules of magnetite (Plate-15a). Sometimes hornblende alteration into chlorite have been noted. Augite crystal is surrounded by hornblende. The presence of xenoblastic type texture of hornblende is also noted in few granite where the biotite and hornblende both are found as inclusion in coarse crystals of hornblende.

**Chlorite**

The chlorite is medium to coarse grained light green in colour usually intermingled with biotite. Fine grained magnetite is present along the prismatic cleavage of the chlorite. It shows usually pale green and pleochroic in thin section.

**Biotite**

Biotite is not very frequent and low in compare to hornblende. Most of the biotite crystal are oxidized form. The exsolved texture of in biotite is very common (Plate-16a ). The biotite crystals are altered and formed the chlorite mineral. At many places the magnetite crystal are present at the cleavages of biotite crystals.

**Quartz**

Euhedral to anhedral in shape, colourless in thin section, without cleavage characterized by first order grey interference colour. Quartz crystal shows the straight extension. They are coarse to medium grained in thin section.

**Orthoclase**

Orthoclase minerals are medium to coarse grained and one of the dominating mineral in this rock. They are colourless low relief minerals Orthoclase minerals are euhedral to anhedral in shape. Orthoclase minerals show the hair like structure perthitic texture is form.

**Microcline**

Microcline is one of the important assecceory mineral of the pink granite rock. These mineral are colourless in thin section, euhedral to anhedral in pink granite. Low relief mineral and no cleavage in microcline is visible. The characteristic feature of this mineral are cross hatched twinning (Plate-15c).
Plagioclase

They are colourless in thin section, euhedral to anhedral in shape. Plagioclase crystal shows the lamellae twinning. Plagioclase mineral contain the inclusion of biotite and magnetite, hornblende mineral. The plagioclase lamellae are very thin. The interference colour is mostly first order grey in plagioclase. The plagioclase noted saussaritized (Plate-15b).

Albite

Medium to coarse grained. Albite may differentiate to plagioclase albite mineral show thin lamellae. Albite minerals shows the grey first order interference colour. Albite are low relief mineral (Plate-15c).

Magnetite

Medium to fine grained in thin section. Magnetites are present in the form of inclusion as well as parallel to the cleavage. Magnetites are the opaque, euhedral to anhedral in shape mineral. Magnetite is formed around the reaction rim of biotite crystals (Plate-17a).

Zircon

Zircon is only present in biotite mineral in the form of pleochroic holoes (Plate-5c). But many places large crystal of zircon are also found (Plate-16c).

Sphene

Sphene is usually euhedral in shape, light brown in colour (Plate-16c), feeably pleochroic mineral. The cleavage are seldom and obvious in thin section. They are appeared as secondary product which was formed by the alteration of biotite mineral.

Ilmenite

Ilmenite are deep red in thin section. In the thin section ilmenite are anhedral and long rectangular outline. At some places ilmenite are altered and formed leucoxene. Leucoxene is a fine grained aggregates.
3.3 QUARTZ REEF:

The NE-SW trending quartz reef is the most spectacular land marks geological feature massif of the Bundelkhand. In the study area many places quartz reef cut across the granitoids and gneisses rock. At many places the quartz reef are sinistrally displaced. The two set of joints and tension joints are present that reflects the late tectonic activity in the quartz reef. Megascopically quartz reef show dominantly grayish white colored but the pinky white, milky white colored reefs are also present. They are hard, compact massive in nature. Series of milky white secondary veins of quartz traverses the greater part of quartz reef. Under the microscope quartz reef represents the very coarse grains of quartz and feldspar. The quartz reef shows the varied texture and large rectangular grains of quartz with straight borders and undulose extinction. Feldspar, magnetite and chlorite are also observed in thin section of quartz reef. Epidote veins are also observed in the thin section of quartz reef. The microcline is medium to coarse grained, colourless to cross hatched twinning are common, altered to fresh in thin section. Quartz crystals and series are common inclusion in microcline minerals. Quartz, sericite and opaque are present along the fracture plane.

3.4 DOLERITE DYKES:

The ENE-WSW trending great Mahoba dyke passes from the Mahoba town and is about 11kms in length. Dolerite dyke is also exposed at Thana. Megascopically dolerite is dark green or melanocratic in colour, hard and compact in nature. Prismatic crystal of pyroxene an orthopyroxene can be identified in hand specimen but at places grayish white leucocratic band and streaks (patches) of feldspar are also recognized.

Microscopically sub-ophitic texture is common in most of coarse and medium grained variety of dolerite dyke (Plate 17c) the following minerals are identified.

- Pyroxene, orthopyroxene (hypersthene) and clinopyroxene (augite) and plagioclase feldspar are present as essential.
- Mineral while magnetite, hornblende are present assecceory
- The secondary minerals are mostly epidote quartz, chlorite in dolerite dyke.
Clinopyroxene (augite)

Augite crystals are euohedral to anhedral to anhedral in shape. It shows the light green, colourless and short prismatic crystals. Augite crystal gives high relief, second order interference colour, high extension angle mineral. At many places the plagioclase (labradorite) crystals are embedded in the augite crystal. They form the ophitic texture (Plate 18a ). According to the thin section of dolerite dyke the clinopyroxene crystals are less altered in comparison of plagioclase crystals.

Plagioclase

Plagioclase is colourless, observed as long as laths of euohedral to anhedral crystals. The anhedral crystal is often large as compared with those of other plagioclase. It shows the polysynthetic twinning, low relief and also shows the higher extinction angle. The labradorite crystal is embedded in clinopyroxene crystals (Plate 18b). The plagioclase grains are twinned and saurriticised, saussuritised plagioclase mineral gives the epidote and quartz crystals.

Magnetite

Magnetite crystals are dark black in colour, course to medium grained in thin section. The magnetite crystal are found along the cleavage plane of pyroxene crystals.

Epidote

Epidote is present as the secondary product which is formed by the saussssoricitisation of plagioclase feldspar minerals. It is an observed as granular aggregates. Epidote is mineral of high relief, colourless in plane polarized light but under cross nicol, the epidote minerals shows second order interference colour.

3.5 MYLONITISED ROCKS:

Recrystallised protomylonites, ultramylonite and mylonite phyllosite rocks have been observed at many place. Hanuman temple and Nauranga, Chando near the Bijnagar Sagar dam. The well developed S-C mylonite are present in the pink granite rock where basic rock emplaces along E-W trending dolerite rock. They have been
found to medium to fine grained but at places coarse grained variety also observed. These rocks have diverse physical appearance texture and mineral composition. Four type of deformed mylonites have been observed at Mahoba area (1) protomylonites (2) ultramylonites (3) mylonite and (4) phyllonites. Megascopically they show medium to fine grained where quartzo feldspathic masses quartz, feldspar and flakes have developed and rotated (Plate ). Mesoscopic shear also developed in mylonite and ultramylonite. Following mineral assemblage have been identified:

**Chlorite**

Chlorite is medium to fine grained, xenoblastic to subhedral in the mylonite. The elongated scally crystals of chlorite are weakly pleochroic. The chlorite are light green in thin section and due to the alteration of hornblende. Medium grained garnet has been found in the matrix of chlorite.

**Actinolite**

Actinolite crystals are fine grained, light green in colour fiberous aggregates of actinolite is generally oriented with in the schistosity plane.

**Quartz**

Quartz is medium to coarse grained crystals, anhedral but elongated in thin section. Quartz crystals are colourless, low relief no cleavage highly elongated are present in thin section of quartz crystals. The aggregates of quartz crystals are observed around the mylonite planes. They have commonly shows the undulose extinction due to the higher strain effects. Coarse grained crystallized crystals of quartz are observed in thin section of mylonite rocks which shows ribbon texture.

**Orthoclase (K-feldspar)**

Mostly euhedral to anhedral elongated and fractured, medium to coarse grained crystals of orthoclase and microcline are present in thin section of mylonitic rock. Both of the orthoclase microcline minerals are colourless and low relief minerals in thin section. In the thin section of the orthoclase crystals at many places the phenocrysts of orthoclase are rotated which indicates the sense of shear. Allowed K-feldspar changed to microcline.
Plagioclase

It is observed as medium to fine grained crystals. At many places the magnetite crystals are embedded in the plagioclase crystals. In the thin section of plagioclase crystal alteration in to epidotes & services feldspar are also recorded. Plagioclase crystals are the lamellae are very thick and thin. The thin lamellae of plagioclase defined the development of albite crystals.

Garnet Medium to coarse, ideoblactic crystal of garnet have been formed in the matrix of chlorite matrix. They are usually in granular aggregated devoid of any inclusion. The EPMA analyses showed high MNO. The aoperstite types garnet has been first time reportion from any shear zone of Mahoba area. The recrystallized plagioclase and crystallized suggest that mylonite were recrystallized at 320°C, 2-3 Kbar P-T condition.
1a: Biotite Gneisses rock of Lodha pahar where the fine grained magnetite are aligned along the cleavage as well as boundary of biotite crystal.

1b: Biotite crystal are aligned along the S1 and S2 schistosity plane.

1c: Coarse grained crystals of biotite and magnetite are aligned along the gneissosity.
2a: Thin section of Biotite gneisses where the fine grained of magnetite are present at the boundary of biotite crystal.

2b: The biotite crystal are break along the cleavage plane and reactive with magnetite and quartz form the silliminite crystal.

2c: Biotite minerals are aligned along the gnessosity plane. Biotite are break along the cleavage plane and form radiating pattern of silliminite.
3a: Alteration of biotite and formation of sillimanite crystals. No cleavage are present in biotite.

3b: Biotite sillimanite gneisses, the sillimanite occurs in radiating pattern and also along the cleavage of biotite.

3c: In the biotite gneisses rock, biotite minerals altered along the cleavage plane and form the chlorite minerals.
4a: The thin section shows the exsolved texture and formation of chloride. Medium grained of muscovite and elongated crystals of apatite are present in the biotite gneisses.

4b: Thin section shows the alteration of biotite along the cleavage plane, react with magnetite and quartz and form the radiating pattern of sillimanite.

4c: Sillimanite rim are formed around the coarse grained crystal of magnetite. Orundum are also present in the thin section.
5a: Radiating pattern of sillimanite are formed by the biotite and coarse grained of magnetite.

5b: Zircon occurs in abundant in the altered biotite gneisses rock.

5c: Zircon are present in the form of pleochroic hallows in biotite.
6a: Zircon and biotite are aligned along the gneissosity plane, coarse grain of quartz crystal are also present.

6b: Two colour of biotite green and yellow, the biotite crystal are breaked along the cleavage plane. Biotite minerals goes to reaction.

6c: Coarse grained garnet crystal. Biotite crystal are aligned along the gneissosity plane.
7a : Radiating pattern of sillimanite are formed by the biotite mineral.

7b : Coarse grained crystal of zircon, which is surrounded by the biotite crystals. At one place Zircon and biotite shows the corone texture.

7c : Biotite gneisses, biotite crystals are aligned along the gneissosity plane. Coarse grain crystals of apatite are also surrounded by biotite crystal.
8a: Coarse grained crystal aligned along the S1 sition is present. One set of cleavage in biotite crystal. They are aligned along the sistocity plane. The coarse grained crystal of apatite are surrounded by the biotite crystal.

8b: Idiomorphic coarse grain Hornblende crystals . the chloritization takes place along the cleavage plane of hornblende crystal.

8c: Thin section shows the hornblende react with the magnetite and quartz crystal and form the Cpx minerals.
9a: Coarse grained crystal of hornblende and magnetite and amphibolite rock

9b: Coarse grained crystals of hornblende magnetite and quartz crystal along the gneissosity plane.

9c: Twin perfect two set cleavage in hornblende. The hornblende crystal are altered in cleavage plane and form the actinolite and chloride crystal.
10a: Coarse grained hornblende crystal are surrounded by the medium grained magnetite crystal. No cleavage are present in hornblende crystal.

10b: Coarse grained hornblende and biotite crystals aligned in S2 plane from the biotite bearing amphibolite.

10c: Thin section shows the two colour of biotite crystal, light green and light brown. They are aligned in gneissosity plane. The hornblende crystal doesn't show any cleavage.
11a: Coarse grained of hornblende and magnetite are aligned in the gneissosity plane. The hbl and magnetite and quartz react and form the Cpx minerals

11b: Hbl-Opx-biotite-plagiclase-Kfs+quartz-magnetite

1lc: Coarse grained of hornblende and quartz crystal are aligned in the gneissosity plane.
12a : All the crystal are aligned in the gneissosity plane the coarse grained of Sphene and altered orthoclase are present.

12b : Coarse grained crystals of rutile and silliminite magnetite are present in

12c : Thin section shows the crystal of hbl and orthoclase quartz microcline magnetite are aligned in the direction of gneissosity plane. The quartz is leeser than the orthoclase crystals.
13a: Gneisses rock with Sillimanite and biotite

13b: Thin section of biotite schist. The coarse grain of magnetite also present.

13c: Coarse grained biotite are present in the thin section of schist rock. The magnetite crystals are present at the boundary of biotite.
14a: Biotite crystal are aligned along the s1 sistrosity plane. Secondary phase of epidote vein are developed in the biotite crystals.

14b: This section shows the evolved texture in the biotite. The rim of sillimanite is formed around the coarse grain of magnetite. Pleochroic hallows are present in the biotite crystal.

14c: Relict of the biotite in hornblende granite.
15a: Coarse grained crystal of orthoclase and microcline and hornblende and biotite are present in granite.

15b: Coarse grained crystal of orthoclase are serisitized and perthite texture are also present.

15c: Thin section shows the reaction rim of sillimanite around the biotite crystal.
16a: Coarse grained of biotite and quartz and orthoclase are present in granitic rock.

16b: Coarse grained crystal of leucite is present in pink granite rock. The biotite crystal are present at the boundary of leucite crystal. This crystal is highly fractured.

16c: Coarse grained of sphene and biotite are present in granitic rock.
Amphibolitic rock and also coarse grained Cpx and amphiboles are present in the thin section.
Amphibolitic rock and also coarse grained Cpx and amphiboles are present in the thin section.