4

PETROGRAPHY

PETROGRAPHY

GENERAL

A critical evaluation of the petrographic characters of the various rock types has led to a complete reinterpretation of metamorphic and igneous events of the area. The texture and mineral assemblage of the metasedimentaries, basic rocks and granites, have enabled the author to throw new light on the geological evolution of this area. In the following pages, a systematic account of the various microscopic characters of the different rock types has been given.

PELITIC MEMBERS

The majority of the metasedimentary rocks are represented by this group, This group comprises cordierite -garnet (almandine)-sillimanite gneissic granulites, cordierite - biotite -gneisses, biotite gneisses.

Cordierite- garnet (almandine) - sillimanite gneissic granulites

These rocks are medium to coarse grained in nature. The dominant constituents are cordierite, almandine, (garnet) along with sillimanite, quartz, k-felspar, biotite, hypersthene, spinel, rutile, ilmenite, graphite. Under microscope these rocks exhibit granulitic to gneissic textures.

Cordierite forms colourless crystals with irregularly elongated grains conformable with foliation. They have vaguely defined boundaries and usually form more than 25% of the rock. In some cases poikilitic grains contain inclusions of quartz, k-felspar, biotite and garnet, spinel. It exhibits customary pleochroic haloes and is optically (+)ve . The swirling mats of acicular sillimanite of microscopic scales form inclusions in the core of some cordierite grains. (Plate IV.1). Polysynthetic (Plate IV.2) as well as sectoral twinning (Plate.IV.3) is shown by few cordierite grains.

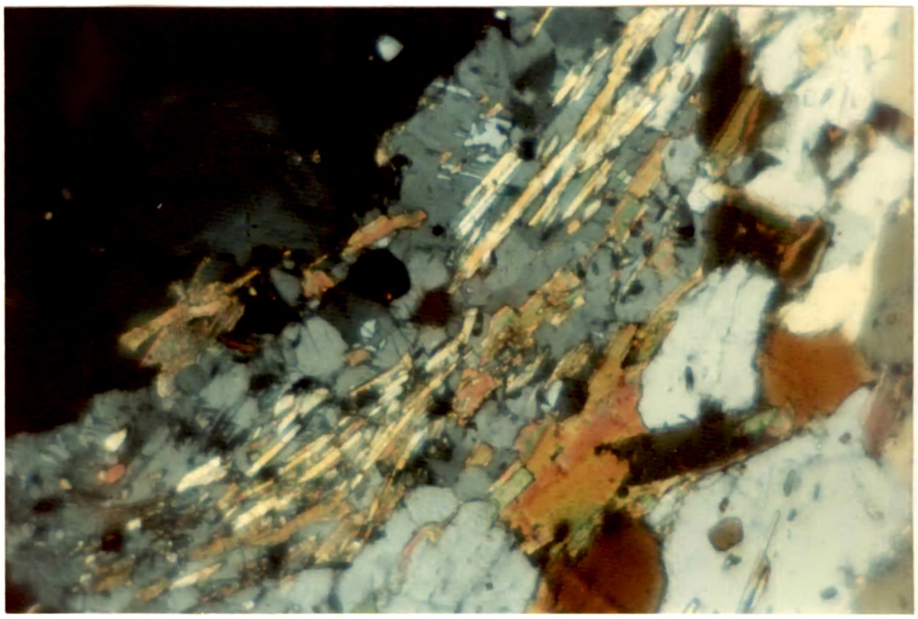

Plate IV.1 Swirling mats of acicular sillimanite within the cordierite in cordierite garnet sillimanite gneissic granulites (XN, X70).

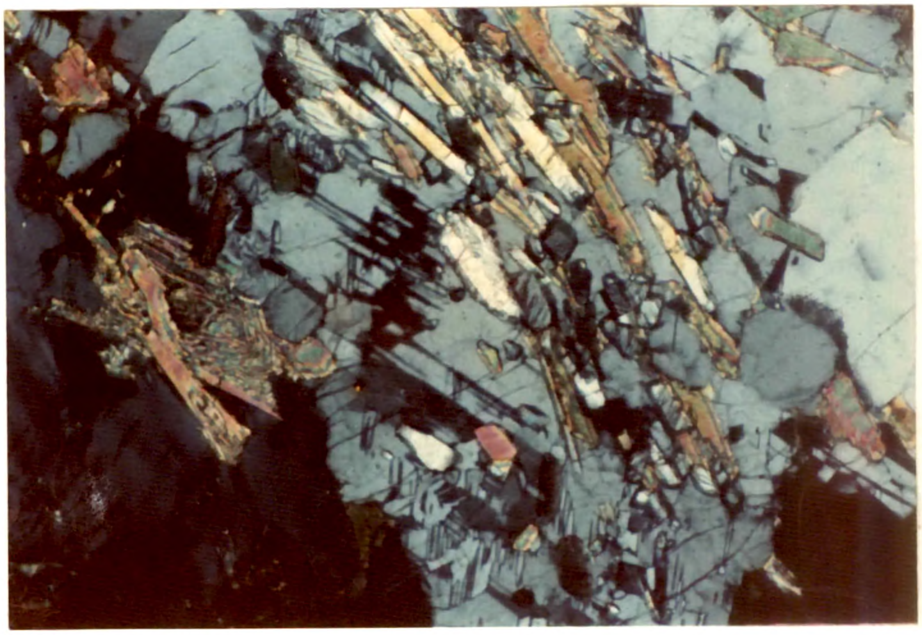

Plate IV.2 Cordierite showing polysynthetic twinning in cordierite - garnet - sillimanite - gneissic granulites (XN, X70).

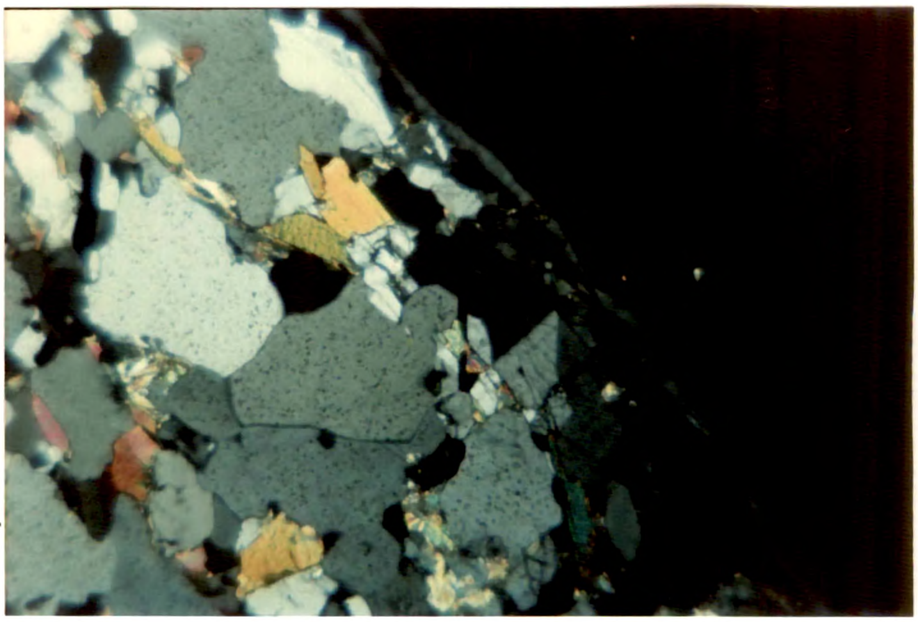

Plate IV.3 Cordierite exhibiting sectoral twinning in cordierite - garnet - sillimanite - gneissic granulites (XN, X70).

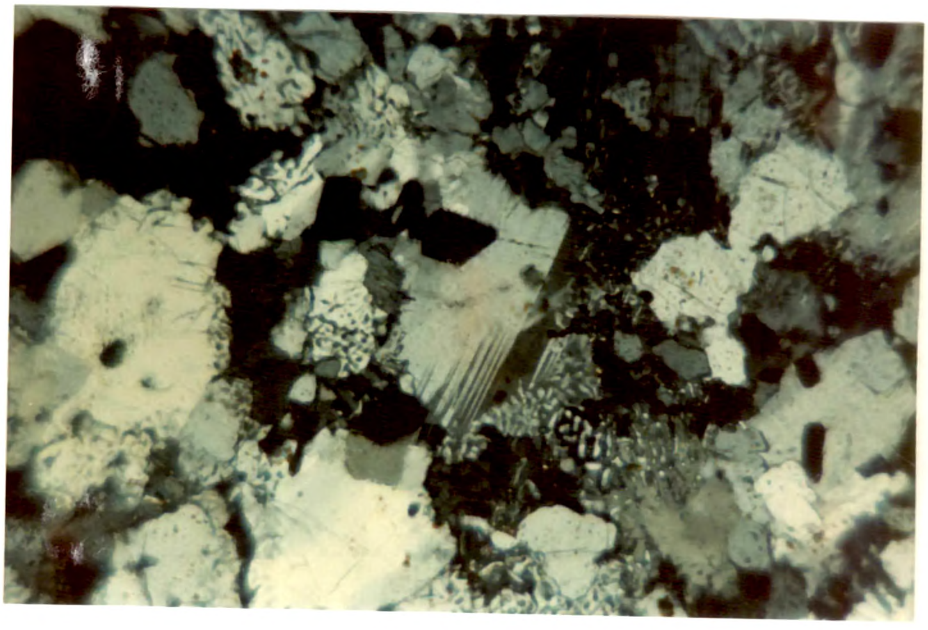

Plate IV.4 Photomicrograph showing symplectite structure along the fringes of cordierite - quartz (XN, X70).

Cordierite alters to various minerals especially along grain borders and cracks within grains. The common alteration product is fine green or yellow mica (pinite). In some cases the alteration to pinite extends across the grain living a few remnants of unaltered cordierite. In few grains randomly oriented rutile needles are observed. It is noteworthy that along the boundaries of cordierite and quartz, symplectite structure is seen (Plate IV.4), which is common in cordierite granulites reported from different parts of world.

Almandine (garnet) which has characteristic mauvish pink colour in hand specimen, is pale pink to colourless in thin section. It remains completely isotropic under crossed nicols. It occurs in varying sizes e.g. irregular rounded elongate parallel to foliation and is much cracked. The cracks being either irregularly distributed or transverse to the elongation. It is nearly poikilo porphyroblastic with inclusions of quartz, felspar, biotite, sillimanite, graphite, zircon (Plate. IV.5). Garnet may be concentrated in bands or scattered through the rock and often forms the major constituent by volume. The occurrence of sillimanite inclusions in garnet and cordierite may suggest that this metamorphism has taken place within the stability field of the sillimanite, Fareeduddin et al., (1991).

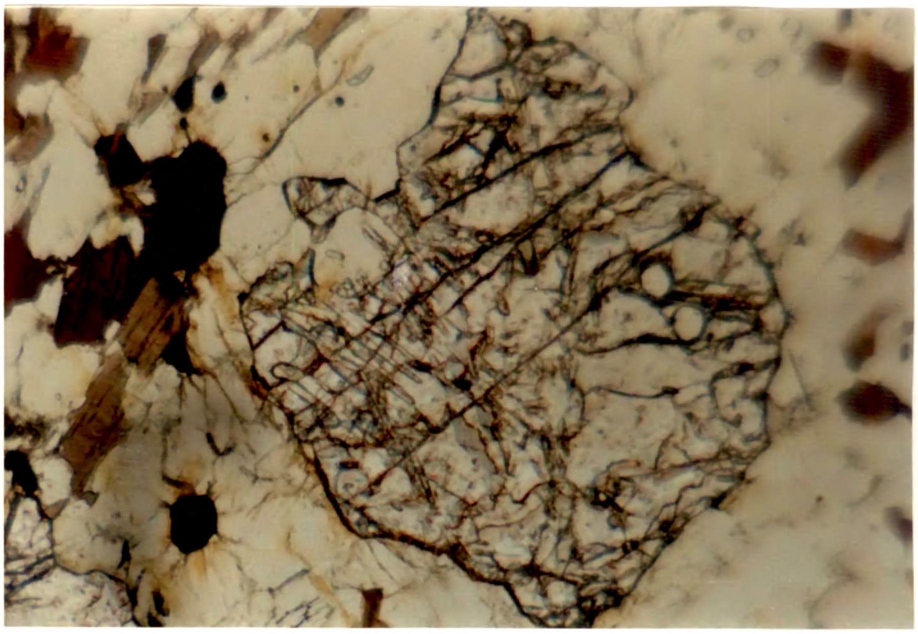

Plate IV.5 Photomicrograph showing poikilo-porphyroblastic nature of almandine (garnet) (PPL, X70).

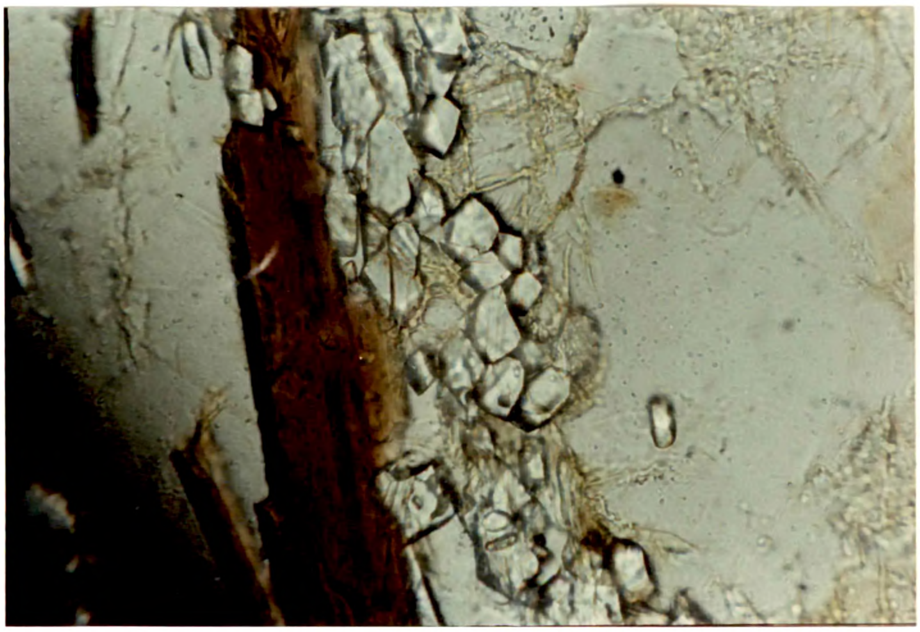

Plate IV.6 Sillimanite showing well developed basal parting (PPL, X).

Sillimanite exhibits two textural varieties. One variety consists of well developed acicular crystals with easily discernible basal parting occurring predominantly within cordierite (Plate IV.6). The second variety of sillimanite consists of mats of fine grained fibrolite within and between crystals of cordierite. The occurrence of fibrolite in and around cordierite is most prominent near contacts with k-felspar.

Quartz is either clear or with a few small patches of dust like inclusions. It generally occurs in several sizes, but mostly as elongated bodies parallel to the banding or small irregular grains in the quartz felspar mosaic. Frequently quartz also occurs as constituent of myrmekite or intergrown with garnet in porphyroblasts.

Alkali felspar mostly perthitic is commonly concentrated in layers and gives the rock a gneissic appearance. Most of this felspar forms untwinned to patchily twinned grains. In some of the section microperthitic felspar occurs, while in some cases orthoclase (extinction angle about 6^{o}) or microcline is observed. In one case k-felspar shows both twinned and untwinned grains (Plate IV.7). Elongate grains are parallel to foliation and anhedral grains form quartz felspar mosaic and the amount of kaolinisation is variable.

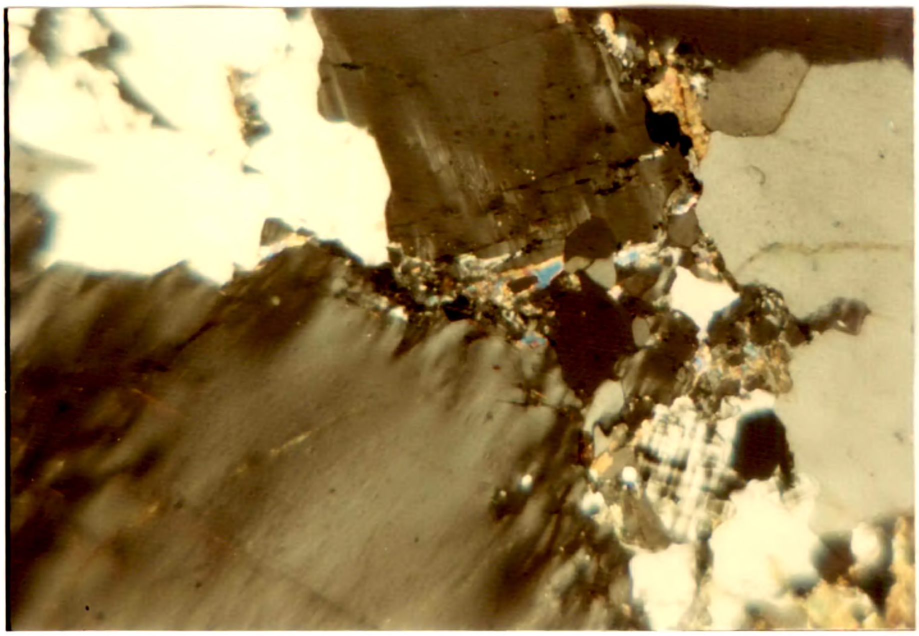

Plate IV.7 Felspar showing twinned and untwinned grains in biotite gneisses (XN, X70).

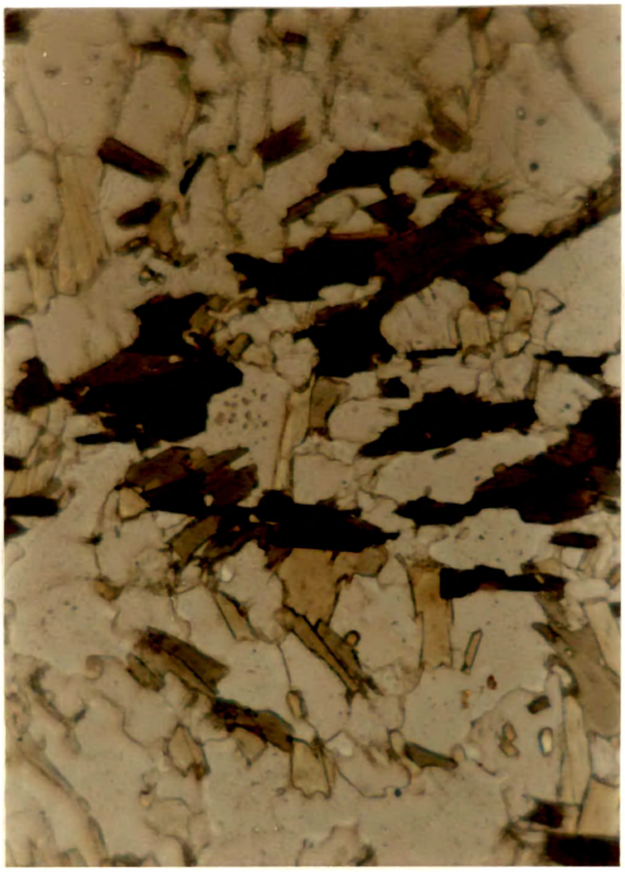

Plate IV.8 Photomicrograph showing biotite developed across the foliation (PPL, X70).

Biotite is associated with garnet and sillimanite and occurs mainly as small well oriented flakes with pleochroism x = pale yellow or colourless, Z= dark brown or reddish brown. Pleochroic haloes around zircon are common. Biotite laths often continue in the same orientation through porphyroblastic garnet, cordierite, microcline etc. and biotite clearly replaces either garnet or cordierite. The biotite laths cut across the above minerals and the abundance of biotite in these rocks led the author to believe that these biotite laths may be of later generation (i.e. connected with retrogression and granitisation), Foxy red biotite (II) occurs across the foliation. This biotite appears as a late phase (Plate IV.8) and it is rich in Fe-Ti oxide. It is often developed along plate fractures or as symplectite fringes intergrown with quartz, Nambiar et al., (1992) has reported such biotite flakes across all other mafic minerals indicating their late formation.

Hypersthene is aluminous in nature and feebly pleochroic (light pink to light green) and often forms either large tattered plates which are often sieved with inclusions of quartz or biotite and iron ores or small anhedral grains. The aluminous hypersthene is also reported by Desai et al., (1978) from Balaram - Abu Road and Devaraju & Sadashivaiah (1975) from Satnur - Halguru area of Karnataka.

In these rocks, spinel occurs as small green anhedral grains and is the most prominent accessory. It occurs in the groundmass or as inclusions in cordierite and/or garnet and altered plagioclase.

Graphite occurs in few sections as irregular opaque flakes with ragged edges, skeletal growths are also present. Zircon is always present in small well rounded grains and is often colourless and enclosed in biotite and garnet.

Iron ores are present in the form of ilmeno-magnetite patches of leucoxene with plates and strips of magnetite.

It is significant to note that various rock types of the pelitic members show variation in both textural characteristics and mineralogical assemblages. In granulites proper, the k-felspar is invariably perthitic and there is little variation of cordierite and garnet. The presence of rutile needles as well as granulitic texture (i.e. elongated quartz, felspar, cordierite etc.) point to their formation under granulitic facies metamorphic conditions. The mineral assemblages synchronising with amphibolite facies and metasomatism caused more development of biotite at the expense of cordierite, almandine and hypersthene. As a result of more biotite and quartz assemblages, these rocks assume more gneissic appearance (Plate IV.9) and therefore show

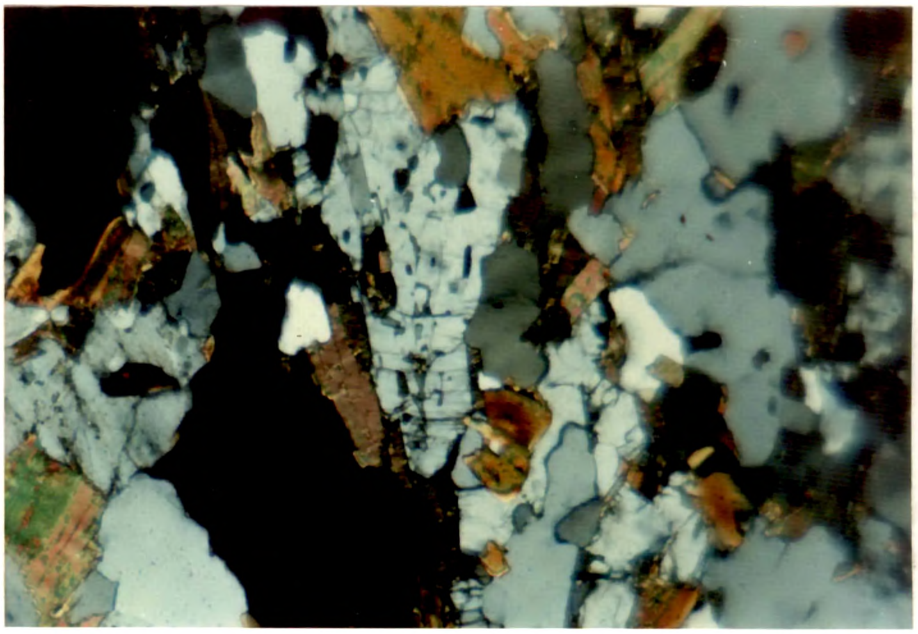

Plate IV.9 Photomicrograph showing gneissic bands with increase of quartzofelspathic material (XN, X70).

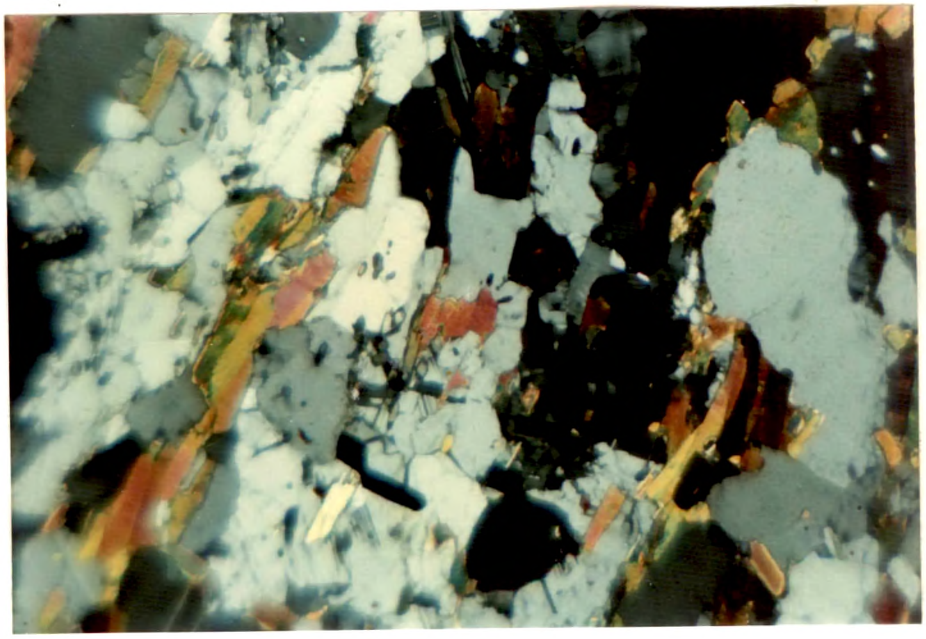

Plate IV.10 Photomicrograph showing abundance of biotite and k-felspars (XN, X70).

more folding alongwith quartzofelspathic bands. Within these rocks, the marginal presence of rutile needles and the relict high grade minerals indicate that these rocks once belonged to granulite facies conditions.

The biotite gneisses, which the author thinks to be the ultimate product of the granitisation is completely devoid of original high grade minerals mentioned above. They show abundance of biotite and felspars (k-felspar and plagioclase) (Plate IV,10).

This association of rocks containing diverse mineral assemblages indicates that they correspond to pyroxene -granulite subfacies, hornblende -granulite subfacies and almandine - amphibolite subfacies of regional metamorphism. This aspect is discussed further in chapter VI.

CALCAREOUS MEMBERS

This group includes mainly calc granulites, calc gneisses and marbles. The calc granulites vary in appearance from dark greenish to dark green, medium to fine grained in nature and are generally recognisable by their rusty weathered surfaces. They are invariably composed of diopside and scapolite. Calc gneisses are light grey to green in colour and medium grained equi granular rocks. The main constituents are calcite, diopside and quartz, k-felspar (microcline). Marbles are exposed as lenses within calc granulites and comprise calcite, forsterite and dolomite. Sphene and phlogopite occur as accessories (Plate IV.15).

With increasing proportion of quartz, microcline and plagioclase felspars, this rock assumes more gneissic appearance and has been termed as "Calc gneisses" (Plate IV.11) and they contain more of sphene, tremolite and less diopside as compared to calc granulites.

Calc granulites

Calc granulites are characterised by the presence of diopside, scapolite, wollastonite and/or plagioclase with minor amounts of calcite, sphene and sulphide ores.

These rocks are medium to coarse grained and show parallel arrangement of constituent minerals in the form of layers with varying richness of diopside. Otherwise they are massive showing granoblastic texture (Plate IV.12).

Diopside forms large anhedral grains with rounded ragged margin and is pale green or colourless. The pale green colour is indicative of higher iron content. The mineral shows good prismatic cleavage and the common alteration products are sphene and iron ores. Most of the grains show extinction angle between 35° to 37°.

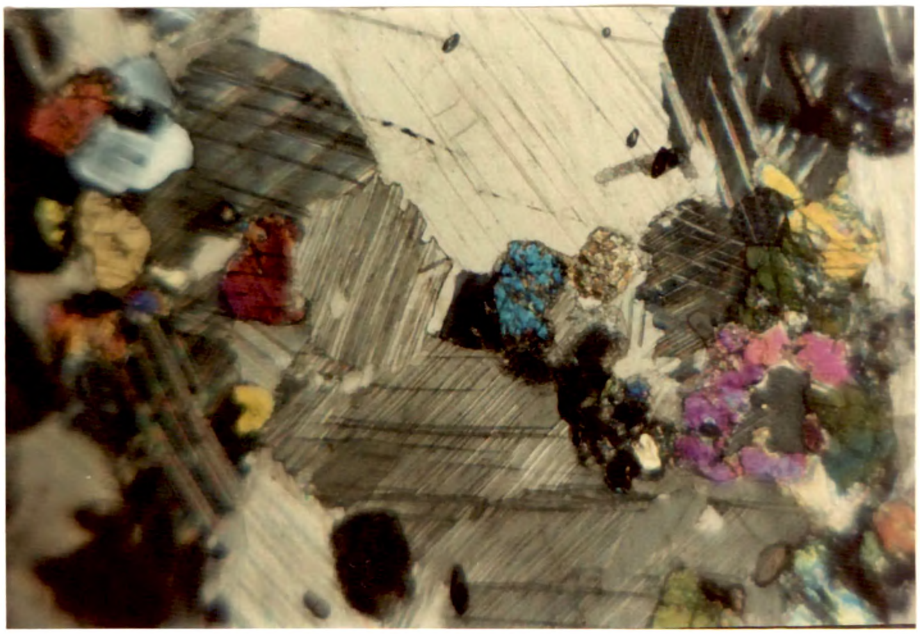

Plate IV.11 Textural characteristics of calcgneisses (XN, X70).

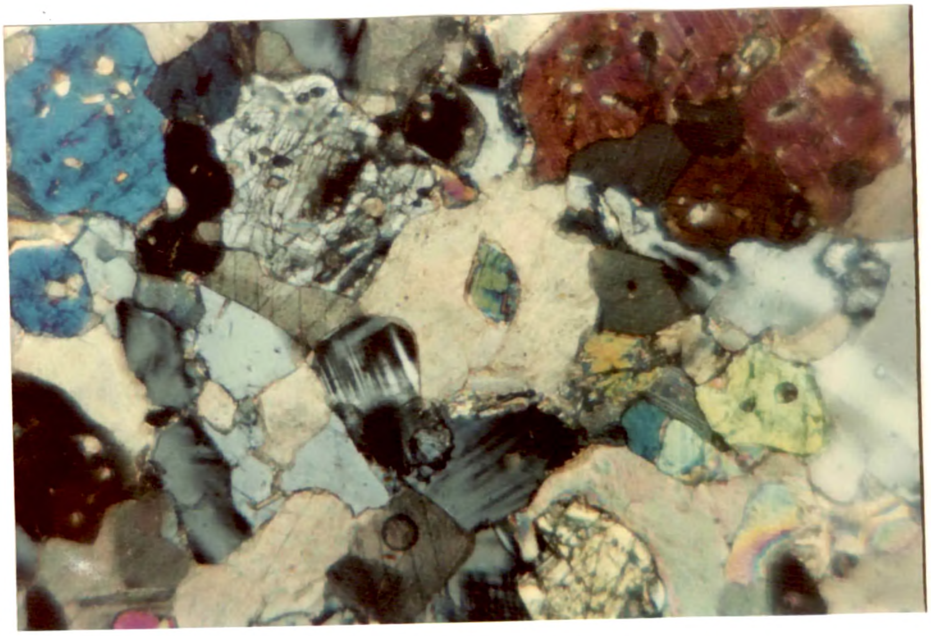

Plate IV.12 Granoblastic texture in calcgranulites (XN, X70).

Scapolite is colourless and forms idiomorphic grains and cleavage is not very well developed but has got inclusions of apatite, zircon and needle like bodies of rutile (Plate IV.13). It has got moderate birefringence and shows first order grey polarization colours. Sometimes, it may show association with plagioclase. Even when plagioclase is absent, scapolite is found to be present.

Wollastonite shows large prismatic crystals and granoblastic aggregates together with pale green diopside. The mineral exhibits parallel extinction and first order grey polarization colours.

Plagioclase has high anorthite content. It forms anhedral to subhedral crystals. The mineral always shows characteristic lamellar twinning.

Microcline occurs as sproadically subhedral grains and is identified by its freshness and typical cross hatching. Microcline with little plagioclase shows interstitial appearance.

Calcite is the most prominent mineral and is universally present. It occur as well recrystallised equant grains. Occasionally, it also forms sutured aggregates. Large crystal of calcite contain inclusions of quartz, diopside and plagioclase. The mineral is

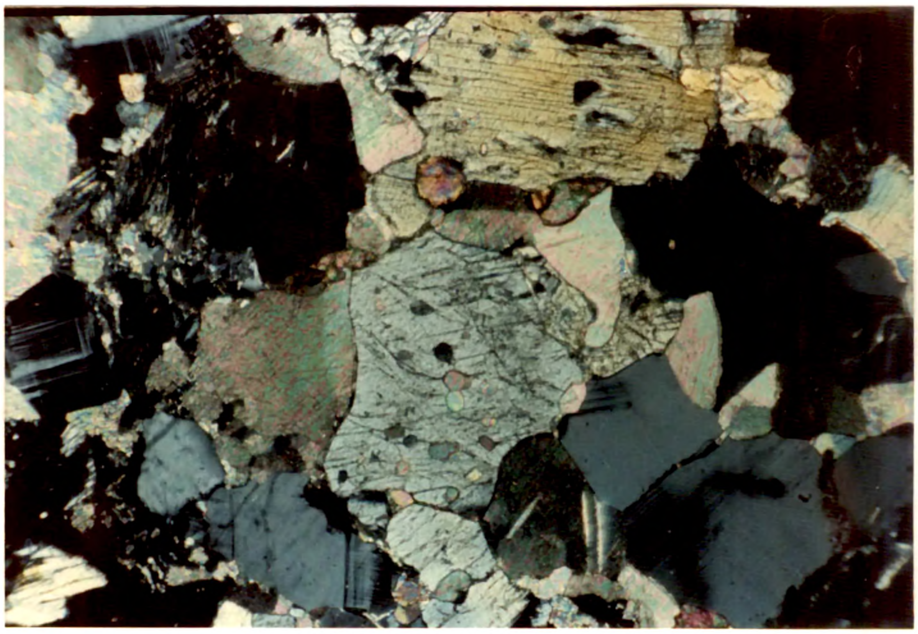

Plate IV.13 Well developed scapolite with inclusions of apatite, rutile and zircon. (XN, X70).

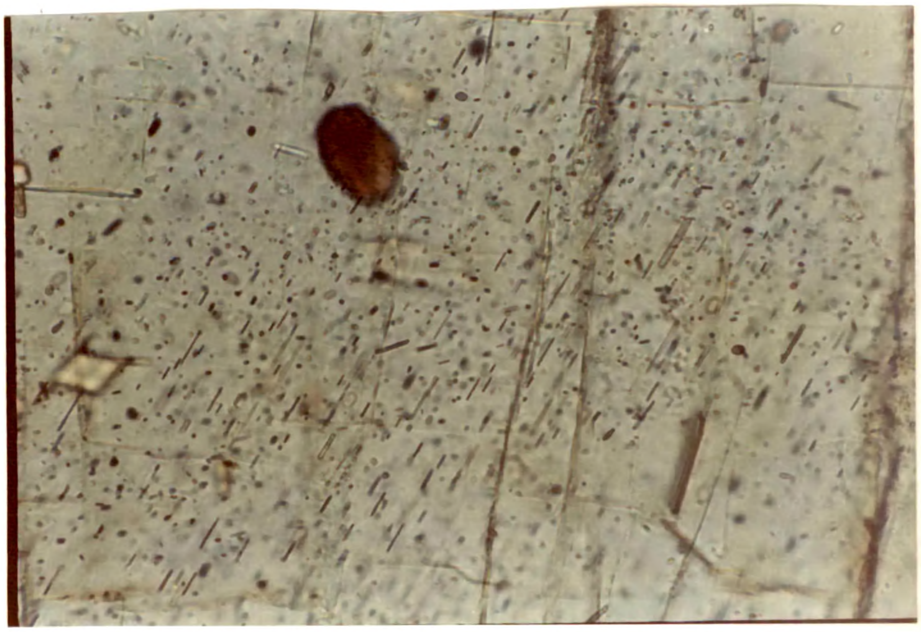

Plate IV.14 Photomicrograph showing rutile needles in quartz in calcgranulites (XN, X70).

readily identified by its very high birefringence, rhombohedral cleavage and twinkling in plane polarised light. It shows symmetrical extinction.

Calcite in marbles occurs as a mosaic of interlocking grains, slightly elongated in the direction of foliation. While in the silicate rich layers, its proportion varies and generally occurs as interstitial grains together with other calc silicates.

Dolomite occurs in the form of rhombohedral crystals as well as massive aggregates. It shows high birefringence and is characterised by twinkling and symmetrical extinction.

Quartz shows variable grain sizes and undulose extinction and contains minute dusty inclusions perhaps of rutile (Plate IV.14). At places elongate leaves of quartz alternating with narrow foliae containing equigranular diopside is also visible.

Clinozoisite is seen mostly confined to interstitial spaces and forms anhedral grains. Berlin blue anomalous polarization colour is the diagnostic property of the mineral. This mineral is seen to develop at the expense of plagiocalse.

Tremolite is present in a subordinate amounts. When present it forms bladed crystals with somewhat ragged outlines. Its prismatic section shows extinction between 10^{o} to 20^{o} and grey polarization colour.

From the mineral assemblages occurring in pelitic and calcareous members, it is found that hydrous phases are associated with the anhydrous phases of the pyroxene - granulite subfacies, forming mineral associations which can be accomödated only in hornblende -granulite subfacies. The hornblende - granulite subfacies is thus characterised by mineral assemblages consisting of hydrous minerals (hornblende, biotite, phlogopite and sphene) associated with anhydrous minerals of pyroxene - granulite subfacies in apparent equillibrium.

BASIC ROCKS

The term "Basic Rocks" is used here to include

1) 'Metagabbros' showing cryptic layering, exposed around south and southeast of Danta.

2) Hornblende granulites' near Tarsulighati on way to Danta - Ambamata road.

3) Amphibolites' which occur throughout the study area within metasediments.

Meta gabbros

Metagabbros are dark green to greenish in colour and fine to coarse grained and are compact in nature.

The thin section studies of these rocks exhibit an ophitic to subophitic texture and are massive in nature. They comprise clino and orthopyroxenes, plagioclase (labradorite), hornblende, biotite and epidote. More commonly pyroxenes and plagioclase show orthocumulate to adcumulate structures (Plate IV.16). Mineral proportions vary widely and in some layers pyroxenes predominate and thus correspond to pyroxenites indicative of their ultramafic character. However, in some layers, the calcic plagioclase (labradorite) is dominant and suggests their anorthositic character. The planar fabric are not well developed but tectonic fabrics, although poorly developed, clearly show that the minerals belong to metamorphic assemblage of granulite facies. The structures and textures reminiscent of primary igneous features and some remnants of primary minerals may be identified on the basis of thin section studies. It is possible to subdivide the layered rock into ultramafic unit (100% mafic minerals), mafic unit (more than 80% plagioclase). It is possible to see a primary upward sequence. Although the textural features indicate their primary nature by and large, both the pyroxenes are granoblastic and commonly show triple junctions meeting at 120° (Plate IV.17). The plagioclase and pyroxenes show polygonal mosaic and a triple junction. However, in these layered rocks, olivine is strikingly absent.

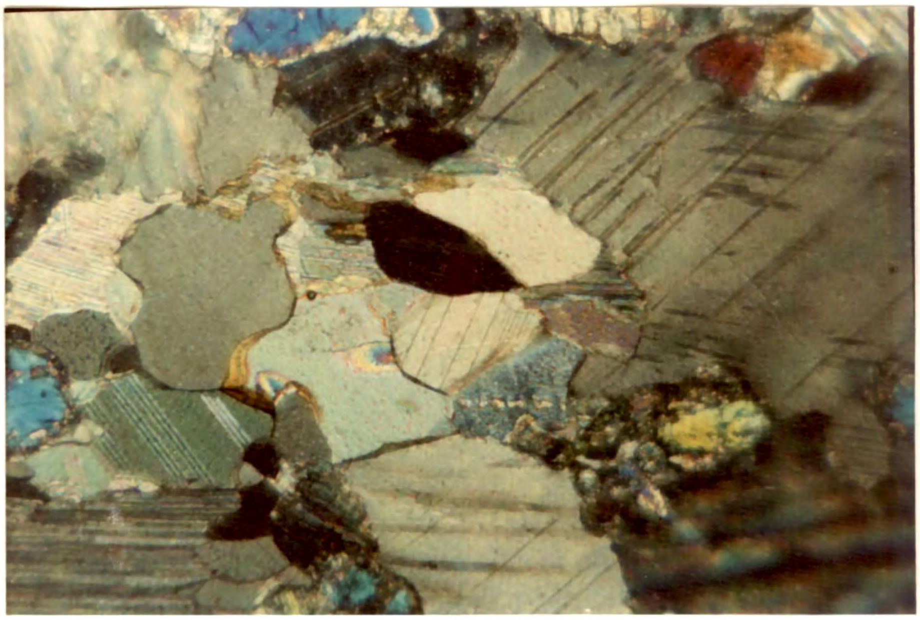

Plate IV.15 Textural characters of marbles (XN, X70).

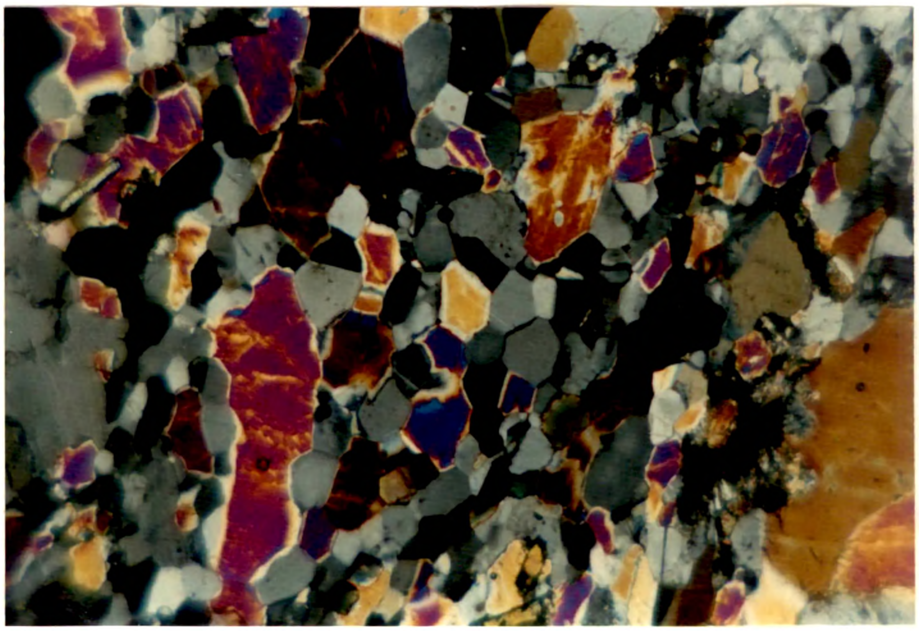

Plate IV.16 Photomicrograph showing orthocumulate-adcumulate structure in metagabbros (XN,X70).

Monoclinic Pyroxenes

The monoclinic pyroxenes are represented by diopside and augite.

Diopside varies in colour from pale green to dark green and is non pleochroic but it is usually fresh and shows an extinction angle of more than 40°. The mineral shows second and third order interference colours.

Augite which is usually colourless shows variable extinction angle and both are optically (+)ve and exhibit second and third order interference colours. In some cases the clinopyroxenes occur in association with orthopyroxenes and larger poikilitic crystals of clinopyroxenes are replaced by hornblende.

Hypersthene (orthopyroxene) is full of purplish dust (rutile needles) and shows schiller inclusions (bronzite) (Plate.IV.18). These textures represent primary igneous pyroxenes. This hypersthene shows light green to light pink pleochroism and shows parallel extinction and second order interference colours.

It is striking to note that both brown hornblende and foxy red biotite invariably show the presence of rutile needles, thus indicating their titanium rich nature. In one case pyroxene shows biotite inclusions

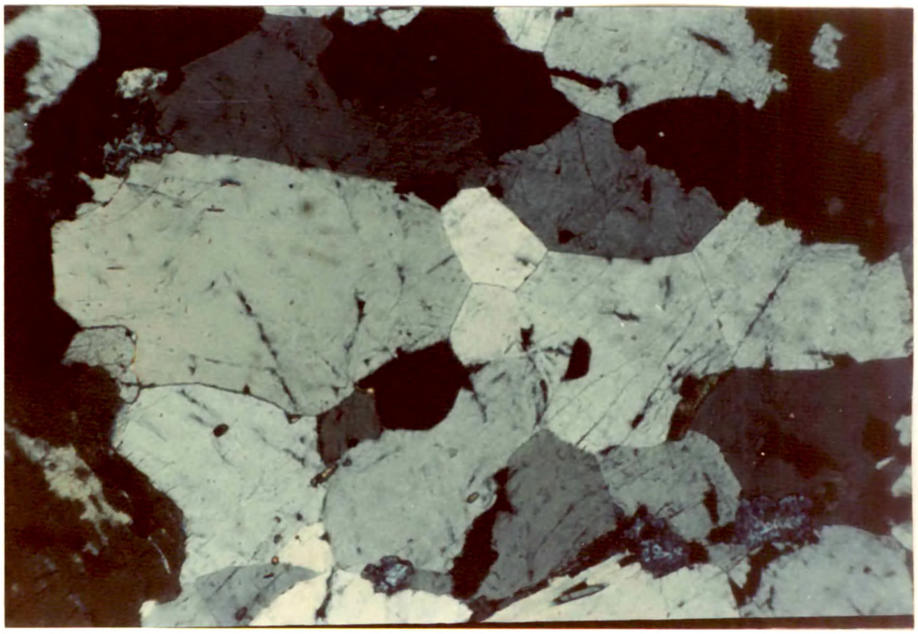

Plate IV.17 Photomicrograph showing triple junction in metagabbros (PPL, X70).

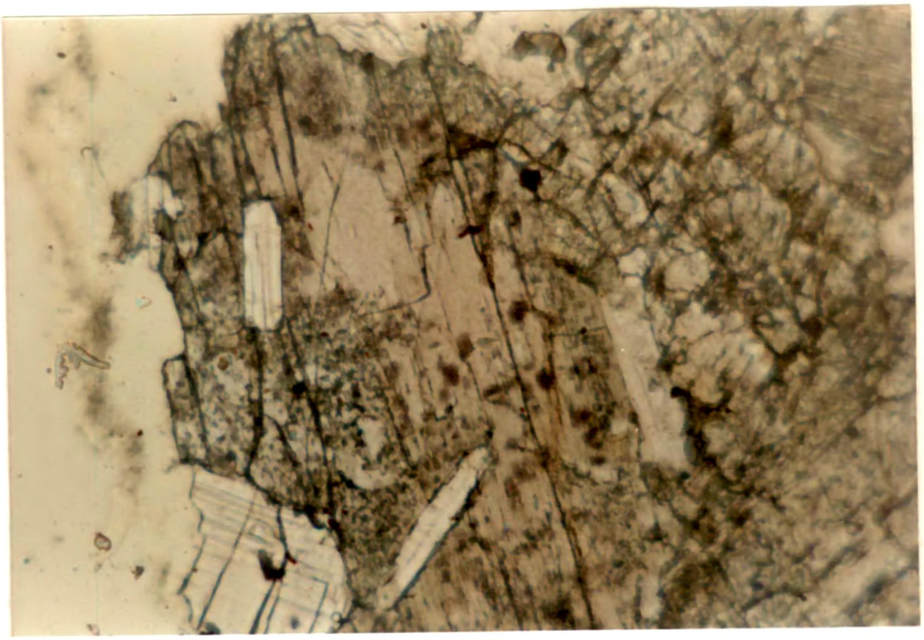

Plate IV.18 Hypersthene showing inclusions of rutile needles (PPL, X70).

(Plate IV.19) and were noticed by Groves (1935) in charnockitic rocks of Uganda.

Plagioclase is present in the form of labradorite or bytownite with anorthite content more than 72% and shows very good lamellar twinning. It is usually fresh and shows triple junction meeting at 120° . In some cases the felspar shows dense segregation of purple rutile needles.

Epidote might have developed by hydrothermal replacement during Erinpura granite emplacement. Epidote and its varieties such as zoisite and clinozoisite is seen to develop at the expense of plagioclase felspar.

Hornblende showing pleochroism in brownish green to green colour usually replaces either diopside or hypersthene and shows extinction angle varying 18° to 25°. It shows second order polarization colours (Plate.IV.20).

Biotite exhibits pleochroism from yellow to dark brown and is seen to have developed at the expense of pyroxene and/or hornblende.

The brown hornblende and foxy red biotite could be stable and indicate their formation under hornblende granulite subfacies. Green hornblende and yellow biotite are secondary products formed during subsequent diapthoresis.

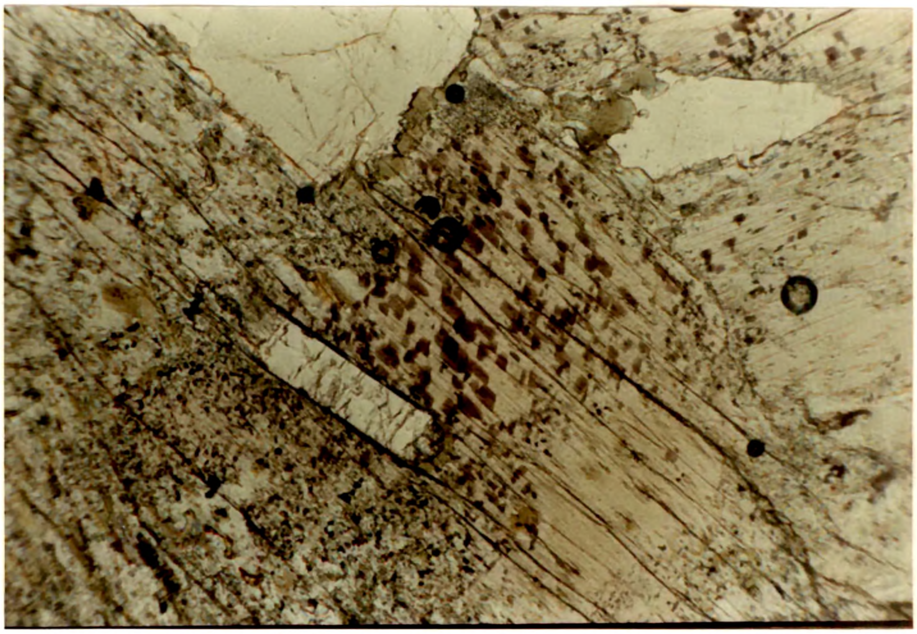

Plate IV.19 Photomicrograph showing biotite inclusions in pyroxenes in metagabbros (PPL, X70).

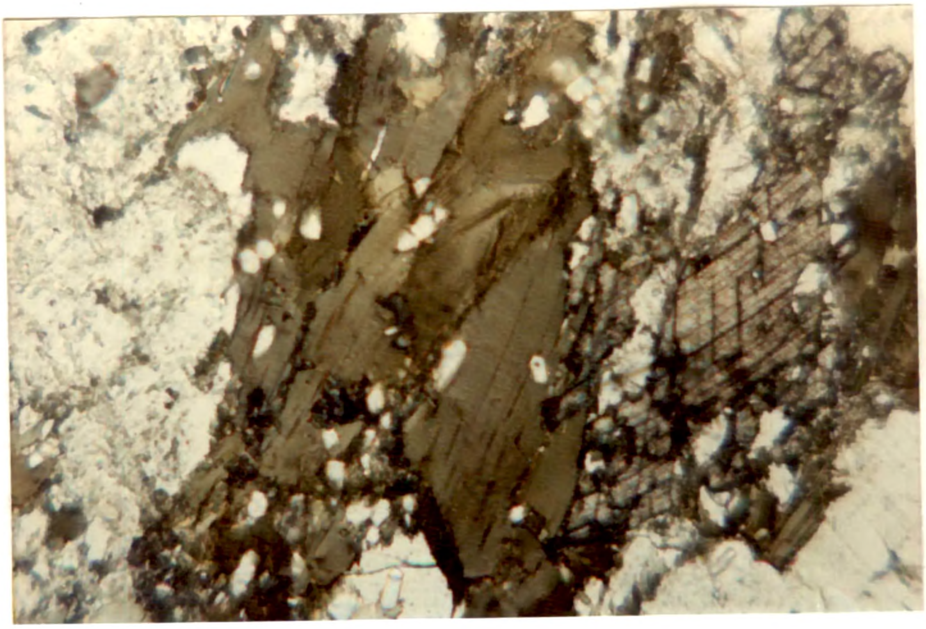

Plate IV.20 Photomicrograph of prismatic sections of hornblende in metagabbros (PPL, X70).

Hornblende granulites

In thin sections, these rocks show xenomorphic inequigranular textures containing porphyroblastic hornblende. Mineralogically they are seen to contain quartz, microperthite, hornblende, plagioclase with accessory biotite, zircon, iron ores, rutile, graphite. Strikingly they show plenty of apatite needles (Plate IV.21) and nearly all the minerals are extremely fresh.

Quartz is variable in shape and size has either rounded outlines or elongated ribbons. All the quartz grains show undulose extinction and presence of minute dust like inclusions of rutile needles.

Alkali felspar occurs in the form of microperthite. The grains are very fresh and are equidimensional but show incipient crosshatched twinning. The perthites occur in the form of thin strings or stringlets, while in others even the coarser types of inclusions are prominent. This has been identified as string perthites. The other varieties of perthites observed are vein perthites and coarse grained braid perthites.

On other hand, plagioclase is quite subordinate and is generally low in anorthite content and is of oligoclase andesine type. In some of the plagioclase minerals, bent twin lamellae are characteristic feature.

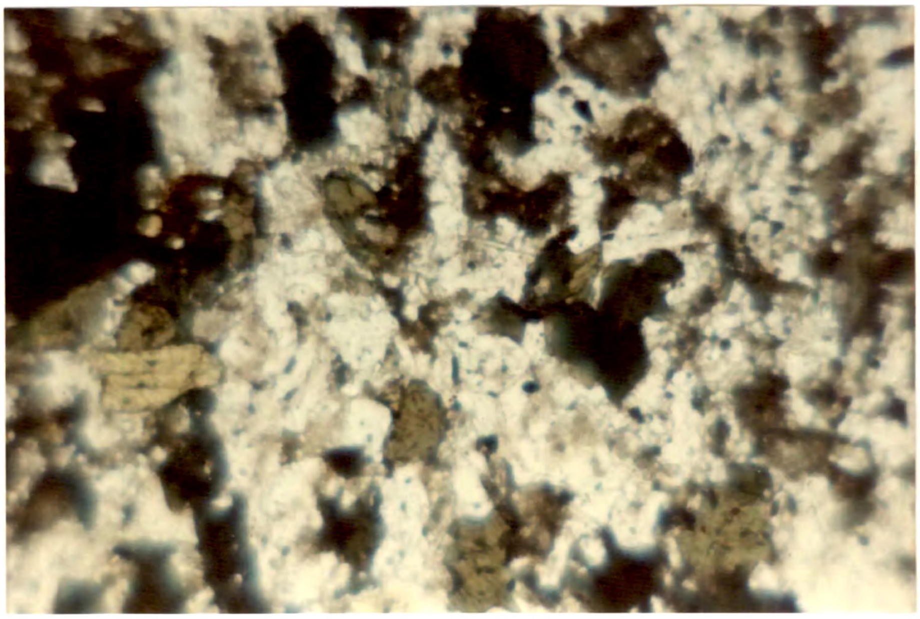

Plate IV.21 Hornblende granulite showing inclusions of apatite needles within hornblende (PPL, X70).

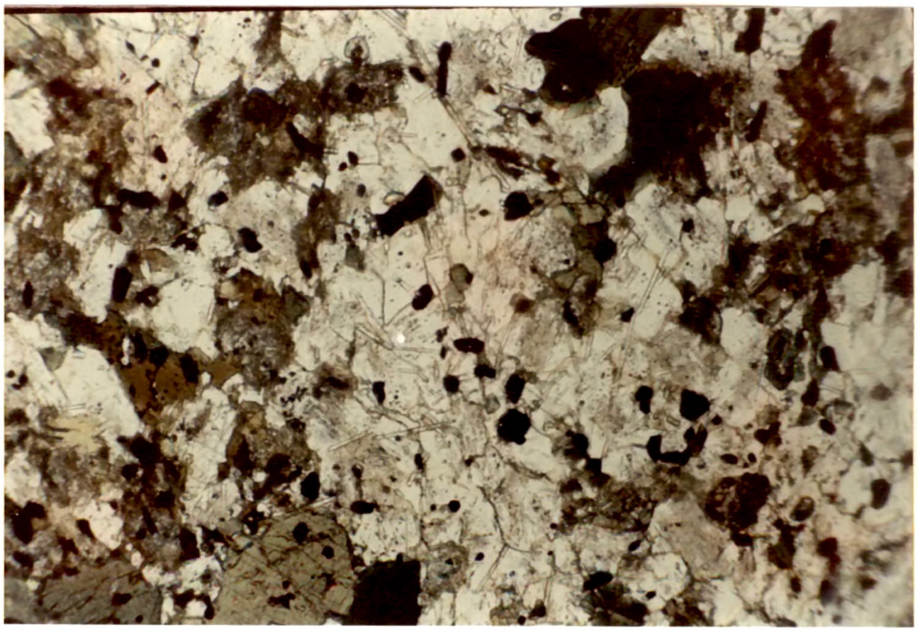

Plate IV.22 Hornblende exhibiting crescent shaped bits in hornblende granulite (PPL, X70).

Hornblende is normally arranged as foliae and is pleochroic in the shades of yellowish green to dark green or brownish green. Many of the hornblende grains are stubby or skeletal and form pools or channels of interlocking granules filling the spaces between the felspars at places. The hornblende exhibits granular crescent shaped bits producing a sieve structure (Plate IV.22). Many of the grains are prismatic with one set of cleavage showing an extinction angle of 12° to 16° and when two sets of cleavages are present, it is characteristic to see intersection of two cleavages at 124° or 56°.

Opaque ores, zircon, apatite and graphite form common accessories.

The presence of abundant opaque ores, crescentic pools of hornblende, rutile needles and perthitic k-felspars has prompted the author to suggest that these rocks belong to hornblende granulite subfacies of Turner and Verhoogen (1960) and appear to be identical to hornblende granulites reported in SriLanka by Cooray (1972).

Amphibolites

Amphibolites of dark greenish grey to black colour are characterised by the presence of varying amounts of hornblende, plagioclase, biotite. The common accessories are zircon, opaque ores and apatite.

Quartz is quite subordinate and is present in some places only. The k-felspar is confined only to migmatized amphibolites where quartz is also abundant (Plate IV.23).

Plagioclase is usually clear but at places cloudiness or patchy alteration is visible. Zoning is rare and type of plagioclase usually found in these amphibolites is andesine to oligoclase.

Hornblende is pleochroic in the shades of blue or green and is strikingly different from the hornblende described in hornblende granulites. The mineral is usually poikilo - porphyroblastic in nature with inclusions of plagioclase, biotite, iron ores and some times apatite. This mineral shows variation in extinction from 0° to 16° and most of them are prismatic sections with one set of cleavage.

In the migmatized amphibolites, the hornblende becomes more bluish green and shows marginal to complete alteration to biotite.

Biotite is strongly pleochroic in the shades of yellow to reddish brown and it occurs with or without hornblende.

Epidote is an alteration product of plagioclase and is present in the form of zoisite and clinozoisite.

Quartz shows minor grains parallel to foliation and is anhedral showing usual polarization colours, its margins are corroded and invariably shows undulose extinction.

When the amphibolites are subjected to migmatization, there is increase of k-felspar and quartz. The k-felspar usually develops vermicular quartz or myrmekite texture at the contact of plagioclase and k-felspars. The epidote minerals, commonly zoisite and clinozoisite, form small granules replacing plagioclase phenocrysts as well as in the groundmass. The iron ores form discrete grains and are associated either with ferromagnesian minerals or scattered throughout the rock. Some sulphide ores like chalcopyrite and pyrite are observed in these amphibolites.

The mineral assemblages described above indicate that the amphibolites and their migmatized derivatives represent metamorphic conditions of the amphibolite facies of Turner and Verhoogen (1960). However, quartzo-felspathic segregations are found only in gneissic amphibolites.

ORIGIN OF BASIC ROCKS

The basic rocks of the study area are interbanded with rocks of known sedimentary precursors of pelitic and calcareous parentage and are essentially parallel to the bedding planes of such sediments. The basic rocks are therefore themselves part of this succession and may have been sedimentary or volcanic in origin. At the sametime, the form of some basic bodies indicates that some of the basic rocks of the appropriate composition appear to have been subjected to high grade regional metamorphism. The total absence of pyroxene in these amphibolites as well as the absence of gradation between granulites and amphibolites has led the author to believe that the amphibolites, the hornblende granulites and the metagabbros (Pyroxene granulites) could indicate their variation in space and time. Most of the hornblende and biotite present in metagabbros and hornblende granulites are secondary in origin, but it is primary in amphibolite. But for the presence of pyroxene in amphibolite, the author is reluctant to believe that amphibolites have been derived from pyroxene granulite by retrogressive metamorphism. In geological literature, the coexistence of pyroxene granulites and amphibolites have been reported to occur side by side.

The assemblages quartz-microperthite-hornblende-plagioclase in the hornblende granulites is infact diagnostic for the almandine-amphibolite facies; but these rocks are interlayered and intimately associated with biotite gneisses in study area. They might have been formed under the general physical conditions of the granulite facies. DeWaard (1965) suggested that the pair hornblende- quartz should be replaced in granulite facies by clinopyroxene - almandine or orthopyroxene - clinopyroxene. The fact that they do not, suggests that PH_2O was still too high within the hornblende granulites for the postulated reaction to take place. The complete absence of pyroxene, even as relics, from the hornblende granulites of the study area indicates that granulite facies condition were prevalent regionally locally within this horizon, all the physical conditions were not reached. That appropriate temperatures, were infact attained within this granulite horizon is suggested by the presence of microperthite and rutile. It is probable however that PH_2O was initially higher in these rocks than in the surrounding rocks and that for some reason it remained higher during the subsequent metamorphism.

One reason may have been that hornblende granulite horizon remained a closed system. As a result, the dehydration reactions that would have resulted in the replacement of hornblende by pyroxenes were retarded or even prohibited.

The juxtaposition of mineral assemblages characteristic of two different metamorphic facies within small areas like this could indicate either polymetamorphism or the existence of local gradients in temperature and water pressure during the same metamorphic conditions. Recognition now in the study area of mineral assemblages of the almandine-amphibolite facies interlayered with those of granulite facies, thus strongly supports that PH_2O can vary significantly from horizon to horizon in high grade regional metamorphism. The biotite gneisses in which these rocks occur are retrogressed cordierite garnet gneissic granulites and in that case these granulite facies rocks may be enclave or inlier as is suggested by Desai and Patel (1987).

GRANITES

As such granite do not form large bodies in the area but are seen to be distributed over the entire terrain. The granites are coarse to medium grained and light pink to light grey in colour.

Mineralogically these are seen to comprise quartz, k-felspar, micas, hornblende and accessory minerals. The k-felspars are represented by orthoclase and microcline and albite-oligoclase are the prime plagioclase felspars.

In a general way these rocks show allotriomorphic texture and intergrowth textures between quartz and felspars. In addition, Sharma and Purkayastha (1935) have reported kyanite, garnet, epidote, chlorite as accessories.

Quartz is the most dominant mineral which is anhedral in nature and shows first order grey and yellow polarization colours. In some cases the strain shadows and undulose extinction is also visible. The other mode of occurrence of quartz is vermicular nature or myrmekitic nature and graphic intergrowth with K-felspar (Plate IV.24).

Microcline is characterised by partial to impartial cross hatched twinning and occur in close association with plagioclase. It is very common to see the formation of myrmekitic textures and vermicular quartz at the contact. The other k-felspar is monoclinic variety in the form of orthoclase has got one set of cleavage, low relief and first order grey polarization colours. The other mode of occurrence of this k-felspar is in the form of graphic intergrowth with quartz. Usually both the felspars are quite fresh with very little signs of alterations. The plagioclase felspars exhibit characteristic lamellar twinning and have anorthite content varying between 0 to 20%. The plagioclase felspars are seen to altered to sericite and rarely epidote.

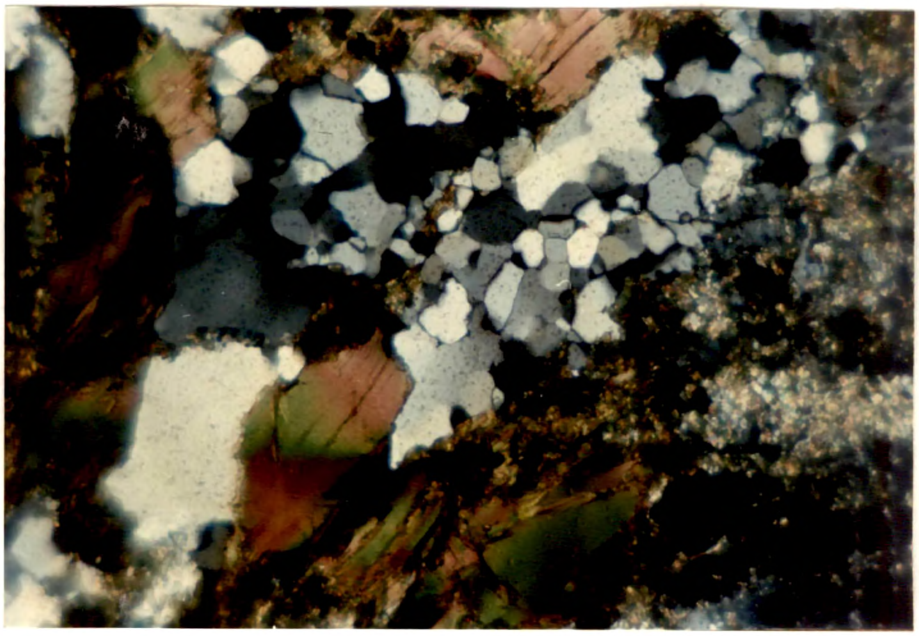

Plate IV.23 Migmatized amphibolites showing quartzfelspar rich layers (XN, X70).

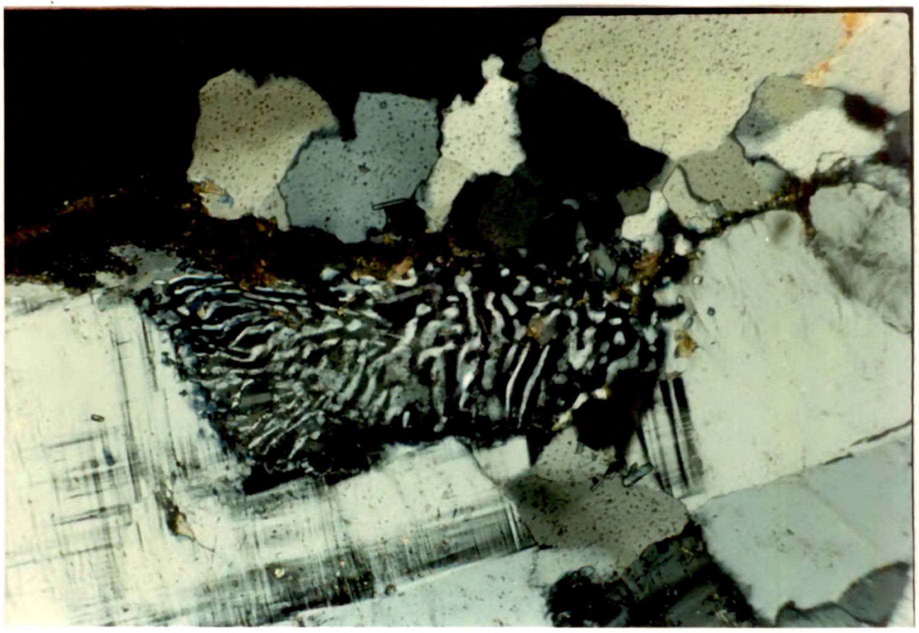

Plate IV.24 Vermicular or myrmekitic intergrowth of quartz and felspar in granites (XN, X70).

Hornblende is pleochroic from light green to bluish green, shows two sets of cleavages and second and third order of polarization colours and exhibits 12^{o} to 16^{o} extinction angle.

Micas are of two types mainly biotite and muscovite. Muscovite is colourless and shows straight extinction and one set of cleavage and shows red and green higher order interference colours. It occurs with or without biotite & is seen to altering to sericite.

Biotite shows yellow to dark brown pleochroic colours. They show one set of cleavage, parallel extinction, and third order polarization colours. Some of the grains show presence of pleochroic haloes around zircon.

Among the accessories, **Zircon** shows bold relief and higher order interference colours. **Zoisite** is characterised by moderate relief and higher order polarization colours. **Tourmaline** shows light brown to dark brown pleochroic colours. They show one set cleavage, subhedral nature, and show second or third order polarization colours.

Associated with granites coarse grained pegmatites containing quartz, felspars, tourmaline, muscovite are present. Fine grained quartz and felspars and absence of tourmaline is present in the form of aplite.