CHAPTER - III

FIELD STUDY AND PETROGRAPHY

3.1. FIELD STUDY

INTRODUCTION

The main objective of the field study were to (1) identify different types of mafic metavolcanic rocks which forms the host rock for gold mineralization in the schist belts of Hutti and Ramagiri in the eastern Dharwar craton and Gadag Schist Belt in the western Dharwar craton, (2) identify the field relationship of the mafic metavolcanics with the surrounding lithologies and their contact relationship with the surrounding granitoids, (3) collect samples of the host rocks, ore veins and wallrock alteration zone to study the nature of the fluid, and intensity of the fluid alteration the mafic metavolcanics have undergone in the Hutti, Ramagiri and Gadag schist belts. The following paragraphs will summarize the field observations made and samples collected for petrographic and geochemical studies in the above mentioned three schist belts.

3.1.1. HUTTI - MASKI SCHIST BELT :

The geological map of Hutti-Maski schist belt redrawn after Biswas et al (1985) showing sample locations is shown in Fig.2.2. Field observations were made for about a length of 40 kilometers, along the length of the Hutti-Maski schist belt from Hutti in the north to Udbal in the south and for about 12 kilometers along the width of the belt from Uti in the north east to Madriankota in the north-western part of the
belt where good exposures of the mafic metavolcanics with limited soil cover are present. The entire field work in the belt can be described in terms of four major traverses with Hutti as the base camp. The traverses include

1. Hutti - Wondalli - Chinchergi - Uti traverse
2. Hutti - Anwari - Topaldoddi - Pamankallur traverse
3. Hutti - Madriankota - Gurgunta traverse
4. Hutti - Pamankallur - Buddini - Udbal - Maski traverse

Detailed sampling of different textural varieties of mafic metavolcanics were done for petrogenetic studies. The mafic metavolcanics of the Hutti Schist Belt are represented by three textural varieties of amphibolites such as (1) the medium grained schistose amphibolite, (2) the fine grained massive amphibolite and (3) the coarse grained spotted variety. In the southern part of the schist belt, the lower metamorphic grade equivalents of the amphibolites represented by the chlorite-carbonate schists are present.

Important locations where good outcrops of both the mafic and felsic rocks are present and hence field observations have been made include Wondalli, Palkanmardi, Chinchergi, Uti, Madriankota, Anwari and Topaldoddi in the northern part of the schist belt and Pamankallur, Buddini, Udbal and Maski in the southern part of the schist belt. The hook-shaped belt is surrounded by granitoids on all sides which in general, have sharp tectonic contact with the mafic rocks. However, in the northern part of the schist belt, near Uti and Madriankota villages, one phase of leucocratic granite crosscuts the metabasalts and include xenoliths of the later, indicating the intrusive nature of the contact in these areas. In many places, the contact is covered by soil developed
from sheared lithologies. The mafic rocks in the north eastern part of
the schist belt near the granitic contact are of higher metamorphic
grade (middle to upper amphibolite facies) represented by well
recrystallized amphibolites and that on the southern and western
contacts are of a relatively lower grade represented by chlorite -
carbonate schist. There are quartz and carbonate veins in the chlorite
schist and the quartz vein show the development of pinch and swell
structures, indicating that the deformation continued beyond vein
formation. There are both dextral and sinistral shearing in the
metabasalt and the shear planes are smeared with biotite in some
places. Specks of sulfide minerals like arsenopyrite and pyrite are
present in the chlorite schist. At the western contact, the rocks are
highly sheared and both mafic and felsic rocks are pulverized.
Spheroidal weathering is also seen in the Pamankallur area.

In the Chinchergi area, the metabasalts show evidence of folding
and shearing deformation south of Chinchergi village, where two
textural varieties of amphibolites viz., the fine-grained massive
amphibolite and coarse grained spotted variety are seen. The fine-
grained amphibolite is a well foliated rock and show F3 type open folds
and the orientation of the axial plane of the fold is N15°E. Pillow
structures with cherty layers caught up in them are seen in this fine-
grained variety indicating that their protoliths were emplaced under
sub-aqueous conditions. Coarse grained amphibolite is juxtaposed with
the fine-grained variety with sharp lithological boundary. An acid
volcanic unit represented by quartz porphyry is seen. This rock is
medium grained consisting of bluish gray quartz as the dominant
mineral and is well foliated and two sets of foliation giving rise to an
anastamosing appearance is seen on the weathered surface. However,
foliation is not seen on the fresh surface. The trend of the foliation is N30°E which is parallel to the strike of the rock and the dip of the foliation surface is almost vertical.

In the Madriankota village, the metabasalts are represented by the medium grained well foliated schistose amphibolite and the trend of the foliation is E-W and the dip of the foliation surface is 75° due North. North of this village, in the river bed good exposures of the metabasalt and the granite are seen. The contact of the metabasalt with the granite is sharp and tectonic. The rocks on either side of the contact are mylonitized and mylonitic banding is prominent in the metabasalt.

In the Palkanmardi area, in the northeastern part of the schist belt, a conglomerate horizon with well rounded pebbles and cobbles of granitic composition embedded in a fine grained matrix is seen. The clastic pebbles are rounded and at places are stretched and elongated. This may be due to varying degrees of deformation that the rocks must have undergone. The pebbles are stretched parallel to the foliation of the matrix and the pebbles themselves have gneissic foliation and appears to be similar to Champion Gneiss occurring along the eastern margin of Kolar Schist Belt.

In the Wondalli area, the rocks are mainly intermediate and acid volcanics which are carbonitised, very fine grained and well foliated. The trend of the foliation is almost E-W. Mineral lineations are present in the mylonitized dacitic volcanics and they are steeply dipping in the southern direction. Epidote veins are present along the sub-horizontal fractures in the intermediate volcanics.
In the Uti area, which represents the northern most part of the schist belt, the metabasalts are represented by both fine grained and coarse grained amphibolites. The fine grained metabasalts are well foliated and there are tongues of leucocratic granite in the metabasalts which indicates an intrusive nature of the contact in this area. For the purpose of petrogenetic study, we will consider only the dominant mafic rock types of the belt namely the three textural varieties of amphibolites and the chlorite schists.

Other lithological units such as the acid and intermediate volcanics are not dealt with in detail in this work. The second part of the work is to understand the nature of fluid alteration by studying the mineralogy and geochemistry of the ore vein and wallrock alteration zone and the unaltered metabasalt in all the three schist belts. For this purpose, underground mine samples were collected from the Hutti gold mine which can be described in terms of four profiles representing four important "reefs" namely the (1) Oakley's Reef (2) Middle Reef (3) Zone - I Reef and (4) Strike Reef.

The Reef's are a series of parallel gold - quartz - carbonate veins running generally parallel to the schistosity of the host amphibolite which are oriented N20°W and dips west at about 75° and are parallel to each other. The entire lode system is generally parallel and are arranged in an en-echelon branching pattern. The gold -quartz - carbonate lodes are being mined systematically since 1948, and the present average gold content is about 8 gm/ton with an average silver content of the gold being 8%. Samples collected from the three profiles include one ore vein and one wallrock alteration sample from either side of the reef and in the fourth profile apart from the ore vein
Fig. 3.1. Transverse section through the village shaft of the Hutti Gold Mine showing sample location.
unaltered metabasalt on either side of the vein was collected instead of wallrock alteration samples mainly to observe the differences in mineralogy and chemistry between these two varieties. A transverse section through the village shaft of the Hutti gold mine showing sample locations were shown in the fig (3.1). The following paragraphs describes the details of geological observations of the four important reefs.

Oakley's Reef: This reef dips west at about 70°, and it is generally of lower grade than the other reefs. There are extensive quartz "blows" mainly of white quartz of low gold content and with more sulfides, the average sulfide content being about 5 weight percent. Hanging wall and foot wall contacts of this reef are generally not well defined and considerable quartz often occurs in the wallrocks, in the form of veins, veinlets and stringers or dissemination's carrying gold values. This reef is comparatively wider than average, lode width being about 6-7mts in the ore shoot portions, and gold values extend into the altered wallrock.

Middle Reef: This ore vein dips west about 70° and is generally similar to the Oakley's Reef, except that the auriferous quartz is blue-gray quartz instead of white quartz. Visible gold occurrences are more frequent and are confined to the blue-gray quartz. Sulfide development is somewhat low, but gold distribution in the lodes are again extremely erratic. Minor gold values persist into the altered wallrock.

Zone - I Reef: This ore vein was discovered by surface geophysical methods (I.P method) in the I-traverse of a grid survey and hence the name. The main characteristics of this reef are practically exclusive blue-gray quartz and a very strong strike-slip (strike fault) which persists
throughout the whole area so far developed. Visible gold occurs invariably at the hanging wall and foot wall contacts and the grade is normally higher than other reefs.

Strike Reef: In this reef both white quartz and blue-gray quartz occur, and values are again highly erratic. White quartz is generally of very low grade whereas much visible gold has been observed in the blue-gray quartz. Bifurcation of this reef occurs (Fig.3.1) and both limbs of the reef show similar characteristics, the conjunction of the limbs apparently pitching steeply northwards and being very wide (40 meters), well mineralized and with high gold content. Recent studies of this reef (Raju, 1996) indicates that gold values occurs in the form of amoebae-shaped ore shoots with a definite northerly pitch arranged in en-echelon pattern.

In all, twelve samples were collected from the underground mine at Hutti from the southern drive of the 646 meters level. Intensity of wall rock alteration varies from one reef to another and generally varies from about a cm to less than 10 centimeters. Apart from these twelve samples, samples of the metabasalts and acid volcanics with sulfides in them were also collected from the newly developed Uti Mine in the northern part of the Hutti belt.

3.1.2. RAMAGIRI SCHIST BELT

The geological map of Ramagiri Schist Belt showing location of drillhole sites in the western and central blocks is given in Fig.2.3. Field studies in the Ramagiri Schist Belt with the objective of deciphering the nature of fluid alteration by studying the wallrock alteration and ore
Fig 3.2(a). Schematic diagram showing exploratory drilling operation being carried out by G.S.I. in the Zone - IV at the western block of the central arm of Ramagiri Schist Belt.
Fig 3.2(b). Schematic diagram showing exploratory drilling operation being carried out by the G.S.I in the Zone - V at the central block of the central arm of the Ramagiri Schist Belt.
zones in the western and central blocks of the belt and compare the data obtained with that of Kolar and Hutti Schist Belts. Since detailed petrogenetic studies were already done by Zachariah (1992), Zachariah et al (1995,1996), field observations and sample collection were restricted only to the mineralized central block and the western block. Drill core samples were collected from these two blocks, where drilling operations were being carried out by the Geological Survey Of India. In the central block exploratory drilling were being done in Zone-V. In the Zone-IV which is on the western block, beds dip steeply towards west and therefore drilling operations were carried out from east to west. The various litho units encountered in this zone include unaltered metabasalt, followed by an alteration zone which is a zone of silicification, sulfidation and intense carbonation, which is also called as the "ore zone" and again into the unaltered metabasalt. In the Zone-V, drilling operations were being carried out by the G.S.I from the central block towards the western block contact and in to the western block metabasalt. The various litho units encountered in this zone include metagabbro, acid volcanics, acid volcanic with iron formation, carbonaceous phyllite with sulfide mineralization, acid volcanic with carbonate alteration and this is followed by the metabasalt unit at a depth of 108 meters. A schematic diagram showing drilling in the two zones is shown in the figures 3.2(a) and 3.2(b).

3.1.3. GADAG SCHIST BELT

Field studies were done in the Gadag Schist Belt in the western Dharwar craton just to compare the metavolcanics of this area with that of the eastern Dharwar craton and the nature of gold mineralization in this younger schist belt. Unlike the schist belts of
eastern Dharwar craton where the gold-quartz-carbonate vein mineralization is hosted solely by the mafic metavolcanics, the Gadag Schist Belt hosts the auriferous quartz veins in both the metavolcanics and meta sedimentary units. The different lithounits of the metavolcanic suite are metabasalt, meta andesite, chlorite schist, and the acid volcanics represented by the quartz porphyry. The various lithounits of the meta-sedimentary suite are metagreywacke, argillite, metaconglomerates, banded iron formation, limestone, and garnetiferous quartz-mica schists. There are three different lode systems of gold mineralization in the Gadag Schist Belt namely the central lode system, the western lode system and the eastern lode system in the central, western and eastern part of the schist belt respectively. Of these only the central and western lodes are being mined at present. The metavolcanic-hosted gold mineralization occurs mainly in the western lode system of the Gadag gold field which is named as the Hosur mine and is operated by the Bharat Gold Mines Limited (BGML).

In the Central lode system gold mineralization is hosted by the metasedimentary unit (metagreywacke) and the major mining activity is taking place 2 kms south of Attikatti village and is called as the Mysore Mine which is operated by the Hutti Gold Mines Limited (HGML). In the present study, which is only a preliminary study of the Gadag Schist Belt in the western Dharwar Craton, samples of the metavolcanics were collected from surface outcrops to compare the petrological and geochemical characters of these rocks with the metavolcanics of eastern Dharwar craton. Important locations where fresh outcrops of metavolcanics occur and hence field observations have been made and samples collected include Hosur, Nagavi, Beladhadi, Doni and the area
Fig. 3.3. Longitudinal section of the Mysore mine in the Gadag Schist Belt showing sample location.
around Mysore mine in the central part of the schist belt. The geological 
map of the Gadag Schist Belt with sample locations is shown in the 
Fig.2.4. Underground mine samples were also collected from the 
Mysore mine in the central part of the Gadag schist belt, where the gold 
mineralization is hosted by the meta greywacke which is very fine 
grained. Gold occurs as quartz-vein lodes within the greywacke.

Samples collected from the Mysore mine include one sample of 
the ore vein from the Adit-2 level of the middle reef and one ore vein 
sample each from the two different levels (315 ft and 500 ft levels) of 
the East Reef. Wallrock alteration samples on both Hanging wall and 
foot wall sides of the ore veins were also collected in all the three 
profiles. The longitudinal section of the Mysore mine showing sample 
locations is shown in the Fig.3.3.

3.2 PETROGRAPHY

3.2.1. INTRODUCTION

The petrographic studies carried out in the present work on the 
host rock samples, ore veins and wallrock alteration zone samples in 
the Hutti, Ramagiri, and Gadag schist belts include both thin section 
and polished section studies. While the thin section studies were done 
in great detail from the rocks of the entire Hutti belt, in the case of both 
Ramagiri and Gadag belts a brief study on some of the important 
samples from the wallrock alteration zone and ore horizon were done 
mainly to understand the nature and intensity of fluid alteration in these 
two belts. Polished section studies were done on the wallrock alteration 
and ore samples from all the three schist belts mainly to identify the
different sulfide minerals present and their abundance's and use this information to substantiate the geochemical studies.

3.2.1. HUTTI SCHIST BELT

Thin section studies carried out on the metavolcanics of the Hutti Schist Belt indicate that the mafic volcanic rocks represented by three different textural varieties of amphibolites and chlorite schist form the predominant rock types in the belt. Minor amounts of intermediate and acid volcanics are found interleaved with the amphibolites in the northern part of the belt. The amphibolites are grouped into three different rock types on the basis of their texture, such as (1) the medium grained schistose amphibolite (2) the fine grained massive amphibolite and (3) the coarse grained spotted amphibolite and they occur in abundance in that order. The schistose amphibolite in the northern part of the belt is a well recrystallized rock consisting mainly of hornblende (~80 modal %), plagioclase and quartz. In this rock type there are two generations of hornblende, one of which is slender and prismatic in habit while the other is an euhedral hornblende which is enclosed in the prismatic variety. The euhedral hornblende could be of younger generation formed probably due to re-heating by the nearby granitic intrusion and is particularly characteristic of amphibolites close to the granitic contact on the north-western side of the belt. The higher amounts of hornblende (~80%) could be possibly explained by a reaction involving precursor pyroxene and plagioclase giving rise to hornblende + quartz + ilmenite.

\[ \text{Pyroxene} + \text{Plagioclase} + H_2O \rightarrow \text{Hornblende} + \text{Quartz} + \text{Ilmenite} \]
The higher amounts of opaques in thin sections can be explained by the above reaction by the way of ilmenite in the product. The massive amphibolite is a fine grained equigranular rock with anastamosing foliation. The orientation of amphibole grains are somewhat chaotic, probably due to closely spaced brittle shearing in two different directions, and the rock is mylonitised. Quartz and feldspar are granulated giving a smudgy appearance. Some of the calcic plagioclase have altered to clinozoisite. The coarse grained variety under thin sections has a metamorphic fabric with two sets of foliation. The quartz and feldspar are granulated and form the matrix with broken up hornblende porphyroblasts occurring as "augens" in them. The hornblende augens could have developed as a result of shearing in two different directions at small angle. The plagioclase grains swerve around the hornblende augens. The textural relation seems to suggest that the rocks suffered a period of brittle deformation after they were metamorphosed to amphibolite grade. Some of the metabasalts have retained their original igneous texture with plagioclase laths forming the matrix and the clinopyroxene as phenocrysts in them. Some of the clinopyroxene phenocrysts have been altered to actinolite by static metamorphism and that is followed by the fluid alteration by which the actinolite was partially converted into biotite. The Ca and Al released as a result of this fluid alteration have resulted in the formation of epidote.

The metavolcanics in the southern part of the Hutti-Maski schist belt are represented by the chlorite-carbonate schists. The rock under thin section consists of fine grained chlorite, calcite, quartz, plagioclase, and opaques (which are seen as sulfides in the hand specimen) with well developed schistosity. The rock is highly deformed and even the opaques are aligned in one direction, indicating high stress conditions.
The calcite veins cut the schistosity of the rock indicating that they are later veins, but themselves are broken up. Thus we can divide the entire schist belt into a high grade (lower to middle amphibolite facies) block occurring to the area north of Pamankallur and a low grade block (upper green schist to lower amphibolite) occurring to the area south of Pamankallur. In view of ubiquitous low grade alteration and high degree of deformation, it is difficult to decipher if the difference in metamorphic grade has any geological significance.

The thin section study of the wallrock alteration zone samples and ore veins collected from the Hutti underground mine indicate the following. The wallrock alteration samples are composed of hornblende, plagioclase, quartz, biotite, carbonates and sphene. Most of the hornblende grains have been partially converted to biotite by the hydrothermal fluid. The actinolite grains wherever present in small amounts in some of the host amphibolite have been converted into chlorite. The calcium released in the above process forms the carbonates, which include calcite and ankerite. Thus the hydrothermal alteration in the Hutti Schist Belt has resulted in the processes of biotitization, carbonatization, chloritization (in some places), silicification and sulfidation. The overall mineralogy of the mineralized zone of the Hutti gold fields indicate that the rocks have undergone a high grade metamorphism (lower to middle amphibolite facies) prior to low grade alteration and bears similarity in this respect with the rocks Kolar Schist Belt.
3.2.2. ORE MINERALOGY OF THE HUTTI SCHIST BELT

Four Ore veins and six alteration zone samples collected from the Hutti mine were studied under the reflected light microscope. The ore vein is a gold-quartz-carbonate vein which appears to be fracture fillings in the host amphibolite. The fractures are probably brittle - ductile shear zones which are parallel or subparallel to the dominant foliation of the host country rock and the vein material commonly include varying amounts of fragments of the host amphibolite. The quartz veins have been granulated, sheared and subsequently recrystallized. The wallrock alteration zone is a few centimeter thick bleached zone and consists of amphiboles, biotite, sulfides and varying amounts of vein material. The sulfide minerals identified from the ore veins and alteration zone samples include arsenopyrite, pyrite and pyrrhotite in the order of decreasing abundance. Scheelite is the most predominant oxide mineral although it is present only in a few wallrock alteration samples. Arsenopyrite and pyrite constitute more than 90% of the sulfides. Arsenopyrite occurs as large euhedral crystals (Plate-5) whereas pyrite usually occurs as subhedral grains. The sulfide content varies from one "Reef" to another with zone-I reef having the maximum abundance (~6%), followed by Middle Reef, Oakley's Reef and Strike Reef having the least abundance of sulfides(~1%). Wall rock alteration zone samples generally have a greater abundance of sulfides than the corresponding gold-quartz veins and the abundance of sulfides decreases as one moves away from the alteration zone into the unaltered metabasalt. Scheelite is present in disseminated form in the wallrock alteration samples in the Hutti mine as well as in the samples collected from the newly developed Uti block. This shows that alteration is pervasive and not restricted to certain zones or pockets.
The sulfide mineralogy with arsenopyrite forming a major portion of it (~70%) is typical of Hutti gold field and in this regard differs from Kolar and Ramagiri gold fields where pyrrhotite and pyrite dominate the sulfides respectively.

3.2.3. RAMAGIRI SCHIST BELT:

Detailed thin section studies were carried out on the zone-IV drill core samples collected from the western block of the Ramagiri Schist Belt. The various lithounits encountered in this zone are unaltered chlorite actinolite schist which is very fine grained, wall rock alteration zone characterized by the presence of actinolite-chlorite-albite-sericite-carbonate schist with intense silicification and sulfidation forming the "ore zone" and again into the unaltered metabasalt. The chlorite - actinolite schist is a medium to fine grained rock consisting of amphiboles chiefly of pale green actinolite, chlorite, plagioclase and quartz. The fine-grained texture of this rock is probably an original igneous texture, but it is equally possible that some granulation occurred during shearing and led to the reduction in grain size. The schistose foliation is well developed and some of the plagioclase have undergone saussuritization typical of low grade fluid alteration. The shearing and associated alteration are intense as we move in to the "Ore Zone" from the unaltered chlorite-actinolite schist and there is a strong mineralogical reconstitution of the metabasalt. The rock in the ore zone essentially consists of chlorite, carbonates (mostly calcite), quartz and opaques. The rock shows pinch and swell structures with quartz bodies forming the augens in the pinching portions and chlorite swerve around these quartz "augens". The quartz lenses in the ore zone could have formed by the alteration of original basaltic rock which
involves the liberation of silica from the alteration zones and that mobilization and consolidation of silica thus released along favorable structures, probably brittle fractures could have given rise to these quartz lenses. Most of the gold-quartz vein in the Ramagiri Schist Belt have developed in planes parallel to the original chlorite carbonate schist - metabasalt contact and have undergone shearing and folding deformation reflecting almost the same fold pattern as that of the contacts (Sastri et al, 1973).

It appears that the tholeiitic protoliths in the Ramagiri Schist Belt have been subjected to upper green schist to lower amphibolite facies of regional metamorphism by which the rock was converted to actinolite schist consisting mainly of actinolite, plagioclase, quartz and little chlorite. This assemblage upon interaction with the hydrothermal fluid have given rise to chlorite + carbonate + clinozoisite + albite + quartz + sulfides. The actinolite part of the actinolite schist has been almost converted into chlorite in the wallrock alteration zone. This reaction resulted in the release of silica which forms the quartz. The fluid-wallrock reaction also resulted in the albition of the plagioclase. The calcium released in the above processes goes to make up the carbonates (mainly calcite). The overall mineral assemblages of the mafic rocks of the mineralized central block of the Ramagiri Schist Belt indicate that the rocks have undergone lower metamorphic grade (greenschist facies) alteration and differs from the other two major auriferous schist belts of Kolar and Hutti where the rocks have undergone a relatively higher grade (lower amphibolite facies) alteration.
The ore minerals of the auriferous quartz lodes of the Ramagiri gold fields in the order of decreasing abundance are pyrite, arsenopyrite and chalcopyrite. Pyrite constitutes nearly 85% of the sulfides and forms large euhedral crystals. The sulfide mineral assemblage with pyrite forming a major portion of it is typical of Ramagiri Schist Belt and differs from Kolar and Hutti Schist Belts where pyrrhotite and arsenopyrite dominates the sulfides respectively.

3.2.4. GADAG SCHIST BELT

Petrographic studies of the mafic metavolcanics of the Gadag Schist Belt indicate the presence of two predominant rock types namely the schistose amphibolite and the chlorite schist. These two rock types were collected mainly from the western part of the belt near the Hosur mine area and these metavolcanics host gold mineralization in this area. The schistose amphibolite is a medium to coarse grained rock consisting of actinolite, plagioclase, chlorite, quartz, and carbonates (mostly calcite). The rock has undergone extensive saussuritization of plagioclase and silicification and carbonatization are also common. The chlorite-carbonate schist forms an important litho unit in the vicinity of auriferous zones in the western part of the belt. The rock consists of chlorite, sericite, clinozoisite, quartz and opaques (which are sulfides as seen in hand specimen), with well developed schistosity. The mineral assemblage mentioned above indicate that the mafic metavolcanics of the western part of the Gadag Schist Belt indicate that the rocks have undergone typical lower grade (green schist facies) metamorphic alteration similar to that observed in the Ramagiri Schist Belt of the eastern Dharwar craton.
a. Photograph showing xenoliths of metabasalts in the leucocratic granite indicating the intrusive nature of the contact in the Uti area in the north-eastern part of the Hutti Schist Belt.

b. Photograph showing F3 type open folds in the metabasalts of the Chinchergi area in the northern part of the Hutti Schist Belt.

c. Photomicrograph showing hornblende "augen" in the coarse grained spotted variety of amphibolite. The "augen" could have formed as a result of shearing in two different directions, one cutting the other at a lower angle. Under crossed nicols. 12.5x.

d. Photomicrograph showing a big crystal of sphene in the wallrock alteration metabasalt sample from the Hutti mine. Under crossed nicols. 12.5x.
a. Photomicrograph showing mainly hornblende phenocrysts in a plagioclase ground mass with lot of opaques in the coarse grained spotted variety of amphibolite from the Hutti belt. Under parallel nicols. 12.5x.

b. Photomicrograph of an ore vein sample from Hutti mine, showing abundant rock fragments in them. Under crossed nicols. 12.5x.

c. Photomicrograph of a wallrock alteration zone sample from the Hutti mine showing extensive biotitization of amphiboles. Under parallel nicols. 25x.

d. Photomicrograph of an unaltered amphibolite showing big phenocrysts of hornblende. Under crossed nicols. 12.5x.
PLATE - 3.3

a. Photomicrograph of an ore vein from Hutti Schist Belt showing a big crystal of quartz grain which is broken due to brittle deformation, indicating that deformation continued beyond vein formation. Under crossed nicols. 12.5x.

b. Photomicrograph of a wallrock alteration zone from the Ramagiri Schist Belt showing typical greenschist facies minerals such as epidote (bright green-yellow int. color), fine grained chlorite (extinct position) and carbonates (gray int. color). Under crossed nicols. 12.5x.

c. Photomicrograph of a wallrock alteration sample, showing extensive carbonate alteration in the Zone-IV drill hole of the western block of central arm of Ramagiri Schist Belt. 12.5x.

d. Photomicrograph showing extensive albitization in the wallrock alteration zone sample 4-19 from the Zone-IV drill hole in the Ramagiri belt. Under crossed nicols. 12.5x.
PLATE - 3.4

a. Photomicrograph showing relict actinolite lenses in the chlorite - carbonate schist sample 4-17, from the western block of the Ramagiri Schist Belt. Under crossed nicols. 12.5x.

b. Photomicrograph of a wallrock alteration zone from the Ramagiri belt. The quartz lenses could have formed by the breakdown of actinolite to chlorite. The quartz veins also show pinch and swell structures. Under crossed nicols. 12.5x.

c. Photomicrograph of an alteration zone sample 4-15 from the Ramagiri belt showing the development of fine-grained sericite (center). Under crossed nicols. 12.5x.

d. Photomicrograph showing calcic plagioclase, clinozoisite (bluish gray int. color) and carbonates in the metabasalt of the Gadag Schist Belt indicating a low grade metamorphic alteration. Under crossed nicols. 12.5x.
a. Photomicrograph showing a euhedral Arsenopyrite crystal from the Zone -I Reef of Hutti gold mine. Under crossed nicols. 12.5x.

b. Photomicrograph showing sulfide minerals (mainly pyrite) occurring as veins which are aligned parallel to the schistosity of the host rock in the Ramagiri Schist Belt. Under crossed nicols. 12.5x.

c. Some fine grained oxide mineral probably detrital magnetite, in the carbonaceous phyllite collected from the Zone-V, in the mineralised central block of the Ramagiri Schist Belt. Under crossed nicols. 12.5x.

d. Photomicrograph showing a single grain of arsenopyrite crystal in the ore vein from the Hutti belt which is broken due to brittle deformation. Under parallel nicols. 12.5x.
a. Photomicrograph showing fine grained scheelite mineralization (white int. color) in the host metabasalt from the Uti block in the Hutti belt. Under crossed nicols. 12.5x.

b. Photomicrograph showing euhedral rhombshaped arsenopyrite crystal in the acid volcanic unit from the Uti block in the Hutti Schist Belt. The arsenopyrite has been stretched parallel to the long diagonal of the rhomb. Under parallel nicols. 12.5x.

c. Photomicrograph showing anhedral pyrrhotite (Brick red and green int. color) and subhedral arsenopyrite crystals in the wallrock alteration zone sample from the Hutti belt. Under crossed nicols. 12.5x.

d. Photomicrograph showing a big crystal of pyrite with inclusions of arsenopyrite in a metabasalt sample from the Wondalli block of the Hutti Schist Belt. Under parallel nicols. 12.5x.
a. Photomicrograph showing wallrock alteration zone sample from the Hutti mine showing calcite vein cutting the schistosity of the host rock. Under crossed nicols. 12.5x.

b. Photomicrograph showing very fine grained oxide mineral (white int. color) probably scheelite in the metabasalt of the Uti block in the Hutti schist belt. Under parallel nicols. 12.5x.

c. Photomicrograph showing sphene (center) in the wallrock alteration zone sample from the Hutti mine. Under parallel nicols. 12.5x.

d. Photomicrograph showing albitization (grayish - white int. color) of the wallrock (HO -8) in the Hutti Schist Belt. Under crossed nicols. 12.5x.