CHAPTER I

1.1 Introduction

In recent years lot of attention of scientists has been concentrated on the study of Banded iron formations (BIFs) both on account of its academic as well as economic importance. In India, Karnataka Craton contains a large number of greenstone belts which occur more or less as rectilinear belts with varying widths surrounded by a gneissic/ granitic complex. BIFs invariably constitute an important litho-stratigraphic unit in almost all the greenstone belts of Karnataka Craton. BIFs occurring in the western parts of Karnataka associated with the greenstone belt popularly known as 'Shimoga schist belt' has special significance. This formation which constitutes the marker horizon although the Shimoga schist belt has interesting lithology, structures, geochemistry, and associations. These BIFs have been studied by earlier workers in different segments. The one that has been selected for study is a segment popularly known as the "Bababudan region" or the "Bababudan schist belt".

Though literature exists right from the last century about this schist belt in general and BIFs in particular, there does not exist a detailed account indicating the stratigraphy, the mineralogy and origin of these important formations. In the present study an attempt is made to review the stratigraphy, mineralogy, geochemistry and the
origin of the BIFs in light of the recent works world over on similar formations.

1.2 Regional Geology

1.2.1 Peninsular India

While several attempts have been made to geologically divide Peninsular India in the past, Rogers (1986) recently divided this part of India into five crustal areas (Map 1) as follows:

1. Dharwars and granulite terrain
2. Eastern Ghats
3. Bhandara
4. Singhbhum
5. Aravalli/Bundelkhand.

The term 'Dravidian Shield' is also used by Rogers (op.cit.) for the area including both the Dharwars and granulite terrain. In this shield, Dharwars are most prominent, interesting and controversial among the rock formations of the Indian Peninsula. There are attempts to distinguish west and east Dharwars separated by Closepet - Bellary granite and the Western Dharwar is taken as the type area and hence, referred to as 'Karnataka Craton' (Taylor et al., 1984); 'Dharwar Craton' (Pichamuthu and Srinivasan, 1984) or 'Karnataka Nucleus' (Radhakrishna and Naqvi, 1986) as shown in the Map 2.
Map 1—Cratons and joins in peninsular India. Rift valleys are: I—Godavari; II—Narmada-Son; III—Mahanadi; IV—Damodar. Thrusts are: 1—small thrust in Western Dharwar craton; 2—Eastern Ghats front; 3—Sukinda; 4—Singhbhum (Copper Belt); 5—Son valley thrust, inferred westward; 6—Great Boundary fault. Ch—Chotanagpur.
Map 2.—Generalized geological map of Karnataka nucleus. Note the occurrence of younger K-granitic plutons in the form of a garland encircling the Karnataka nucleus. NHI—Nuggihalli, KUL—Kunigal, KRP—Krishnarajpet. HNP—Holemursipur, RBR—Ranibennur.
1.2.2 Karnataka Craton

The area investigated (Bababudan schist belt or Bababudan region) forms a part of the Karnataka craton within the South Indian shield which happens to be one of the important Precambrian shields of the world. The Karnataka craton exposes several low-grade and high-grade schist belts amidst a vast granite-gneissic complex. Bruce-Foote (1886) proposed the name of 'Dharwar System' for the schistose rocks consisting of metamorphosed sedimentary and volcanic rocks. According to him, the Dharwar schists were deposited on the eroded surface of the granites and the gneisses with a marked unconformity. Therefore, the granites and the gneisses surrounding the schist belts were termed as 'Fundamental Gneiss'. The conglomerates exposed along the western margin of the Sigegudda schist belt, along the southern margin of the Bababudan schist belt and a few other places were regarded by him as the basal conglomerate marking the unconformity. Gradually, a number of workers (Smeeth, 1899, 1901; Holland, 1902; Sampat Iyengar, 1909) brought out evidences indicating that the gneisses and the granites were intrusive into the schist belts. In view of this, the term 'Fundamental Gneiss' was given up in favour of a more descriptive and non-committal term 'Peninsular Gneiss' (Smeeth, 1916). Thus, from the very beginning, the geologists working on the Dharwar schists have been divided into two distinct schools of thought - one regarding the Peninsular Gneiss as the basement for the Dharwar schists
(Bruce Foote, 1886; Oldham, 1893; Slater, 1899; Radhakrishna, 1964; Nautiyal, 1966; Iyengar, 1971 and Swami-Nath et al., 1974) while the other (Smeeth, 1901; Sampat Iyengar, 1909; Holland, 1902; Fermor, 1909; Jayaram, 1925; Rama Rao, 1940, Pichamuthu, 1947; Srinivasan and Sreenivas, 1972, 1976; Pichamuthu, 1982 and Pichamuthu and Srinivasan, 1984) have upheld the intrusive nature of the Peninsular Gneiss into the Dharwar Schists. Some of the workers (Wetherell, 1904; Maclaren, 1906) tried to bridge the gap between these two diametrically opposite views by advocating 'local refusion' of the gneisses. Thus, the geological opinion on the granite-greenstone relationship is divided and remains a subject of controversy even today. As in other shield areas, Karnataka craton also comprises low-grade terrains and high-grade terrains. The latter is well developed in the southern part of Karnataka occurring as enclaves within the Peninsular Gneiss. Mafic-ultramafic complexes are typically associated with the high-grade schists. The stratigraphic and evolutionary model of Swami Nath et al., (1981) assigns an older age to the high-grade terrains (Sargur Group). According to them, the Sargur Group is separated by a profound unconformity from the overlying Dharwar Super Group (low-grade terrains). The Javagondanahalli schist belt (high-grade schists) had been included by Swami Nath et al., (1976) in the Sargur Group and was, in fact, the largest schist belt among the Sargur Groups. However, Ghosh, Roy and Ramakrishnan (1985) revised
the stratigraphic age of this schist belt and brought it into the Dharwar Super Group. The necessity for this revision questions fundamentally the validity of using higher metamorphic grade as a thumb rule for correlating the schistose rocks of Karnataka (Fermor, 1936).

1.2.3 'Greenstone Belt' Concept

The pioneering research work carried out in the other Archaean shield areas such as Greenland, Southern Africa, Western Australia and Canada have gradually led to the development of the 'greenstone belt' concept. Various models have been proposed to explain the development and evolution of the early crust in terms of the greenstone belt concept with or without invoking the plate-tectonics. According to Windley and Bridgwater (1971), Archaean shield areas comprise low-grade (granite-greenstone) and high-grade terrains each having its own distinctive features (Percival and Coe, 1981) which can be generalized.

1.2.3.1 Application of greenstone concept to the Karnataka craton

Growth of modern geological thoughts on the evolution of greenstone belts elsewhere in the world has had its due influence on the thinking among the geologists of Karnataka. Swami Nath et al., (1976) have proposed a stratigraphic and evolutionary model for the Karnataka craton. They have divided the schist belts of Southern Karnataka into low-
grade and high-grade terrains. They indicate a profound unconformity between the high-grade schists (Sargur Group) and the overlying low-grade schists (Dharwar Super Group). They have also divided the Karnataka craton into a 'western' block and an 'eastern' block roughly along the length of the Closepet granite. The western block contains Dharwar schistose rocks regarded by them as 'Proterozoic basins and geosynclines' which differ from the classical greenstone belts in having a persistent basal conglomerate and enormous amount of clastic sediments. According to them, the eastern block contains 'Keewatin type' of greenstone belts.

Naqvi (1976) regards the volcanic-dominant eastern block schist belts as true greenstone belts. Occurrence of volcanic rocks of komatiitic affinity has been reported from the Kolar shist belt (Viswanathan, 1974; Anantha Iyer and Vasudev, 1979; Rajamani et al., 1985). Primary volcanic structures (pillows) and volcanic textures (spinifex) have been reported by some workers (Naqvi and Hussain, 1979; Desai and Deshpande, 1979; Srinivasan and Sreenivas, 1975). On the analogy of the Barberton model, Naqvi et al., (1978) and Naqvi (1981) are inclined to regard the high-grade schists of Holenarsipur and other areas as early Archaean greenstone belts. However, Ramakrishnan (1981) and Ramakrishnan and Viswanatha (1983) doubt the occurrence of komatiitic rocks in the high-grade terrains. According to them, the mafic-ultramasfic rocks show cumulate textures. They are also inclined to think that long blades of anthophyllite,
tremolite and actinolite which crystallized during metamorphism have imparted a pseudo-spinifex texture.

Radhakrishna (1976) described two groups of greenstones (early greenstones and older greenstones) from the Karnataka craton. Radhakrishna (1983) divided the supracrustals of Karnataka into 'ancient supracrustals' (> 3,400 m.y.), 'older greenstones' (> 3,000 m.y.) and 'younger greenstones' (2,500-3,000 m.y.).

1.2.4 Chronological review of the geological studies in Karnataka

Bruce Foote of the Geological Survey of India (1876, 1882, 1888, 1889, 1900) carried out extensive geological traverses across Karnataka and proposed the term 'Dharwar System' for the schistose rocks of South India comprising sedimentary and volcanic rocks. According to him, the schistose rocks were laid on the eroded surface of the granites and the gneisses (which he termed as 'Fundamental granitoid gneiss') with an unconformity.

Almost at the end of the last century (1898), Mysore Geological Department took up systematic geological mapping of the former princely state of Mysore (which now forms the Southern part of Karnataka) on 1"=1 mile scale. It published a Geological map of Mysore on 1"=8 mile scale. Smeeth (1899, 1901) pioneered the idea that most of the
granitic rocks intruded the schists and hence are younger than them. At the suggestion of Hayden, Smeeth (1916) renamed the 'Fundamental granitoid gneiss' as 'Peninsular Gneiss'. During the period 1898–1916, attempts were also made to classify the Dharwar System. Sambasiva Iyer (1905) and Wetherell (1904) made a bipartite classification. Sampat Iyengar (1905) classified the Chitradurga schist belt into three formations, namely Javanahalli Formation, Chitradurga Formation and G.R. Formation. Smeeth (1916) divided the Dharwar System into a lower 'Hornblendic Division' and an upper 'Chloritic Division'. Smeeth (1901) was a strong proponent of igneous origin for the Dharwar rocks. This view persisted despite the fact that primary sedimentary structures were known to exist in the Dharwar rocks. Sambasiva Iyer recognised ripple-marks in the quartzites of Chitradurga area and contended that it was of sedimentary nature.

Recognition of several undoubted primary sedimentary structures such as rain prints, mud cracks, ripple-marks, current-bedding and graded bedding made by Pichamuthu (1935, 1935b, 1935c) and Rama Rao (1936, 1936a) established beyond doubt the presence of sedimentary rocks in the Dharwar System. Rama Rao (1936, 1962) classified the Dharwar System into an igneous complex followed by two sedimentary cycles. According to him, the regional structure of Mysore is that of a synclinorium plunging southward. He also recognised that the grade of
metamorphism increases from north to south.

Pichamuthu (1951, 1962) described an anticlinal structure from Dodguni area. According to him, the regional structure of the schist belts corresponds to an anticlinorium plunging NNW. He (Pichamuthu, 1953) related the increase in the grade of metamorphism from north to south to the depth of burial. He also proposed a classification (Pichamuthu, 1947, 1967) visualising a geosynclinal model. Radhakrishna (1967) gave a 6-fold classification for the Dharwar System and considered the Peninsular Gneiss as forming the basement for the Dharwar rocks.

Nautiyal (1966) revived the view that the Peninsular Gneiss formed the basement for the Dharwar rocks. Akin to Alpine tectonic model, he proposed a 3-fold classification for the Dharwars based on inferred thrusts. Iyengar (1971) proposed a 4-fold classification and elevated the status of the Dharwars to that of a supergroup. He considered the high-grade schists as forming the base of this supergroup. Swami Nath et al., (1976, 1981) regard the high-grade schists of Karnataka as belonging to an older stratigraphic group (Sargur Group) separated from the overlying Dharwar Super Group by a profound unconformity. Rocks of the Sargur Group are intruded by the Peninsular Gneiss which forms the basement for the Dharwar Super Group. This stratigraphic classification has been adopted into the geological map of Karnataka (half-million scale) released by the Geological
Society Of India (GSI) in 1981.

The classification proposed by Naqvi (1981) envisages a basic-ultrabasic lunar type of primitive crust. It also envisages a profound unconformity both below and above the Bababudan Group.

Radhakrishna and Vasudev (1977) have divided the Dharwar Super Group into three groups and placed them above the Peninsular Gneiss. The high-grade schists intruded by the Peninsular Gneiss have been grouped into a complex (Sargur schist complex).

Pichamuthu (1980) has divided the Dharwar Group into high-grade schists, Bababudan subgroup and Chitradurga subgroup. Each of the subgroups is separated from the other by an unconformity.

Radhakrishna and Naqvi (1986) based on available radiometric data, lithologic and sedimentologic evidences gave the following generalised chronology for the Karnataka Nucleus (Map 2) as presented in Table 1.

<table>
<thead>
<tr>
<th>Date (m.y.)</th>
<th>Event</th>
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<tbody>
<tr>
<td>Late Archaean</td>
<td>Invasion of younger granite (K rich) bordering the nucleus</td>
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<td>2600</td>
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Granulite transformation of older crust along the margins of the nucleus.

3000-2600 Deposition of younger schist belts (Shimoga, Chitradurga, Sandur). Conglomerates, orthoquartzite, mafic and felsic volcanic sequence, banded iron formation, greywackes.

Early Archaean

3000 Main development of migmatitic gneisses

3400 Emplacement of oldest tonalite-trondhjemite gneisses with enclaves of ancient supracrustal sequences.

>3400 Deposition of ancient supracrustal sequences mafic, ultramafic, volcanics and chemical sediments.

Basement predominantly mafic crust.

During the last decade, considerable work has been carried out with regard to the geochemistry of mafic-ultramafic rocks (Jafri and Saxena, 1981; Hussain et al., 1982; Hussain and Ahmed, 1982), metavolcanics (Iyer, et al., 1980; Iyer and Vasudev, 1980; Bhaskar Rao and Drury, 1982) and the Peninsular Gneiss (Bhaskar Rao et al., 1983; Jayaram, 1984; Mahabaleswar et al., 1986). Considerable geochronological data have been generated (Beckinsale et al., 1980; Rajagopalan et al., 1980; Beckinsale et al., 1982; Venkatasubramanian et al., 1982; Balasubrahmanian et al.,
1982; Monrad et al., 1983; Stroh et al., 1982; Jayaram et al., 1983; Drury et al., 1983; Ramakrishnan et al., 1984; and Taylor et al., 1984). Chadwick et al., 1981; Mukhopadhyay et al., 1981 and Mukhopadhyay and Ghosh, 1983: have carried out detailed structural studies. Metamorphism and P-T estimates of high-grade rocks have also received considerable attention (Rollinson et al., 1981; Rajamani et al., 1981; Friend, 1981, 1984; Janardhan et al., 1982; Shivakumar et al., 1982; Raith et al., 1982; Janardhan and Gopalakrishna, 1983; Mahabaleswar and Naganna, 1981; Mahabaleswar, 1984 and 1985 and Srikantappa et al., 1985).

1.2.5 Bababudan Schist Belt

This is also referred to as Bababudan region or Bababudan basin. It is one of the prominent schist belts in the entire Karnataka craton (Map 2) and it is so centrally located in the craton that it borders many other schist belts and also gneisses and granites. Hence there is much significance in studying the schist belt as it will help to establish the relationship of the adjoining formations. The schist belt constitutes one of the typical late Archaean volcano-sedimentary terrains and offers an excellent opportunity for the study of stratigraphy, structure, metamorphism, geochemistry and economic geology. The schist belt is also known for its large reserves of banded iron-formations (BIFs) and for lesser deposits like gold, uranium, amosite asbestos etc.
1.3 Location and Accessibility

The area under investigation lies between N 13° 15' to 13° 45' latitudes and E 75° 30' to 76° longitudes and is covered within the Survey of India toposheet Nos. 480/10, 11, 14 & 15.

The Bababudan hill ranges are situated about 20 km. away from Chikmagalur town and is approachable by an all weather road connecting Chikmagalur town with steel plant town Bhadravathi through Attigundi-Kemmangundi, Tarikere and also via Santaveri-Lingadahalli-Tarikere. The track from Attigundi to Kemmangundi being completely hilly. Chikmagalur town is connected with Bangalore and Mangalore through State and National Highways and Kadur is the nearest railway station which is 40 km. away from Chikmagalur.

1.3.1 Topography

Large parts of the Bababudan area are hilly. The proper Bababudan hill ranges which are in the form of horse shoe shape are referred as ‘Chandradhrona Parvatha’ (mountain of crescent moon) in ancient times, on account of their shape. The hill ranges rise to over an average of 4800' and appear as a major topography in the South Indian Peninsula. The hill ranges rise steeply between 2400' to 2700' in the Bababudan region to constitute several prominent peaks. The peripheral slopes of the ranges are characterised by precipitous scarps exposing the outcrops of
BIFs, while the slopes inside the ranges gently descend to the central plains of Jagar valley. The highest point of the hill ranges which is also the highest in Karnataka is Mulaingiri which rises to 6310' above the mean sea-level and is situated in the southern hill ranges. Other peaks are Rudragiri (5750'), Bababudangiri (6099'), Kalhatgiri (6155'), Kemmangundi (4378'), Hebbegiri (4376') etc. To the surroundings of it is the feature of maidan - an open tract amidst the isolated hills. The lower slopes of the hill ranges are the home of Mysore coffee and numerous plantations cover extensive areas in this region. The hilly area receives abundant rainfall. The numerous cascades, water falls and hill streams which drain the slopes of these hills swell into main stream of Somavahini in the picturesque Jagar valley.

1.4 Rainfall and Climate

The major rainfall is during the period from June to September constituting the southwest monsoon season and the northeast monsoon brings the rain to some extent during October and November. The annual rainfall in the district ranges from 250 mm to 2200mm in the past 29 years. The average number of rainy days in a year is about 92 days, with maximum of 122 days at ghat sections and minimum of 42 days in Kadur. The rainfall is heavy in the hill ranges while the surrounding plain country receives very less.
The climate of the Bababudan region is on the whole very agreeable and warm. There is a rapid increase in the temperature after February. April is generally hottest month. During summer the mean daily maximum temperature is 30.7°C (maximum being 36°C) and mean daily minimum is 19°C. With the onset of monsoon in early June, there is an appreciable drop in the day temperature.

1.4.1 Humidity and visibility

The humidity is very high during the monsoon season, generally exceeding 90%. It is comparatively less during the rest of the year, the driest part of the year being the period from January to March particularly in the afternoon. As Bababudan hill ranges arrest clouds during monsoon, the visibility at the hill top is reduced, due to the shutting of clouds. When clouds are thick, visibility is reduced up to 8 to 10 mtrs. In the monsoon months of June, July and August in parts of hill ranges, the visibility is present only for about 15 to 20 days. Cloudiness decreases during post monsoon period and the sky is mainly clear or feebly clouded during the period from January to March. From April onwards, cloudiness increases, the afternoon being more cloudy usually.

1.5 Drainage

The area under study is drained by (i) Somavahinihalla, (ii) Vedavathi and (iii) Yagachi, which are tributaries of
Bhadra, Tungabhadra and Cauvery rivers respectively.

(i) Somavahinihalla: The meandering westward flowing through the thickly wooded jungle in the picturesque Jagar valley is the Somavahini stream which ultimately joins the river Bhadra in the western part of the Bababudan region.

(ii) Vedavathi: The stream Vedavathi is also called as Agari. It is formed by confluence of two streams - the Veda and the Avathi, which spring from the eastern side of the Bababudan hill ranges and the two streams join near Kadur whereupon they are together called Vedavathi as a single river, which ultimately flows in the river Tungabhadra, a major tributary to the River Krishna.

(iii) Yagachi river: The Yagachi river is also known as Badri which rises in the Seethalayanagiri (near Muliangiri) and flows southwards to join the river Hemavathi, a major tributary to the river Cauvery.

1.6 Flora and Fauna

Bababudan hill ranges generally rise to over 4800' and present a fine example of Peninsular mountain vegetation with compact and most useful forest formation known as 'sholas.' The flower decked meadows on its higher slopes is generally associated with swift flowing cool streams.

There is a continuous stretch of valuable forest encompassing the whole of the Jagar valley. It covers the
hill side densely and gives shelter for coffee plantations. Sholas and hanging woods occupy almost every ravine and hollow tracts of Bababudans. The branches of trees are covered by lichens, mosses, and numerous epiphytes and sometimes by climbers. The loftiest heights are covered with much coarse grass, but always bare of trees. In plain countries natural vegetation is much scarce. The most important crops of the area are coffee and paddy. Other crops are arecanut, tea, cardamom, pepper, ragi, jowar etc.

Fauna is rich and varied in this area. There is a wildlife sanctuary and is divided into two wings called 'Muthodi wing' and 'Lakkavalli wing'. The Muthodi wing previously called as the 'Jagar valley wildlife sanctuary'.

1.7 Weathering and Soil cover

The area has been subjected to weathering and denudation. The soil of the region varies considerably from one part to another, reflecting clearly the lithological variations. In the foot regions of the hill ranges, soil has mixed character. It can be clearly seen that around granite-gneissic terrain, gravelly type of soil occurs. In areas of metavolcanics at the centre of the schist belt, absolutely black coloured soil is seen, whereas around BIFs mostly red to brown soil is seen. The role of weathering in the formation of hematite and other secondary ore deposits is discussed in detail in the last chapter.
1.8 Nature and frequency of exposures

Owing to the thick vegetation cover and intense weathering, outcrops are generally less abundant. However, outcrops of BIFs are better exposed than the associated rocks, particularly all along the hill ranges of the schist belt. Steep dipping BIFs are clearly visible with picturesque beauty along the escarpment slopes of the ridges (Figs. A, 3.3 & 3.4). Stray huge chunks of BIFs rolled down from steep cliffs along slopes and flanks are often mistaken for insitu outcrops. The plain low land areas are mostly cultivated, but some small hills, mounds or elongated small ridges occur, which are commonly made up of granite, gneiss, conglomerate, quartzite, schist, and basic, ultrabasic intrusions of sills and dykes.

1.9 Review of previous work on Bababudan Region:

A critical survey of the literature on the geology of the Karnataka reveals that BIFs of Bababudan schist belt have received the attention of many officers of the State Geological Department, Geological Survey of India and many other research workers. In the forthcoming paragraphs, the author presents the various views expressed by different investigators about the Bababudan schist belt of Karnataka.

Bruce Foote (1882, 1888, 1900) in his paper after detailed survey of the area, considered that the basal conglomerates occupying in this area are resting on
granitoid basement. According to him the conglomerate is overlain by flows of dioritic and basaltic trap intercalated with schist and quartzite followed by a great thickness of traps, trapoid flows and interbedded with quartzite, which in turn are overlain by ferruginous quartzites.

**Slater (1904, 1905, 1906)** felt that except for Kaldurga conglomerates to which sedimentary origin might be ascribed, all other rocks belonged to a basic and acid igneous group. He also said that the Kaldurga conglomerates consist of varied pebbles and represent the crushed phase of quartz porphyry.

Sampath Iyengar and Slater after their extensive work presented the first detailed geological map (Smeeth, 1908) of the area. They classified the rocks into Bobabudan and Tarikere Series.

**Sampath Iyengar (1908)** first reported the occurrence of banded magnetite quartzite together with a few patches of oxidised and enriched hematite ore in the Bababudan hill range. He made several observations regarding the origin of different rock types and also on the structure. He reported magnesio-riebeckite, for which the term 'Bababudanite' was first coined by Smeeth and subsequently worked out in detail by Pichamuthu (1953). Regarding the quartzite of the southern region, Sampath Iyengar was of the opinion that it represents crushed quartz reef and that the pseudo-conglomerate of Chikmagalur was produced through intensive
shearing caused by the intrusion of Chikmagalur granite into the Bababudan schist belt. The Bababudan curvature was ascribed by him as due to the intrusion of the gneissic complex.

Slater (1908) resurveyed the northern portion of the schist belt. He felt that the sequence of rocks in the northern Bababudan area are nothing but lower unit of 'effusive hornblende trap' (Lingadahalli trap), intruded by felsite, quartz-porphyry, keratophyre and overlying this was a series of magnetite quartzite and aphanetic greenstone.

Smeeth (1908) discussed the mutual relationship between the Bababudan Series and Tarikere Series which rest directly on the lower hornblende schists instead of upper ironstone of Bababudan Series. The junction was considered as an erosional unconformity. Debating the position of hornblende trap of the Jagar valley, he felt that they might represent an upper horizon above the ferruginous rocks and he also felt that the granite was intruded by the gneiss.

Balaji Rao (1913) traversed the south-eastern portion of the schist belt and reported concentration of gold and copper in the basal conglomerate at Kalasapura, Mallenahalli, Karthikere, Dhataramakki.

Sampath Iyengar (1915) after detailed survey of the area, concluded that the Bababudan Series formed the base of the Bababudan belt and composed of lava flows and intrusive
sheets of sills represented by green trap hornblende schist, amphibolite, brown mica and chlorite schists, peridotite and hematite quartzite. The mica schist, amphibolite (iron amphibolite schist) and hematite quartzite were regarded as metasomatic alteration of Bababudan schists. The Bababudan Series comprising felsite porphyry and biotite gneiss with opalecent quartz blebs, all of which were metamorphosed into calc-chlorite schist (Keratophyre), siliceous talc-sericite schist and crushed conglomerates of Kaldurga.

Smeeth (1915) revised his earlier opinion that the chlorite rocks (Tarikere Series) rest unconformably on hornblende rocks (Bababudan Series) on the evidence that the iron-formations rested both on hornblende and chlorite schists at different places and were overlain by hornblende schist in Jagar valley. The ironstones resting on hornblende schists in the Tarikere valley could not therefore be regarded as making an erosional unconformity. The isolated iron ore hill between Lingadahalli and Birur and those of Sunkanagiri were outliers separated by folding and denudation. The conglomerates of Kaldurga were seen by him as resembling the autoclastic conglomerates of Kolar schist belt.

According to Jayaram (1922, 1923) the Allampur conglomerates were considered as autoclastic and Kaldurga conglomerates were equated to Champion Gneiss Series.
Pichamuthu (1935, a, c, d, e, f, g) in a series of papers on the area established the sedimentary nature of Kaldurga and Allampur conglomerates, iron-formations and the associated schists and quartzite against the much favoured high tide of igneous opinion of earlier workers. The stratigraphic sequence proposed by him consisted of epidiorite flows associated with spilitic rocks and grading into chloritic quartzite overlain by argillite, schists rich in chlorite, mica, talc, tremolite and actinolite interbedded with iron formation, Galipuje felsite, epidiorite sills and dykes of quartz and dolerite.

Rama Rao (1936) studied some conglomerates of the area and accounted sedimentary origin and the pebbles in conglomerates, he felt as resembling granite porphyry of Ramadurga and Balekal situated further north.

Ramachandra Rao (1938) discussed the relationship of Bababudanite to rhodesite and concluded that rhodesite was an end member of glaucophane-ferri-glaucophane series, whereas Bababudanite according to him was to be regarded as an intermediate member in ferri-glaucophane-riebeckite series.

Pichamuthu (1952a) after determining detailed physical, optical properties and mineral chemistry of Bababudanite, concluded that the mineral was formed as a result of metasomatism and the soda having been transformed from a basic igneous rocks to the banded ferruginous quartzite.
Pichamuthu (1967) considered the possibility of Bababudan belt representing the oldest Dharwar rock in the Karnataka craton.

Chakrapani Naidu (1968) based on microscopic, chemical and X-ray studies of the banded iron-formations concluded that the iron-formations as originally iron rich sediments metamorphosed under the low grade regional metamorphic conditions of green schist facies with temperature of the order 300°- 500°C.

Iyengar (1971) also considered the Bababudan schist belt as structural impress of a much older age than most of the rocks of Dharwar System.

Srinivasan and Sreenivas (1972) have given the geosynclinal succession of Bababudan schist belt commencing with Lingadahalli-Santaveri trap and felsite resting unconformably on the Archaean basement, followed by Chikmagalur granite, orthoquartzite-magnetite-quartzite. This was succeeded by the Lakkavalli intrusion with structural unconformity and are overlain by orthoquartzite and limestone of Nandi-Hosahalli area. Intense granitization had followed resulting in the development of Peninsular Gneiss to the east of the schist belt and the margins accompanied by intrusion of Chikmagalur granite.

Narayana Kutty (1974) presented the physical properties and mineral chemistry of the aegirine and magnesio-
riebeckite occurring in iron-formations. After reviewing the various ideas expressed by others, he opined regarding the origin of minerals as follows: "Since, the magnesio-riebeckite-aegirine zones occur as distinct bands and are not spatially related to basic sill, soda metasomatism need not be a factor in their genesis".

Gavi Setty (1975) estimated the reserves of amosite (about 1000 tonnes) in the iron-formation between Kavikalgundi-Manikyadara in southern Bababudangiri and also around Kemmangundi-Kalhatgiri in north-eastern Bababudan.

Bhaskar Rao and Naqvi (1978) and Bhaskar Rao and Drury (1982), while giving a detailed geochemistry of metavolcanics of the area, concluded that they comprise a bimodal basalt—basaltic andesite—rhyodacite suite, the felsic component being the younger and characteristic of the Santavery area. Their further conclusion that these volcanic rocks are parts of a marginal platform association was questioned and objected by Chadwick et al., (1985) because of their limiting sampling. Further, after detailed trace elemental study they concluded that the volcanics of the area showing calc-alkaline affinities being derived from a common parent magma by combination of pyroxene, olivine, plagioclase and magnetite fractionation.

Viswanathaiah and Venkatachalapathy (1980) reported the occurrence of microbiota in BIFs. Thirteen forms of specific and non-specific taxonic categories have been
described and illustrated.

In recent years officers of National Mineral Development Corporation have surveyed in detail a portion of Bababudan hills in connection with the mineral investigation of BIFs for exploration and exploitation.

Viswanatha and Ramakrishnan (1981) proposed that the Bababudan Group in the Bababudan region be divided into four formations which they called in ascending order as the Kalasapura, the Allampura, the Santaveri and Mulaingiri formations and described each one of the formations in detail.

Naha and Chatterjee (1982) while working on the structure of the area recognised three generations of foldings from small to large scales. The peculiar horse-shoe pattern of the hill ranges was attributed by them mainly due to superposition of $F_3$ folding on $F_2$ folds.

Chadwick et al., (1985) provided a comprehensive description of the lithostratigraphy and structure of the whole basin and enlarged the definition of previous subdivisions of Viswanatha and Ramakrishnan (1981) in terms of introducing additional formations namely the Mundre Formation, which includes the prominent Kaldurga conglomerate in the northeast and the Jagar Formation which overlaps the Mulaingiri Formation and is believed to be the lateral equivalent of Mundre Formation.
Mukhopadhyay (1986) suggested that the F1 and F2 folds might have formed in the early and late stages of the same deformation episode and that the near coaxial refolding of earlier folds during the later stages of progressive deformation at places given rise to reclined or recumbent geometry of the folds.

Chadwick et al., (1986) have concluded that the pre- and syntectonic textures of magnesio-riebeckite are regarded as the products of percolating solutions rich in Na and Mg interacting with host during diageneis at very low grade burial metamorphism and related progressive deformation. They felt that the magnesian siderite and aegirine as commonly replacing magnesio-riebeckite in parts of the tectonic fabric.

Ramakrishnan and Viswanatha (1987) in their recent mapping in the southern Bababudan have confirmed the angular unconformity between the Dharwar cover and Sargur Peninsular Gneiss basement.

1.10 Methods of investigation

The area of Bababudan schist belt was traversed regionally, after reconnaissance survey, mainly to collect samples. For this purpose, earlier maps particularly the one published by Viswanatha and Ramakrishnan (1981) was referred. A systematic collection of samples of BIFs and
associated rocks distributed in the area was carried out. The collected samples were used for petrological, mineralogical and geochemical investigations.

More than 400 representative samples of BIFs and associated rocks were examined in transmitted/incident light. The rocks and BIFs were then classified petrographically on the basis of their mineral assemblages and textures. The optical characters of various minerals such as pleochroism, birefringence, refractive index, extinction angle ($Z^c$) and $2V$ were determined. Microchemical tests including etching test were done on some selected samples for confirmation of carbonate minerals. Modal analyses were carried out for some selected rock types.

BIFs and other iron ores were studied in detail under ore microscope and most of the properties recorded. Based on this, several ore minerals are identified. Quantitative estimations like microhardness have been recorded.

The representative rock samples and BIFs were analysed for major and trace elements and a few for REE. The major and trace element analyses of iron formations and associated rocks were performed with conventional wet chemical methods and trace elements were determined by spectrographic methods. The REE analysis was performed by instrumental neutron activation analysis at Isotop Laboratorie, Riso (Denmark).