

**FIELD GUIDE
TO
Selected Gold Prospects in
Karnataka and Andhra Pradesh**

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A Call for Action

India has been known as the land of gold since ancient times. Numerous old workings for gold exist in almost every state. There is no doubt that it was once a flourishing industry providing employment to a large number of people. For various reasons this activity suddenly ceased and most of the mines had to be rediscovered but the industry failed to recover the earlier status or grandeur. Since making money and not provision of employment was the sole object mining activity became concentrated at one or two places like Kolar and Hutti. Even at Hutti mining was started as a famine relief operation. The history of gold mining at Hutti indicates how a small prospecting venture can be made a profitable through careful management. The numerous other known occurrences of gold can also be brought to the stage of Hutti but lack of interest on the part of the government and industrial establishment has allowed an industry with enormous growth potential and employment to remain stagnant. Exploration seems to go on forever without taking forward steps for development into productive ventures. Valuable time is lost in formalities, in framing rules. Numerous restrictions are imposed and the process of granting mineral concession itself is inordinately delayed, maps and exploration details are withheld offering no incentive to entrepreneurs who are prepared to risk their money.

A more liberal policy is called for. Employment generation and improving the standard of living of the people has been sadly neglected.

The example of China should be an eye opener. China which was way down in the list of countries producing gold, today tops the list overtaking giants like USA, Russia and South Africa. It would be worthwhile to form a special group for studying the ways and means by which that country has been able to take a giant leap and achieve spectacular results.

The identification of obstacles which are hampering the growth of the industry and steps to be taken for revival of the industry should form the main task of the Group Discussion being held. The goal should be to utilize resources lying idle, creation of rural employment on a massive scale and thereby improving the standard of living of the large majority of the rural population of India

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National Seminar on Gold Industry in India

It is to be hoped that this Seminar presages a re-vitalisation of gold mining in India. For far too long has it been forced to play a very minor and subsidiary role in the country's economy, its potential for the development of, usually, backward districts, employment and the production of a metal of international value and demand virtually ignored. All participants may be assured that, properly conceived and executed, most of the known prospects can mature into viable mines. In this connection a start has already been made on a combined opencast and underground operation in the Gadag Gold Field. I wish all participants all success in their endeavours to re-establish an ancient industry in modern form.

L.C. Curtis

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FIELD GUIDE TO SELECTED GOLD PROSPECTS IN KARNATAKA AND ANDHRA PRADESH

INTRODUCTION

- Over 100 occurrences, prospects and deposits of gold are distributed in the Neoproterozoic greenstone belts of Dharwar Craton that occupies an area of 320,000sq km in parts of Karnataka, Andhra Pradesh, Goa, Tamil Nadu and Kerala States. Amongst them there are about 25 deposits with a total gold endowment (gold produced if any + existing drilled resources) in the range of 0.5 to 1 tonne, about 20 deposits in the range of 1 to 6 tonnes of gold and only two major deposits, Kolar and Hutti, with a total endowment in excess of 100 tonnes. The Giant Kolar Gold Fields has produced about 800 tonnes of gold in its mining history.
- Most geologists now acknowledge that significant gold mineralization in the Dharwar Craton is associated with a major event of accretion of volcano sedimentary basins during a convergent tectonic regime. Field data supports a new plate tectonic model for development of the Neoproterozoic Dharwar Craton. The craton comprises a Foreland with its volcano-sedimentary basins classified under Dharwar Supergroup and their basement Peninsular Gneiss containing older supracrustal rocks in the western half of the craton and, an Accretionary complex dominated by polyphase calc-alkaline plutonic rocks interspersed with relics of intra-arc basins (schist belts) in the eastern half (Chadwick et al. 1996, 2000). Kolar, Hutti, Ramagiri, Jonnagiri, Gadwal, Raichur, Kushtagi-Hungund and Sandur belts form part of the Accretionary complex.
- The Foreland basins are characterized by shallow marine or fluvial orthoquartzites, bimodal basaltic and rhyolitic suites, banded iron formation, polymict conglomerates, greywackes and lime stones. They have unconformable or faulted contacts with basement orthogneisses.
- The eastern Accretionary complex comprises multipulse anatectic and juvenile granites and granodiorites with subordinate diorites. The schist belts represent intra arc and marginal basins which are also of mixed-mode type with dominant bimodal volcanic, subordinate sedimentary suites comprising greywackes, psammopelitic sediments and polymict conglomerates. The geochemical characteristics of the metabasalts of the greenstone belts supports the Island arc tectonic setting of schist belts in The Foreland and intra arc basins were thickened by thrusting during NE-SW to E-W shortening.
- The steeply dipping sheets of granite plutons were emplaced prior to, during, and after the main episode (D1) of NE-SW to E-W shortening. Both the Foreland and the Accretionary complex are characterized by several steepened thrusts and crustal scale shear zones.
- Gold and sulphide-gold lodes in the Dharwar craton are hosted by metabasalts (Eg. Kolar, Ramagiri, Hutti belts, Bellara in Chitradurga belt and Hosur in Gadag

belt); metagabbro (Manigatta-Sygattur in North Kolar belt); metaultramafites (eg. Kempinkote in Nuggihalli belt), meta psammopelites and associated polymict conglomerates (Chigargunta, Maharajagadai and Surapalli in Kolar belt), banded iron formation (Ajjanhalli in Chitradurga belt, Mallappakonda in Kolar belt Ganajur, Karajgi, Mangalgatti, Bhavihal, Lakkikoppa, Chinmalgund in Dharwar-Shimoga basin and Hirenagnur in Hutti belt), contact of metabasalt and graywackes/phyllite (Sangli, Attikatti, Kabulyatkatti in Gadag belt; C.K. Halli, G.R. Halli in Chitradurga belt), contact of metabasalt and felsic volcanic rock (Hira-Buddini in Hutti belt) and granodiorites and K-rich granites (Dona East and South Blocks in Jonnagiri belt, Yatkal in Hutti belt, Boksampalli in Ramagiri belt, Honnemardi in Chitradurga belt, margins of Hagari and Kushatagi belts).

- Major gold deposits are commonly located along tensile fractures or faults close to major discordant crustal scale shear zones marking either the margins of schist belts or contacts of major litho units in the interior of schist belts.
- A significant gold deposit is the net product of interplay of gold source rocks, efficient extraction of gold from the source, its transport in a fluid medium through permeable rocks and along open conduits and interaction of fluids with suitable lithologies to deposit the metal. Typically the process of deposition of gold occurs late in the tectonic history of a greenstone belt that is commonly associated with syn-to late tectonic emplacement of granitoids and terrain uplift. Movement of mineralizing fluids occurs in response to geodynamic triggers (eg. seismic events that pump fluids up the conduits), involving changes to the local stress regime that are relatable to far-field stresses propagated across the craton.
- As in other cratons of the world the most common style of mineralization in the Dharwar greenstone belts is structurally controlled, epigenetic, ‘orogenic’ or ‘lode gold’ style most commonly associated with quartz \pm carbonate veining and sulphidation of high strain zones or certain litho units such as BIFs or carbonaceous phyllites.
- Gold mineralization in the Accretionary complex as well as the Foreland took place during progressive development of ductile schistosity during the first major event of deformation (D1) that overlapped with retrogression to greenschist facies associated with hydrothermal activity (solution transfer and volume reduction) along high strain zones disposed parallel or subparallel to the D1 regional schistosity. This event was an integral part of a continuum of NE-SW and E-W orogen-normal shortening and granite emplacement during Neoproterozoic oblique convergence in the foreland and accretionary complex. Conjugate small scale shear zones at a high angle to the D1 schistosity also developed during this continuum indicating that deformation in the continuum became increasingly brittle and localized as a result of dehydration processes.
- Gold mineralization is defined by schistosity-parallel as well as discordant fracture-controlled quartz-carbonate veins, folded in places, localized along NNW, NW, NNE and N-S trending high strain zones of schistose metabasalts, greywackes, BIF, foliated granites and granodiorites, felsic volcanic rocks, polymict conglomerates associated with metapsammopelites (‘Champion Gneiss’). These rela-

tionships show that hydrothermal activity, fracturing, vein formation and precipitation of gold from hydrothermal fluids took place as part of the progressive development of ductile fabrics (penetrative schistosity, pervasive mineral lineations, clast and pillow elongations and such other stretching lineations) closely tied to the D1 deformation continuum during NE-SE to E-W shortening of the craton.

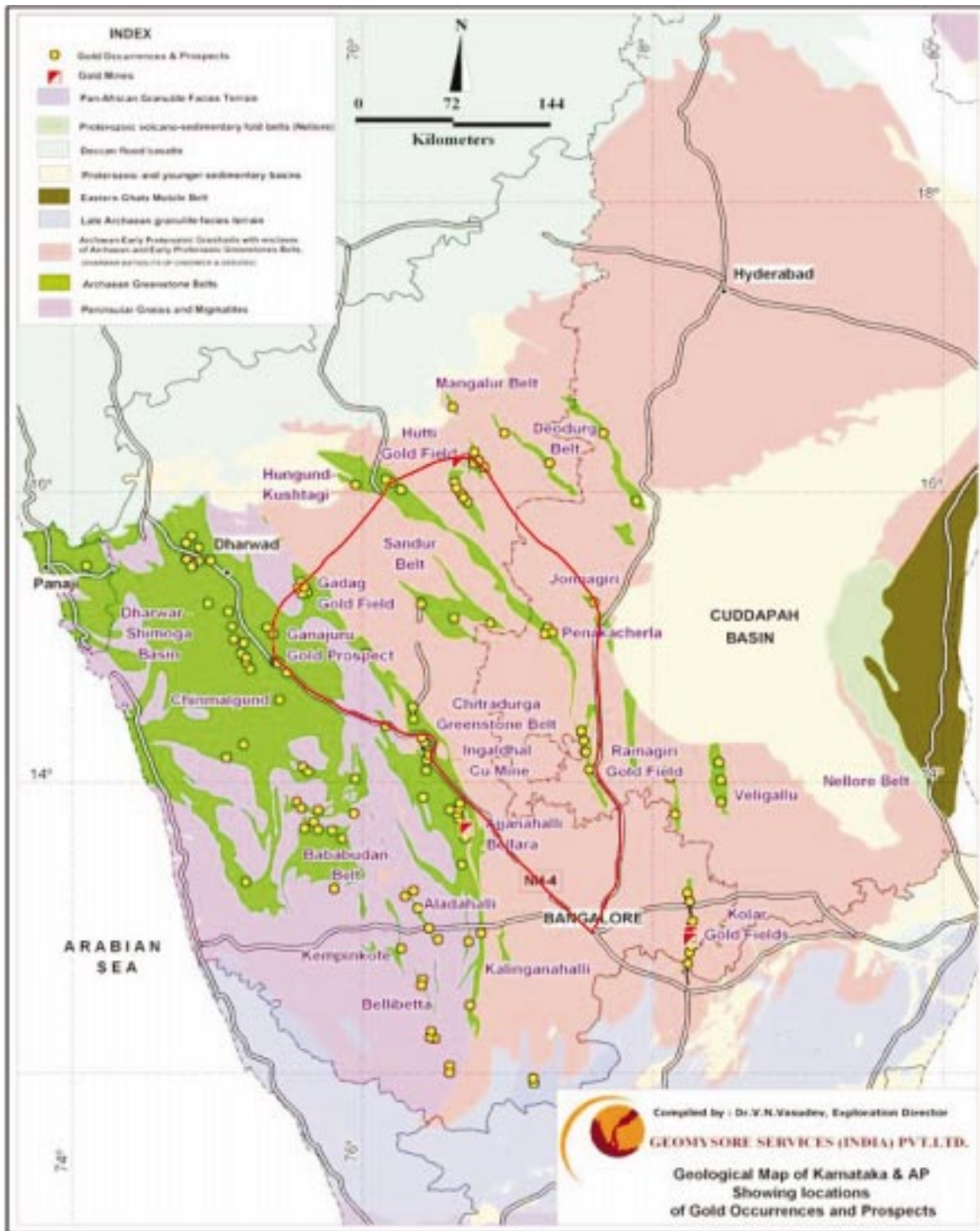
- The timing of the event of gold mineralization in the Drarwar Craton is placed at ~2,547 Ma (Srinivasa Sarma et al., 2009, Econ. Geol. v.103, pp.1715-1727) and is relatable to the timing of emplacement of voluminous granitoids in the eastern Dharwar Craton.
- Hornblende, actinolite and biotite garbenschiefer textures across the schistosity in hormfelses rocks and also in non-hormfelses rocks in shear zone was the result of regional HT-LP facies metamorphism that was closely tied to emplacement of voluminous granitoids between the schist belts. The HT assemblages were variably retrogressed along high strain zones to green schist facies assemblages as a result of hydrothermal activity.
- With this background we will now review the geology and mineralization features of the gold mines and prospects proposed to be visited.

TOUR ITINERARY

The Geological Society of India has planned to take the delegates attending the Seminar on 'Gold Mining Industry in India' on a tour of seven well known gold fields located in Karnataka and Andhra Pradesh States. The following are the seven gold fields proposed to be visited between 30th of May to 5th of June 2009.

- 1) Bellara-Ajjanahalli Gold Fields : *30.05.09 halt at Chitradurga.*
- 2) Chitradurga Gold-Sulphide Zone Comprising Ingaldhal cooper-gold mines and G.R.Halli Gold-Silver deposit : *31.05.09 and proceed to Ganajur via Haveri.*
- 3) Ganajur Gold Deposits near Haveri and its Satellite Prospects : *31.05.09 halt at Gadag.*
- 4) Gadag Gold Fields : *01.06.09 proceed to Hutti Gold Mines and halt.*
- 5) Hutti Gold Mines and its satellite mines at Uti and Hira-Buddini and Hirenagnur Gold Prospect : *02.06.09 halt at Hutti Gold Mines.*
- 6) Jonnagiri Gold Fields : *03.06.09 halt at Adoni after visiting Jonnagiri Belt.*
- 7) Ramagiri Gold Fields : *04.06.09 visit Jonnagiri Gold Field and Ramagiri, return to Bangalore.*

These gold fields are located in the Neoproterozoic Greenstone belts of the Dharwar Craton. This field guide book is intended to provide the delegates with the salient aspects of geology, mineralization and exploration history of these seven gold fields.



Geological map showing the location of 7 Gold fields
 1.Bellara, Ajjanahalli 2. Ingaldhal, G.R Halli 3.Gonjajur 4.Gadag
 5.Hutti 6. Jonnagiri 7.Ramagiri

Fig.1.

BELLARA & AJJANAHALLI GOLD MINE

BELLARA

Ancient workings for gold are located about two km ENE of Bellara, a road- side village on the Sira-Huliyar road. Gold is seen in quartz veins traversing metabasalt described in literature as the Bellara trap. Some amount of prospection was carried out by the Indian Mines Development Syndicate in 1902-1905. Two quartz reefs, one the Bellare Reef- on the top of the low mound, and the other, the Tank Reef at the foot of the hill, were located by sinking several shafts. The results were not found promising at the prevailing low price of gold and further work was suspended in 1905.

Mine dumps lying around the shafts looked promising with visible particles of gold and encouraged by this sign, the mine was reopened in 1944 by the Mysore Geological Department and the Tank Reef explored in two levels. Exploration, however, did not go beyond the stage reached in the earlier years by the Indian Mines Development Syndicate. In the eastern section a few rich pockets of quartz reef carrying coarse gold were encountered but the overall width of quartz reef and the grade proved to be poor and further work was stopped I 1954. About 4000 tonnes were treated in a crude mill and 2000 ozs (62 kg) of gold recovered.

A belt of schists extending from Bellara in the south to Annesidri in the north shows sulphide facies banded iron formation set within volcanic rocks. A major shear zone marks the eastern margin of the Chitradurga schist belt along which there are several mylonitic granitic masses. The structural and geological setting is thus conducive for gold mineralization. The sheared eastern margin of the Chitradurga schist Belt needs to be explored thoroughly.

Drilling Exploration by GSI (*Source: H.S.M.Prakash (1997), Rec.GSI.vol.130 pt.5, p.62*): The drilling work in the Tank Reef and the Bellara Reef was continued. 1,394m was drilled in 8 boreholes, BG-8 to BG-12, on the Tank Reef and BRG-13 to BRG-15 on the Bellara Reef.

Tank Reef: The main lode was traced for 900 m from BG-1 to BG-10. The shear zone is persistent with thin ribbons and veins of quartz with lensoid (pinch and swell type) development as in BG-5(0.8m) and BG-8(2.05m). In addition to the Main lode (West lode or A-lode), three more subparallel lodes were delineated based on drill intersections, namely B, C and D. These lodes range in length from 100 m to 500 m with width varying from 0.30 to 1.50 m. Their Au content varies from <25 ppb to 0.24 g/t.

Bellara Reef: BG-13 and BG-14 drilled at 100 m interval on the Bellara Reef have intersected the quartz lode. 1.9 m thick quartz vein within sheared metabasalt was intersected in BG-13 which showed Au 0.4 to 1.2 g/t over 1 m. BRG-14 intersected a 4m wide zone of quartz vein plus altered basalt. BG-15 intersected an intense fault breccia zone over 1.5m although with no silicification. The Bellara Reef trends N 30° E with easterly dip of 70° and can be traced for 200 m in BRG-13 and BRG-14. Altogether 2,955 m was drilled in the Bellara area and a total of 1,361 core samples were collected from 15 boreholes from BG-1 to 15.

AJJANAHALLI

Ajjanahalli is about 12km north of Bellara and falls along a N-S trending subsidiary shear zone sub-parallel to the main belt margin shear zone to the east. Even here, encouraged by the existence of extensive old workings, the Indian Mines Development Syndicate had driven several adits at different levels in to the Gavigudda. Exploration outlined a large sized ore body within sulphide facies iron formation assaying 1 to 8 dwt (13.6 g/t) in different sections. Gold mineralization is also found in vein quartz localized in silicified and carbonated shear zones. Ore minerals include pyrrhotite, arsenopyrite, and chalcopyrite minor Sphalerite and carbonaceous matter. At least six parallel mineralized bands in the iron formation have been identified. Overall width of the mineralized zone is 150m. a bulk sample of 200 tonnes assayed 3.7 dwt (6.8 g/t) per tonne. About 3 million tonnes of ore analyzing 3.5 g/t tonne on average are estimated to be available.

This property has recently been taken over for development as an open-cast mine by the Hutti Gold Mines Co Ltd. The mined ore is transported for treatment at the mill at Inghal near Chitradurga.

Geology and Mineralisation: The gold field comprises metabasalts, banded iron formation, phyllites and greywacke with intercalated conglomerates. A large oval shaped body of metabasalt and its sub-volcanic dolerite designated as Bellara Trap constitute the core of a northerly plunging tight isoclinal anticline defined by a series of parallel BIF bands. The anticlinal fold closure is prominently exposed between Gungarpente and Ajjanahalli. The axial planes trend N-S and dip steeply to the east. The fold axis plunge north at ~40°. A number of N-S shear planes are traversed by N-S trending and steeply dipping quartz - carbonate veins. Both the veins and the sheared sulphidic banded ferruginous chert carry gold. The mineralized fractures and veins are developed over a very wide zone, of ~1.5 km, in the closure region of the anticline.

The mineralization is structurally controlled and epigenetic. Mineralization involved silicification, carbonatization and sulfidation. Fine grained arsenopyrite, pyrite, pyrrhotite and minor chalcopyrite are the important sulphide phases in the ore. There is no lateritization but deep oxidation up to about 60 meters from the top of the hill. Free particles of gold resided in the oxidized ore. Diamond drill cores from unoxidized depths show layers of sulfides and chert. It is unclear as to whether some or all of the sulfidic ore subsurface is refractory.

Exploration by GSI: GSI conducted exploratory trenching and diamond drilling between 1987 and 1993 and classified the gold field into the following three blocks;

- (i) The Central Block or what is commonly referred to as the Ajjanahalli gold deposit mined by M/s HGML,
- (ii) Ajjanahalli Eastern Block and
- (iii) Ajjanahalli Western Block.

Exploration in Ajjanahalli Central Block (Rec.v.129, pt.5, 1996, p.70): GSI has drilled 3,133m in 21 bore holes (?) and identified 7 parallel mineralized zones which they refer to as lodes. The results of this exploration are tabulated below:

- (1) No of lodes = 7 parallel lodes

- (2) Strike length = Varies from 50m to 670m. Cumulative of all reefs is 1340m.
- (3) Width = Total width of the mineralized zone is 150 m.
 At 2 g/t cut off 6.73 m to 31.71 metres
 At 1 g/t cut off 12.82 m to 52.41 metres
 At 0.5 g/t cut off 15.82 m to 76.32 metres

Resources and Grade of ore = Based on the diamond drilling data GSI has estimated the ore reserves & grade as presented in the below:

Cut off grade	Reserve in million	Av. grade (tonnes)	Gold (kgs)
(A)	2.0 g/t 0.440 mt	3.88 g/t	1,718
(B)	1.0 g/t 0.774 mt	2.76 g/t	2,137
(C)	0.5 g/t 1.511 mt	1.76 g/t	2,660

Mining by HGML in Central Block: In 1993, the **Hutti** Gold Mines started exploratory mining operations in the central block by opening long trenches at different horizons of 710 RL, 680 RL, and 650 RL. Based on this data a total ore reserve of 1.2 million tonnes at 2.5 g/t Au grade was estimated upto the ground level horizon and started experimental opencast mining at a rate of **300** tpd and transported the ore 80km north to the refurbished copper concentrator plant existed at Ingaldhal Copper Mines near **Chitradurga**.

Ajjanahalli Central Block has yielded about 750,000 tonnes of mostly oxidized ore of an average grade of 2 g/t (1.75 to 2.4 g/t). The recovery grade was 1.7 g/t gold on the average. This equates to a metal content of 1.2 tonnes of gold.

AJJANAHALLI WESTERN BLOCK (Rec.v.129, pt.5, 1996.p.70)

This block is located 250m west of Ajjanahalli Central Block and exposes 5 parallel bands of tight isoclinally folded BIF covering an area of 0.3 sq km, having 860 m length and 360 m width. 19 BH have been drilled by GSI. Gold was encountered between 34.40m to 227m depth range. Mineralization is in sheared BIF and carbon phyllite with quartz-carbonate veins carrying sulphides— Py,Po,Apy. Good concentration of Arsenopyrite was met with in BIF in BH: AGW 24 & 25. The mineralization is in grey quartz with ankerite, eg: BH AGW 29. The total strike length proved by drilling was 760 m (GSI Rec. v.126, pt.5, p.174). Thickness of mineralization varies from 0.8 m to 7.5 m.

Reserve: Based on drilling data till end of 1993, GSI has estimated 6.3 lakh tonnes of ore of an av. grade of 2.18 g/t estimated for a length of 250 m and true width of 1.88 m.

Though the mineralization is confined to a zone which is as wide as 8 metres, the sampling was restricted to narrow quartz veins (?) traversing BIF. Entire core lengths appear to have not been sampled.

AJJANAHALLI EASTERN BLOCK

Ancient gold workings are found in two zones of 250 m & 400 m length within BIF bands intercalated with phyllites (argillite-greywacke). The dump from the ancient

workings gave a max of 2 g/t gold. Trenching indicated persistence of gold mineralization over a strike length of 400 m with a max gold value of 9.9 g/t. Gold mineralization is confined to sheared BIF with quartz -carbonate veinlets and oxidised sulphides. The width of mineralized BIF varies from 5 to 11 m. 962 m drilling has been carried out by the GSI (Rec. v.128/5, 1997, p.57) and six parallel reefs have been delineated.

Near the contact of the schistose units with Bukkapatna mylonitic granite, a sample of fuschsite quartzite has given a value of 0.8 g/t gold. Trenching has exposed mafic and ultramafic rocks with ferro-dolomite bands and thin BIF near the contact with the mylonitic granite.

GUNGARPENTE PROSPECT (Rec.v.129, pt.5, 1996, p.70)

A part of the over 12km long BIF band exposed to the west of Gungarpente village is referred to as Gungarpente prospect. This band constitutes the western limb of the tight synclinal fold in the west of the Ajjanahalli Central Block. The BIF is sulphidic and auriferous. The ground explored for gold is 500m long, 3 to 8m wide. Samples have yielded values up to 6.6 g/t. Wall rock alteration involved muscovitization and chloritization.

NERALAGUDDA PROSPECT

An area of 210m x 120 meter is covered by ancient pits opened in phyllites on either side of a long band of BIF and ferrodolomite at 3 km west of Neralagudda and 4 km SE of Ajjanahalli. Visible gold is seen in the oxidised ore of Neralagudda which analysed 2.5 ppm gold. Another zone of ancient pits is located in the BIF ridge W of the above zone.

GSI took up diamond drilling in 1996 (?) but discontinued after drilling a few holes due to objections raised by the Forest Department officials. We understand that the GSI has resumed drilling. Neralagudda has the potential to become a mineable deposit.

Location map of group of Gold deposits
Bellara, Ajjannahalli, Ingaladhhal & G.R Halli
KARNATAKA

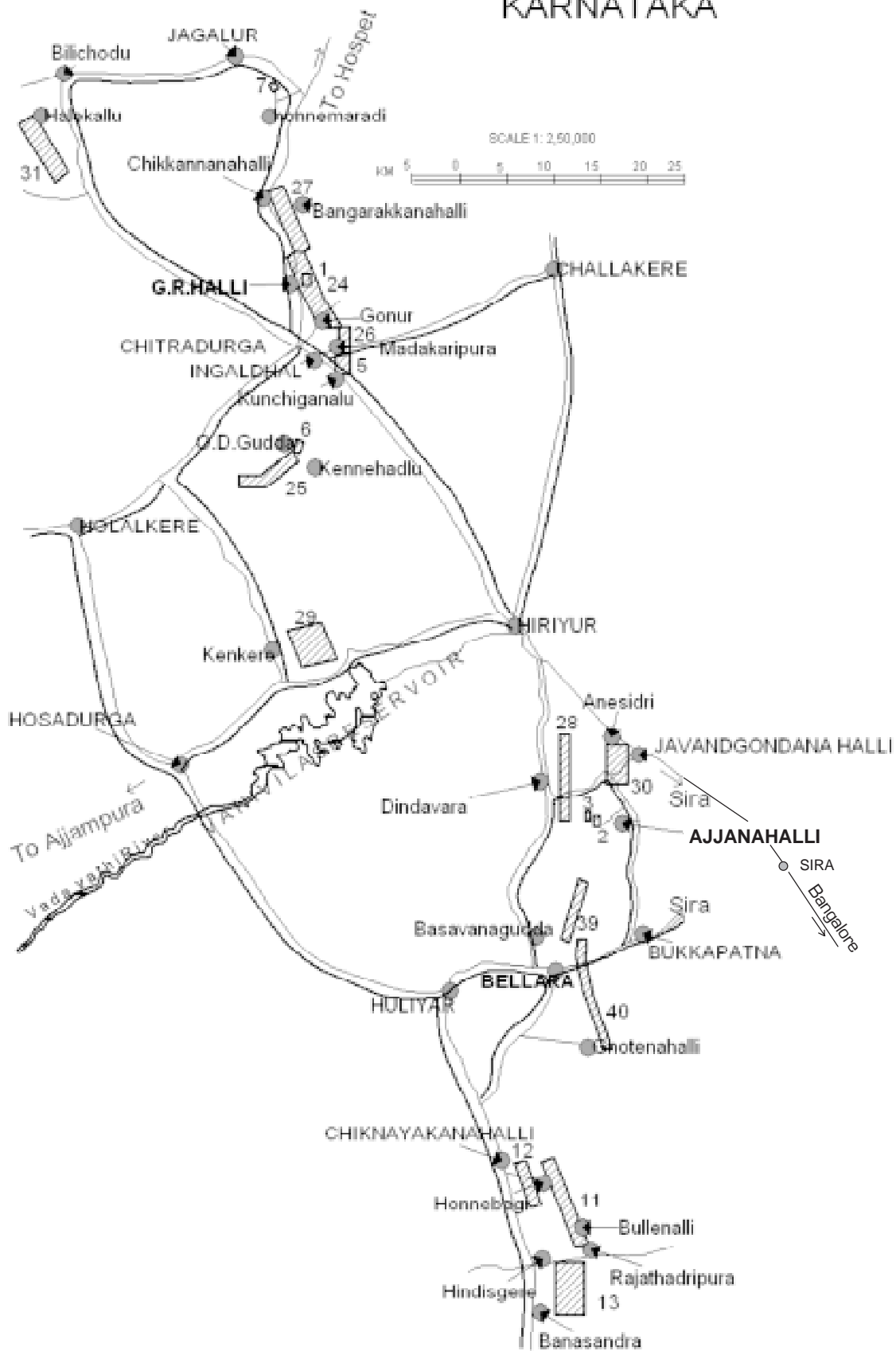


Fig.2.

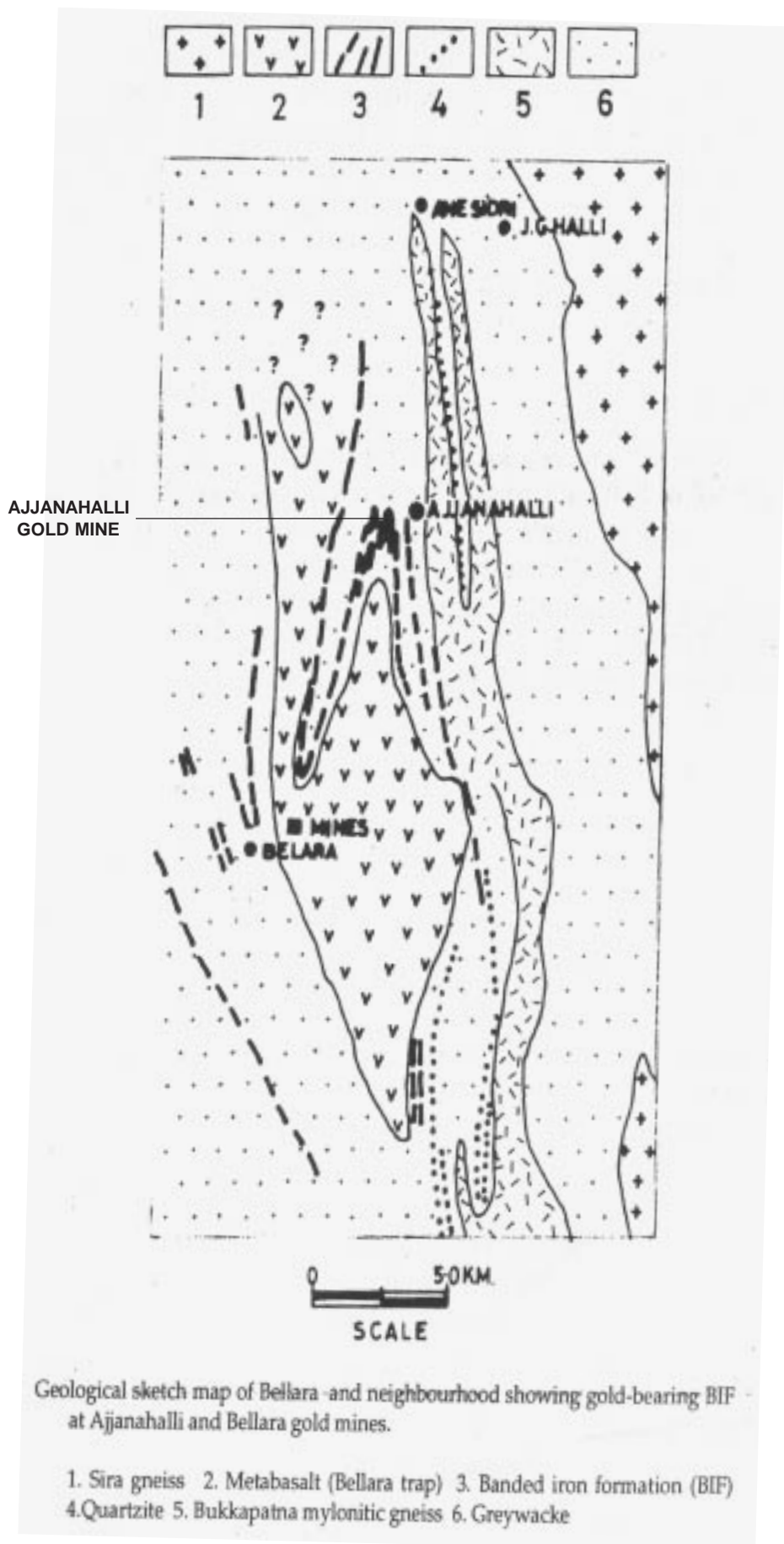


Fig.3.

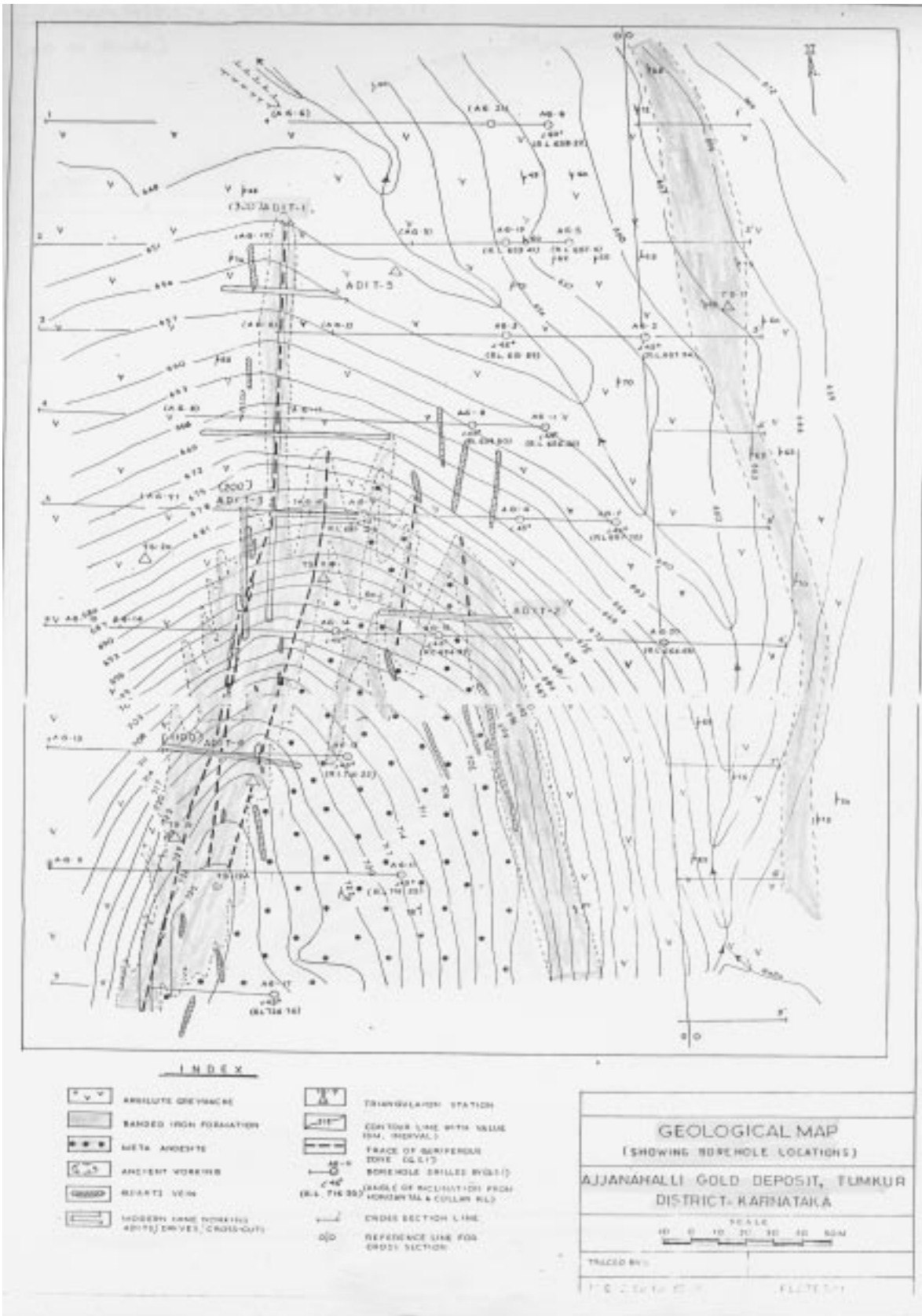


Fig.5. Geological map of Ajjanahalli Gold deposit showing borehole positions

CHITRADURGA GOLD-SULPHIDE ZONE COMPRISING INGALDHAL COPPER - GOLD MINE

INGALDHAL COPPER-GOLD MINERALIZATION

Location, Access and History: The old Ingaldhal copper mine is located 8km south of the Chitradurga town situated at 200km NW of Bangalore on National Highway No.4. The area forms the central part of the Chitradurga Greenstone Belt where it attains a 40km width. Encouraged by the results of drilling carried out by Karnataka State Department of Mines and Geology a company styled Chitradurga Copper Company was formed in 1966 to mine the copper ores and produce copper concentrates (see Radhakrishna B P and Sundarajan V M, 1972, Investigation for Copper in Mysore State, DMG, Bangalore for details). The initial copper resource was placed at 1 million tonnes of an average grade of 1% copper. A 250 tpd copper concentrate plant was commenced in year 1973. 13 underground levels were developed over a strike length of 1000m. The total resources of all categories were estimated at 5.1 million tonnes of an average grade of 0.81% copper as at 31.3.1994 (source Mineral Resource of Karnataka by Radhakrishna B P, 1996, p. 162). The strike continuity of the vein type copper mineralization was established over a length of 3km. In 1984 M/s HGML took over the copper mines and later converted the copper concentrate into a gold ore processing plant. The mine has produced 0.85 million tonnes of copper ore and 34,000 tonnes of copper concentrates until year 1995. The copper concentrate was reported to contain on an average 25% Copper, 4 g/t gold and silver 40 g/t.

Geology and Mineralisation: Extensive pillowed metabasalt and banded cherty and sulfidic iron formations constitute the central part of the belt. This sequence forms the core of a prominent regional anticline south of Chitradurga. Overlying the metabasalt-BIF succession are conglomerates, phyllites, BIFs and greywacke. The core of the anticline is intruded by younger Chitradurga granite.

The schistose metabasalt and the associated volcanoclastites host rich but narrow copper lodes with credits of gold, (1 to 2 g/t) and silver (3.8 to 14.8 g/t). The geological map of the mineralized region near Chitradurga extends over 40 km (see fig. 6).

COPPER ORE RESERVES AND RESOURCES

Based on 13 levels developed up to the end of 1995 and on the available exploration data the following category our reserves are estimated.

		Million Tones	Grade
1	Ore Mined	0.846	1.04% cu
2	Available Blocked Reserves	0.292	0.82% cu
3	Drill Indicated Reserves	3.334	0.85% cu
4	Probable Reserves	1.413	0.73% cu
5	Possible Geological Resource	84.00	0.3% cu and other auxiliary metals

While estimating blocked and drill indicated ore reserves, stopping width of only 1.3 (m) has been taken into account. Small parallel intersections indicated in drilling or mine cross cuts have not been taken into account. Based on the present available data, mineralization extends over a strike length of 5000(m) with an average width of 200(m) the cumulative width of copper lode matter being estimated at 20 meters. Based on this data the reserves are estimated at 84 million tons at 0.3% Cu which would yield about 232000 tons of copper metal. In addition to this there is likely to be substantial quantity of other associated metals such as gold, silver, cobalt, zinc, lead and tungsten. Although Pb and Zn are undesirable in copper smelting there are distinct zones with a high value of Cu+Pb+Zn which may make mining economically viable by hydrometallurgical process. Reserves are estimated only in the area where drilling has been carried out in ICM area. There are good indications of mineralization, both to the north as well as to the south of the present mining area extending over strike length of 30km which require detailed exploration program.

In the north block parallel mineralized zones, gold & Copper is developed over a strike length of 200 meters. 1 to 2 g/t Gold values are persistent.

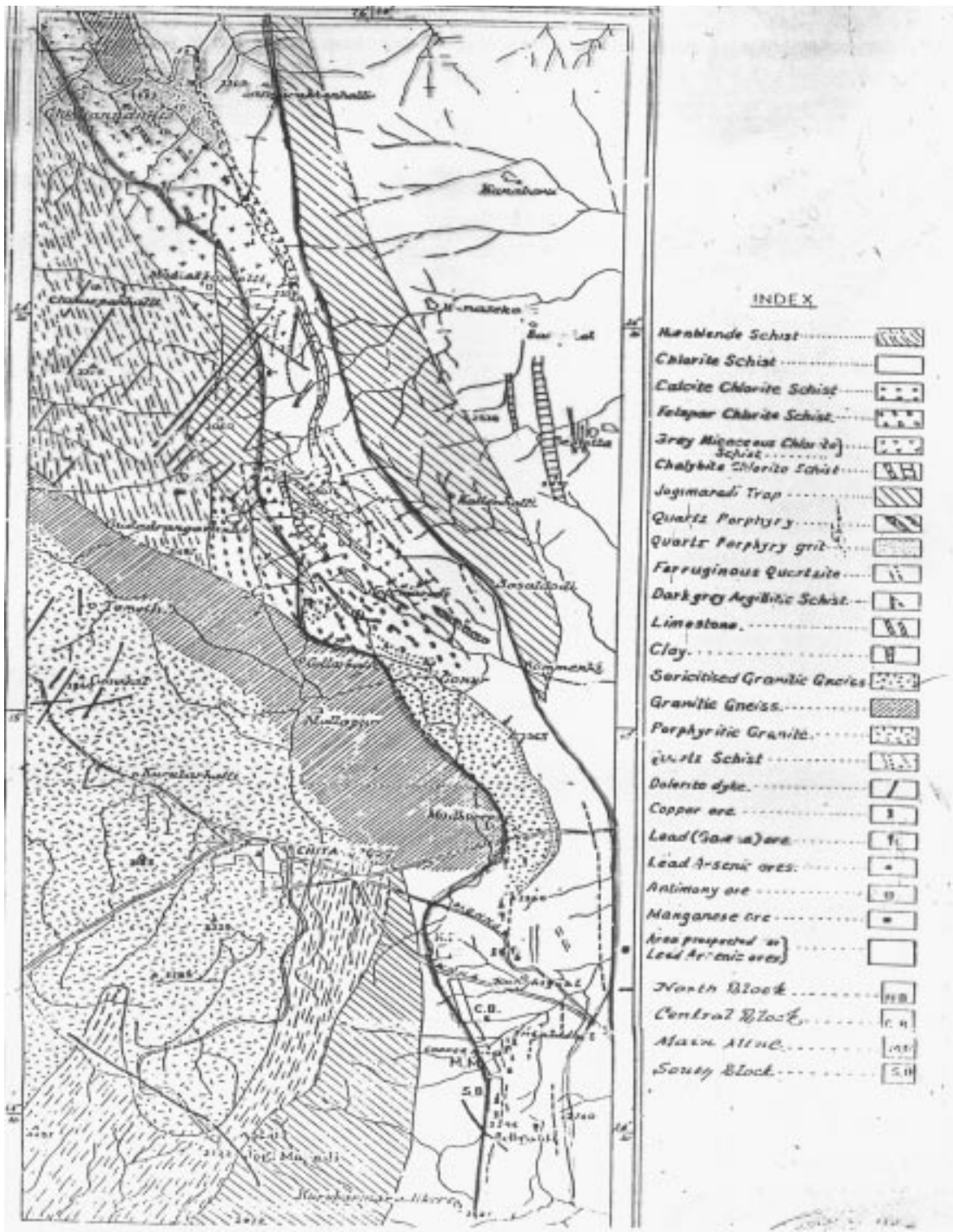


Fig.6. Geological map of the mineralized region near Chitradurga

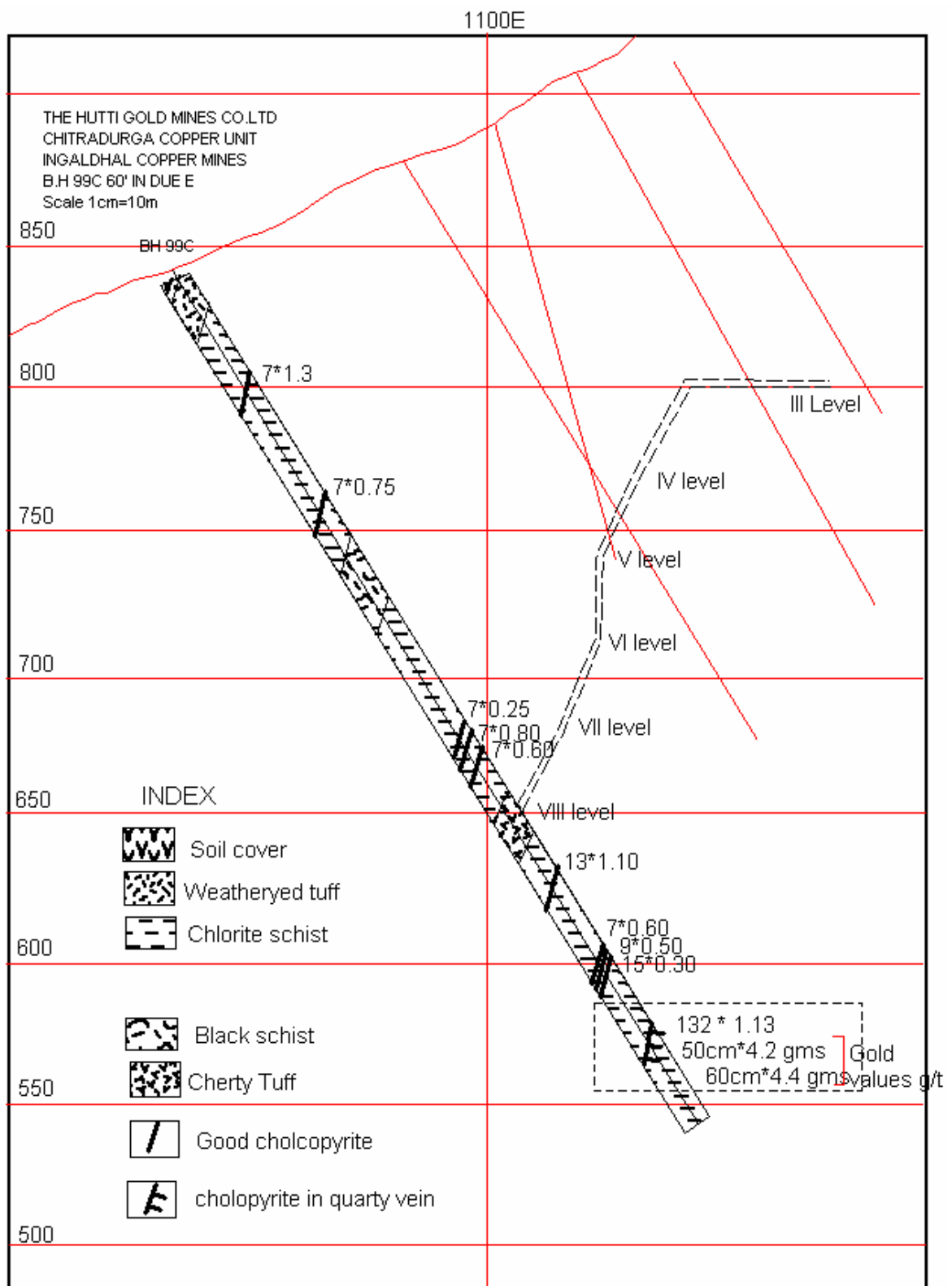


Fig.7. Ingaldhal Copper Mine: Cross section of boreholes showing gold values.

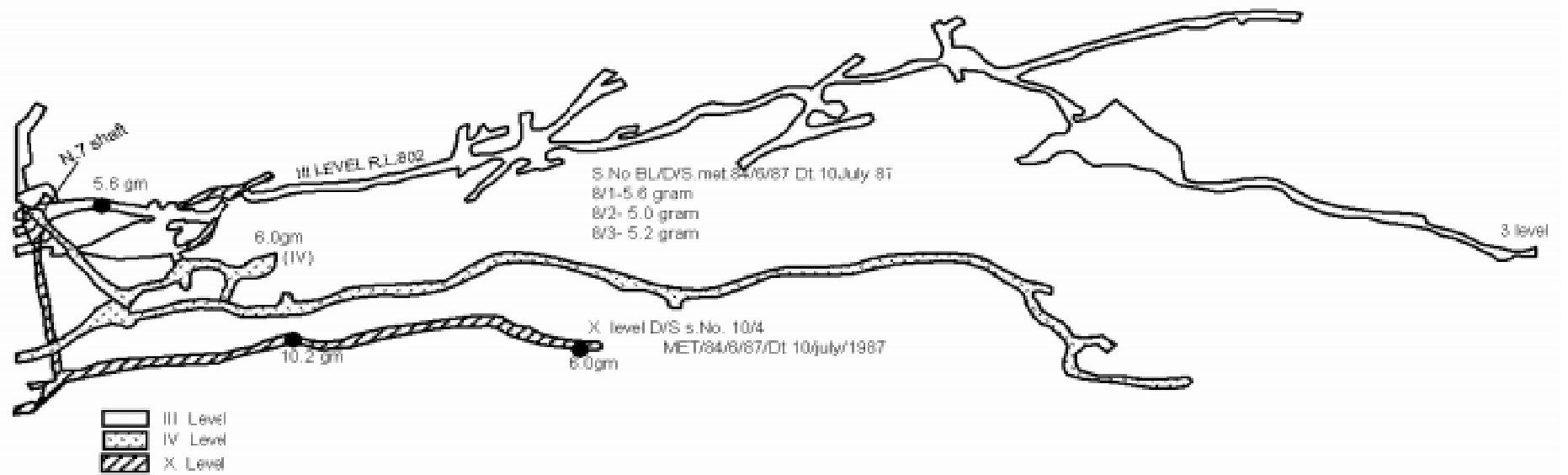


Fig.8. Ingaldhal Copper Mine: Part of underground staggered plan view of III, IV & X level showing Gold values.

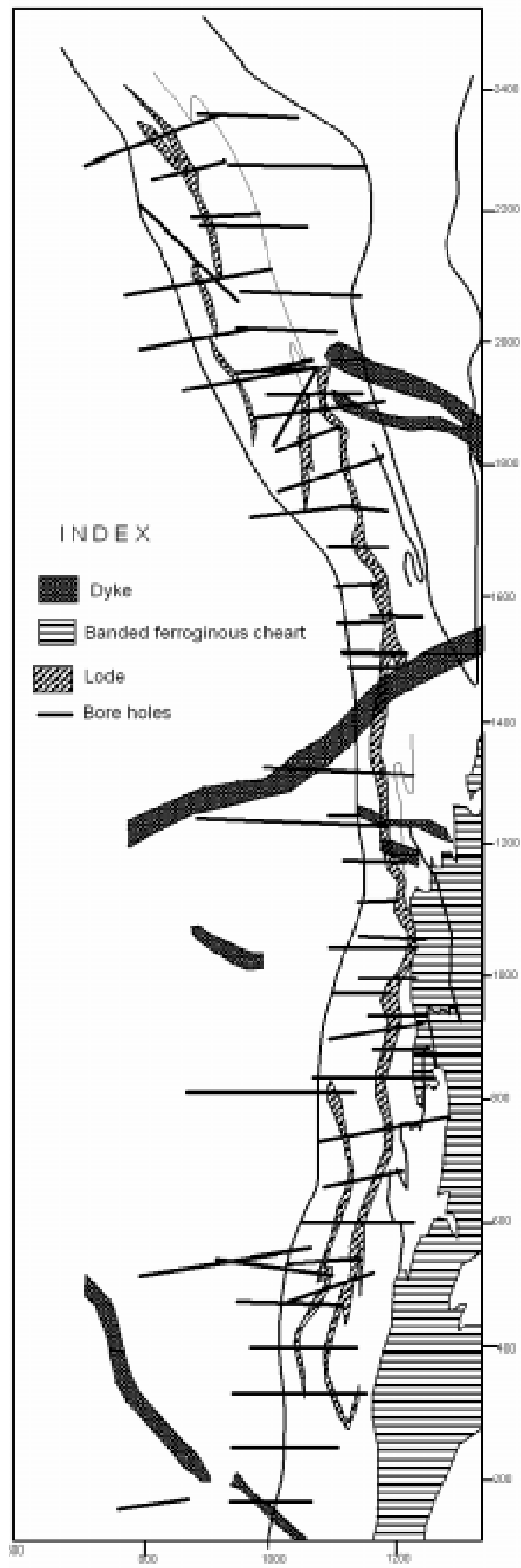


Fig.9. Ingaldhal Copper Mine Area showing intersection of Copper lodes in boreholes.

G.R. HALLI GOLD - SILVER PROSPECT

The Chitradurga gold-sulfide zone: (CSZ) is a 2.5km wide and 40km long mineral-bearing tract. Old workings dot the entire length of this zone. Over 10 gold and sulfide-gold prospects and 15 other auriferous quartz veins have been identified and explored to various stages by DMG, GSI & HGML. Amongst these the important ones are G.R.Halli gold-silver prospect, C.K.Halli gold prospect, Honnemardi gold prospect hosted in mylonitic granite and phyllites.

G.R. Halli South Block Prospect (Fig 10): Covers an area of 1.2 km. x 0.45 km. Within this zone there are several sub-parallel gold-arsenopyrite-galenas bearing quartz veins traversing carbonated metabasalt and phyllite. GSI has completed 2,360m of drilling in 18 boreholes in the prospect. Two zones of mineralisation have been delineated. The zone 1 mineralisation occurs in a lode, which is 1.96m wide with an indicated resource of 0.32 million tonnes of ore at an average grade of 3.3g/t gold and 110ppm Ag. In Zone 2 an inferred resource of 0.68 million tonnes of ore containing 0.4 to 8.94g/t Au has been reported.

HGML took up exploration by mine development and treated bulk quantity to establish grade and recovery of metals. Initial few billions contained 75% silver and 25% gold. The area holds promise for mining of multi metals.

G.R.Halli Central Block (Fig 11): Contains auriferous quartz veins within sheared, chloritised meta-basalt, and carbonaceous argillite greywacke. Detailed mapping and drilling in the prospect by GSI has reported two mineralised quartz veins, which extend over 510m and 260m respectively. The gold content of these veins average 6.06g/t over 67cm width and 332m strike length.

Detailed exploration in G.R Halli area, about 10km north of Chitradurga, led to the delineation and establishment of two promising Au-Ag-bearing sulphidous quartz reefs (north and south lode), besides a few other smaller prospects in their vicinity. The two main reefs are located in G R Halli south block, about 1.0 to 1.5 km east/southeast of the village. These well-defined Au-Ag lodes are narrow, persistent, and curvilinear and are emplaced along the sheared contact of met sediment (argillite/ tuff) and metavolcanics. A total of 913 m drilling was carried out on the northern lode during 1993-94. Four of the 14 boreholes are of II series (fig.11). Ten of these boreholes intersected richly mineralized zones at varying depths. The lode zones consist of sheared silicified carbonaceous argillites/ metabasalt. The sulphides are mainly pyrite, arsenopyrite, subordinate galena, sphalerite and rare stibnite. A positive correlation between the preponderance of arsenopyrite and galena with gold and silver, respectively, is established. The chemical analysis of the borehole core samples gave encouraging Au and Ag values.

Large scale mapping on 1:12,500 scales was continued over an area of 140 sq km around M.N Halli and C.K.Halli. Several complexly folded BIF bands and a number of argillite horizons with quartz vein were delineated. A few BIF bands are found to be auriferous in limited stretches which are target of detailed work. Detailed mapping on 1:1,000 scales in the contiguous area east/ southeast of G R Halli south block was continued and 0.25 sq km area mapped. A poorly exposed lode zone was discovered in the process.

Kotemardi Blocks (Fig.12) : Trench in of 450 cu m at a regular interval of 10-20 m was carried out across the possible extensions of mineralized zones and a total of 425 samples collected.

A trench in Kotemaradi block led to delineation of a lode zone comprising 1-3 sub-parallel quartz reefs with significant gold values. It is locally marked by largely filled up linear ancient workings. These workings extend up to a depth of 1 to 10m, exploiting only the rich narrow portions containing free gold. This zone forms the southeastern extension of the southern lode zone of G.R Halli south block. This zone was tested by drilling a single shallow borehole (GRE-1) in the middle portion. Two trenches (GRT-105 & 106) exposed the auriferous lode below the ancient fill of 5-6 m. The borehole intersected a thin and two prominent lode zones, the analytical values of which are poor. The fire assay results are awaited. About 400m east of northern lode which is being drilled in south block, a highly folded shallow dipping sulphidic quartz reef is delineated along the southern periphery of a large Ferro dolomite body by close-spaced trenching. This zone is narrow, irregular and impersistent. The overall length of the vein is 100m with a maximum width of 1.2m (av. 60cm). Besides, the above two lode zones, another irregularly folded sulphidic quartz vein intruding the schistose metabasalt is delineated towards the northeastern corner of Kotemaradi block. It trends ~ N-S and is exposed in 7 trenches located 20m apart. The gold values in this lode are encouraging.

Systematic pedogeochemical sampling was continued in plains of Kotemardi block and a total of 189 samples were collected and analyzed. The results have indicated a couple of possible auriferous zones with Au as high as 0.34 g/t and 0.67 g/t. Twenty stream sediment samples were also collected from the areas north and south of Kallenahalli and elsewhere, some of which have shown fine gold in panning and thus helped in identifying the prospective areas. Quite a few surface samples among the 142 numbers collected during the large scale mapping have indicated the presence of gold up to 2.0 g/t.

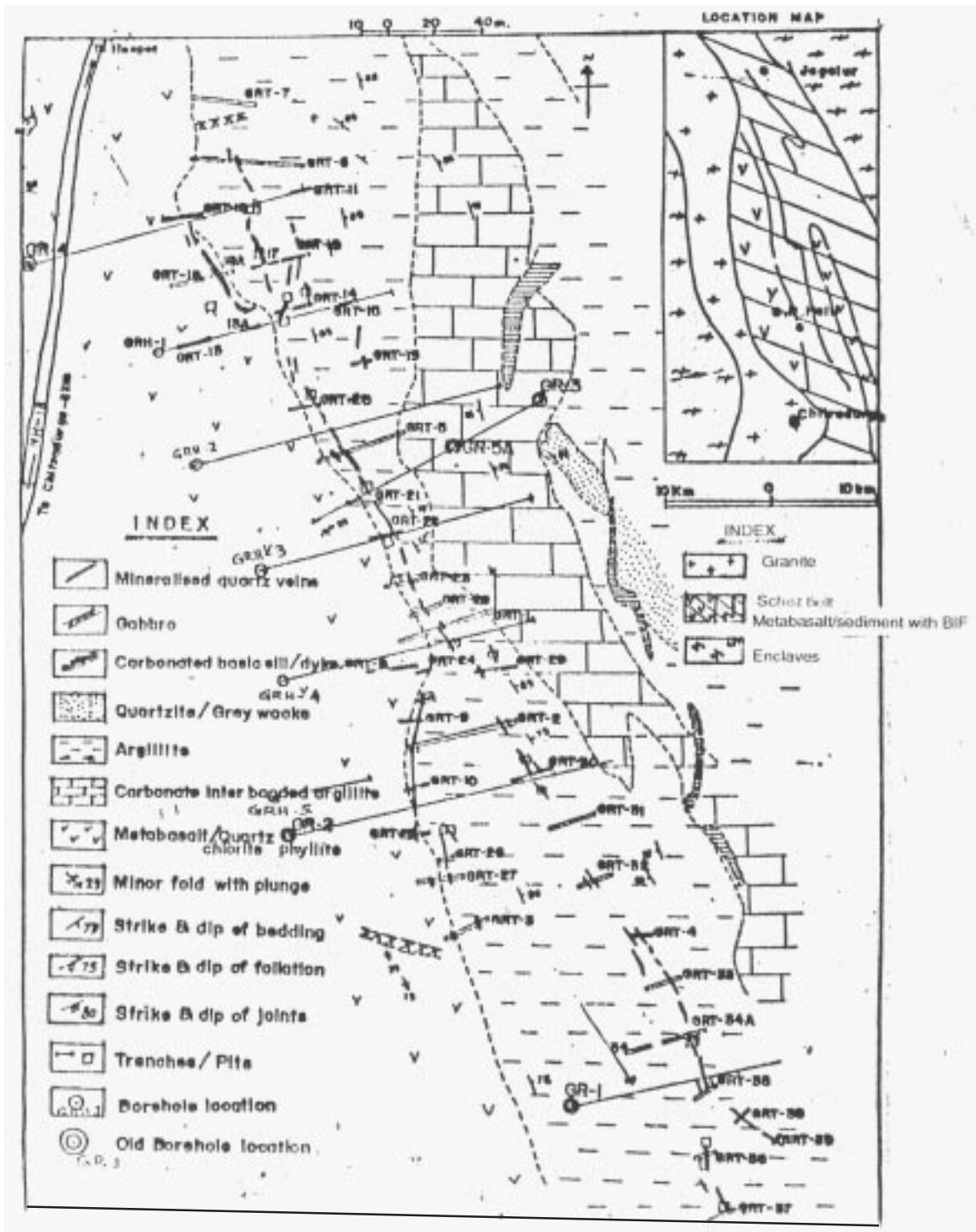


Fig.11. Geological map of G.R. Halli, Central Block (Geology modified after T.S. Seshadri and C. Mallikarjuna).

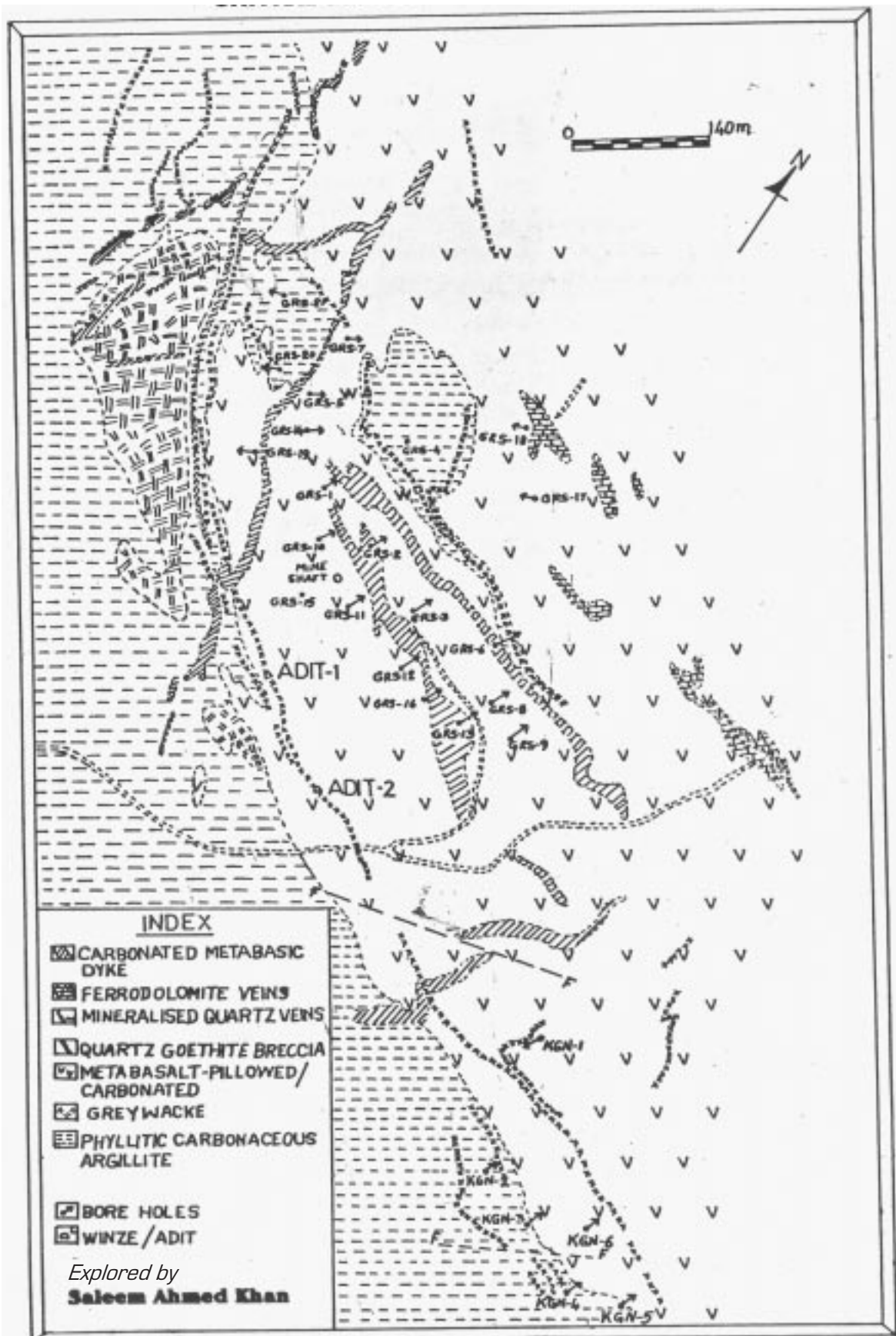


Fig.12. Detailed geological map of G.R. Halli, South and Kotemardi Block, Chitradurga Schist Belt.

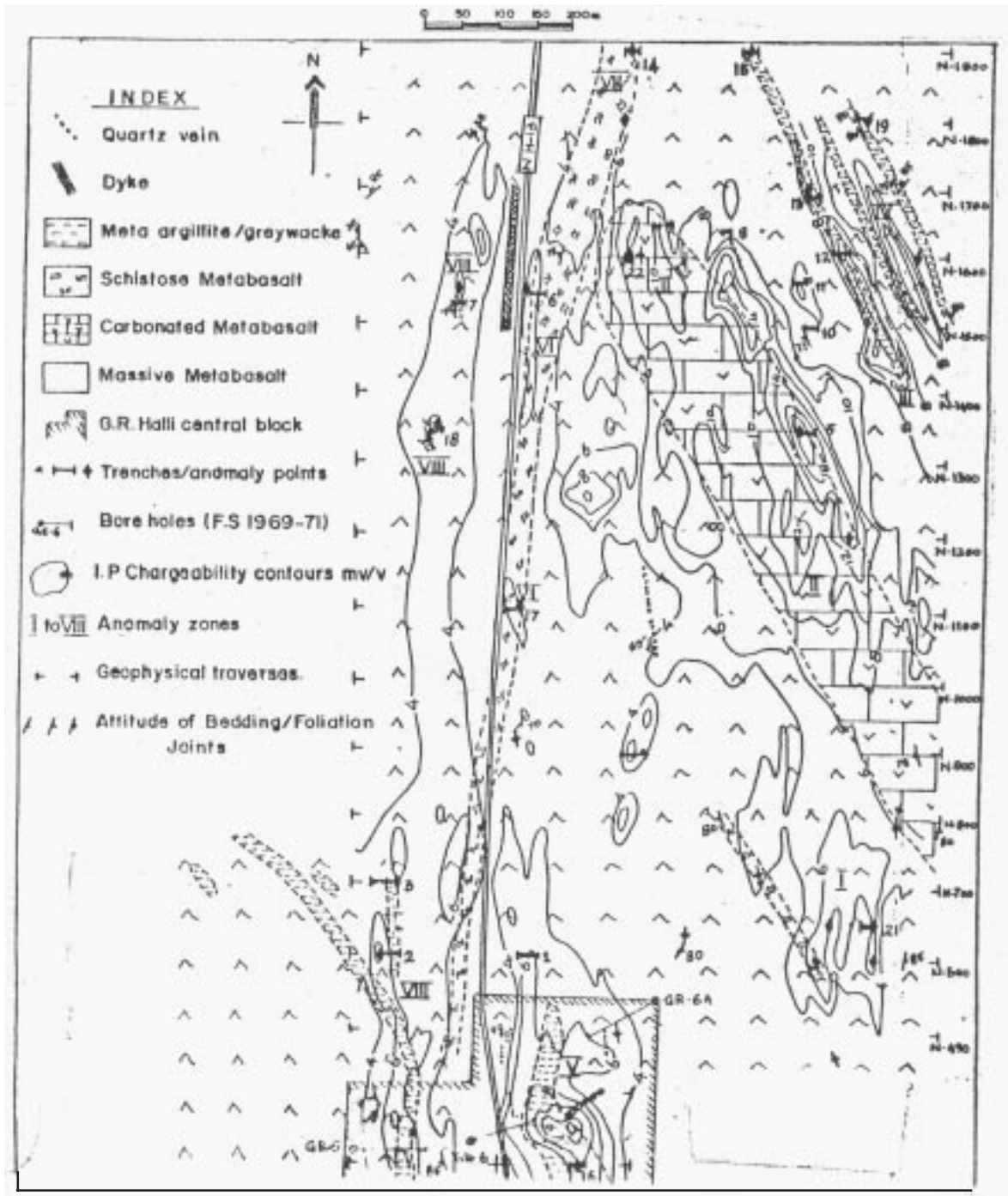


Fig.13. Geological map of the area North of G.R. Halli Central Block, Chitradurga Schist Belt, Karnataka.

GANAJUR GOLD PROSPECT

Ganajur gold prospect is located in the eastern part of the Dharwar-Shimoga (D-S) belt, also called basin, in the foreland region of the Dharwar craton. D-S basin has been known for ancient artisanal gold mining eg. Chinmulgund and Karajgi which have been explored in detail by GSI. Two private companies, namely, Geomysore Services India Pvt Ltd (Geomysore) and Indophil Resources Exploration Services Ltd (Indophil) held a total area of 5,329 sq km under RP licence and carried out exploration. The D-S belt contains a myriad of banded cherty iron formations (BIF) amidst greywacke. The BIFs in the western part of the RP area are magnetite bearing where as in the eastern part they are sulphidic and also auriferous.

The two private companies examined and sampled about 1,350 individual BIFs. Reconnaissance outcrop rock-chip sampling showed gold values in the range 0.5 g/t to 40g/t. correspondingly impressive results were obtained in various channel sampling. 22 most prospective blocks were prioritized on the basis of size potential (+5metres in width) and assay values (+1g/t.). Seven of them thus far, have been scheduled for detailed, systematic exploration and drilling. To date, four have received DTH and RC drill testing. Very encouraging results have been obtained from 4 prospects viz.,Ganajur, Karjagi, Mangalagatti and Bhavihal where Indicated to Inferred Resources have been established. These prospects upon additional drilling have the potential to deliver mineable resources.

Ganajur Main Prospect and its extensions were a discovery by “Indophil” which is owned by Deccan Gold Mines Ltd (DGML). The Main prospect was defined in year 2003 during a programme of reconnaissance rock chip sampling in about 3 sq km area, 8 km northeast of Haveri town. Follow up drilling over a strike length of 400 metres gave strong gold intersections (best are tabulated below). Two RC holes drilled in the thick soil covered northwestern part of the prospect returned high average grades of 3.31g/t gold for 15 metres & 7.71g/t for 39 metres respectively. An Indicated resource of 1.53 million tonnes grading 3.79 g/t has been attributed to the Ganajur Main Prospect. This equates to total metal content of 5.8 tonnes of gold. The deposit is open both along dip and strike directions. Subsequent exploration involving close grid ground mag and resistivity/SP in the soil covered ground to the NE and SE of the Ganajur Main Prospect was helpful in picking up several anomalies. Removal of the soil cover showed presence of oxidized sulphidic BIFs. Channel sampling showed them to be significantly auriferous. 7 new targets have thus come to be established. Future drilling is expected to multiply the size of the potential resource.

Best intersections in Ganajur Main Prospect

HoleNo.	(Width in mt)	Gold Grade
GMP 1	22.87	0.82 g/t
GMP 2 & 3	20.00	3.39 g/t
GMP 4	26.7	1.62 g/t
GMP 8	8.94	1.96 g/t
GMP 13	13.6	4.13 g/t
GMP 14	14.6	3.79 g/t
GMP 16(RC)	15.0	3.31 g/t
GMP 17(RC)	39.0	7.71 g/t

Ganajur Central Prospect: Located in the southeastern extension of the Ganjur Main prospect. This prospect has assumed importance because the very first recce RC hole passed through 7m of mineralized BIF of which 4m showed coarse visible gold averaging 18g/t on assay.

Karajgi Prospect: The BIF at Karajgi was a site of ancient mining. GSI has carried out drilling at this prospect. The results were treated as discouraging. The prospect is located SE of the Ganjur Central Prospect. “Indophil” executed a programme of channel sampling of the sulphidic BIFs. The results encouraged the company carry out reconnaissance RC drilling aimed at locating open pittable resource in the BIF. The drilling was successful at revealing a significant zone of mineralization, 133m long, 8.5m wide with an average grade of 2.88g/t, thus attesting to the gold bearing potentiality of the Karjgi Prospect. The zone is open ended along strike and depth and wait additional drilling.

Fig.14. Gold prospects in Dharwar-Shimoga Basin showing locations of Ganajur and Mangalgatti gold deposits

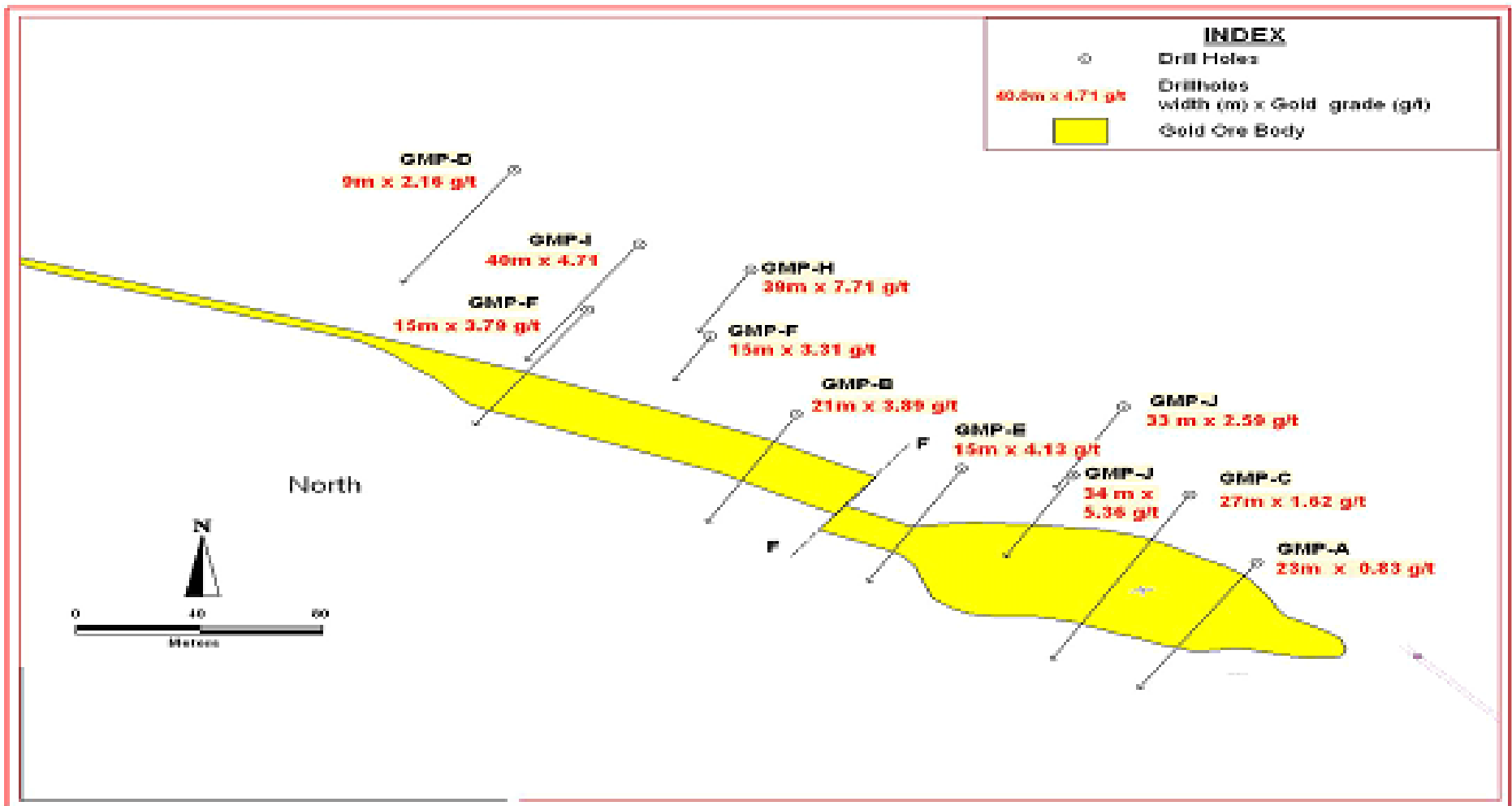


Fig.15a. Plan view & transverse section of Ganajur Gold Deposit.

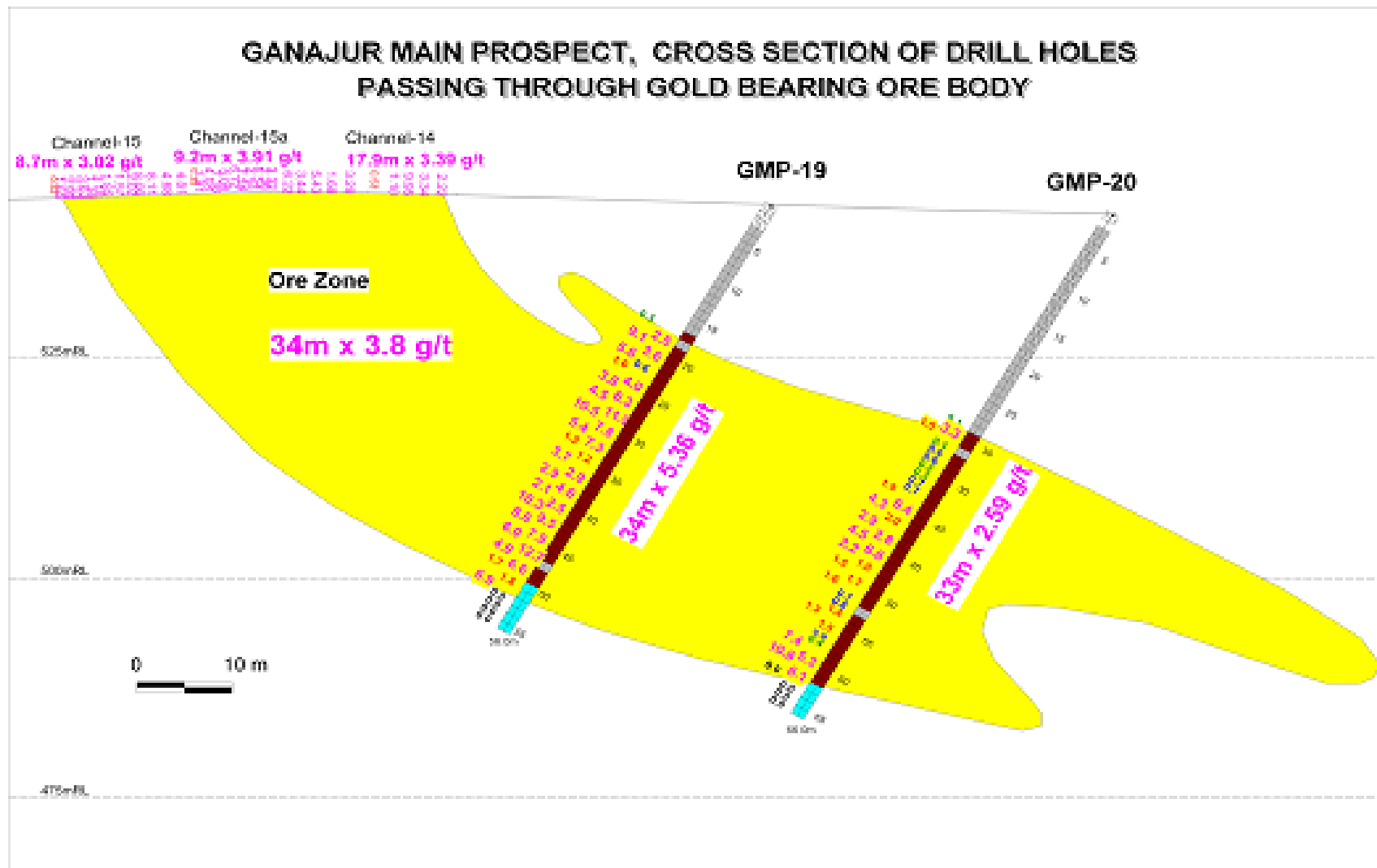


Fig.15b.

GADAG GOLD FIELD

Location, Access and History: Gadag Gold Field (GGF) is located at the northern end of the 450km long Chitradurga greenstone belt. The GGF was also a site of ancient and British time mining activity eg. Kabulayatkatti-Attikatti, Hosur-Champion, Mysore Mines, Sangli Mines, Yelisirur and Venkatapura Mines. The old mines are located 15 to 25km due south of Gadag city. The British companies developed some mines, processed about 48,700 tonnes of ore and recovered about 2,000 oz of gold during 1900 to 1911. Geological Survey of India systematically explored all the gold bearing tracts in the western half of the Gadag belt between Nagavi in the north and Sangli mines in the south including Hosur and Yelisirur. MECL followed it up by reclamation and development of underground mines at Sangli and Hosur-Champion mine. Bharat Gold Mines Ltd. (BGML) started a small experimental stopping and milling operation at Hosur-Champion mine which lasted for a few years.

The old Mysore mine was developed in two underground levels by M/s Hutti Gold Mines Ltd. and processed some ore at a 50 tpd plant during 1994-95. M/s MSPL belonging to Baldota Group rented the 50 tpd plant 1996 and treated 7,424 tonnes of ore from different old open pit resources on experimental basis to understand the problems in the treatment of complex and low grade ores. M/s Ramgad Minerals Pvt. Ltd. (RMMPL) belonging to Baldota Group obtained a Reconnaissance Permit in 2001 to examine all the gold bearing tracts and prioritize the potential targets for detailed exploration (Fig.16). RMMPL has so far carried out 20,000m of drilling and established open pit reserves and under ground resources as given in the following table.

	Tonnage million tonnes	(g/t)	Tonnes of gold	Ounce	Category
Sangli Open Pit	1.8	2.48	4.464	144,000	Reserve
Under Ground	2.2	3.7	8.140	262,580	Resource
Other U/Gr Mines	5.0	4.24	21.00	603,870	Resource
Total	9.0		33.604	1,01,0450	

RMMPL has proposed to establish a 1000 tpd plant at Sangli mines and 500 tpd plant at Kabulayatkatti to treat the refractory ores from the old mine dumps (Sawkar R H and Shankarappa B S, Mineral Processing Technology, MPT, 2007).

Geology and Mineralization: The Gadag belt is composed dominantly of metabasalt in the western half of the belt and sediments in the eastern half. The sediments include greywacke, chlorite actinolite schists, BIF and quartz-sericite schists. Felsic volcanics and thick units of conglomerates occur in the southern part of the known gold field. Gold mineralization within the belt is associated with a number of prominent shear zone, striking NNW-SSE but with important deviations at places (Fig.17). A synthesis of airborne magnetic, radiometric, satellite imagery, aerial photography, soil geochemistry and geological mapping is aimed at defining

1. the position of major lode systems,
2. identifying potentially mineralized BIFs.

3. locating extensions of existing lode systems and
4. Identifying new shear zones which constitute important targets for follow up mine development programs in all the three lode systems.

The known gold prospects could be classified into three groups,

- a) The western group comprising the Hosur-Champion, Yelisirur and Venkatapur prospects.
- b) The middle group comprising Kabulayatkatti-Attikatti, Mysore Mine-Sangli Mine.
- c) The eastern group comprising Sankatadodak Zone

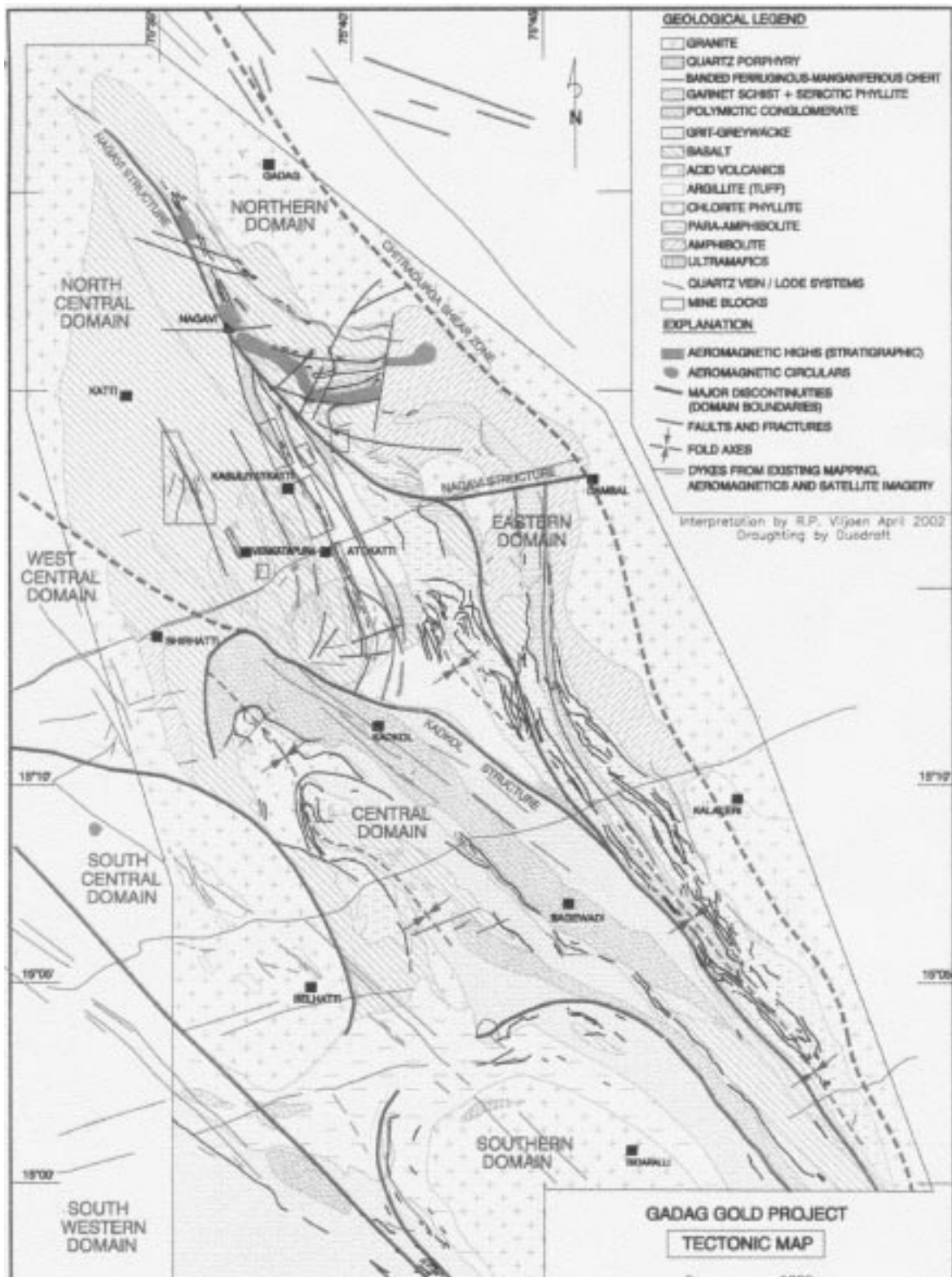
The western group is hosted in metabasalts whereas the middle block is mostly confined to metasedimentary rocks. The eastern group is also hosted by the greywacke suite of rocks. In addition, gold mineralisation is also known from the many units of BIF and their contact with tuffaceous rocks. All known mineralisation are structurally controlled vein systems.

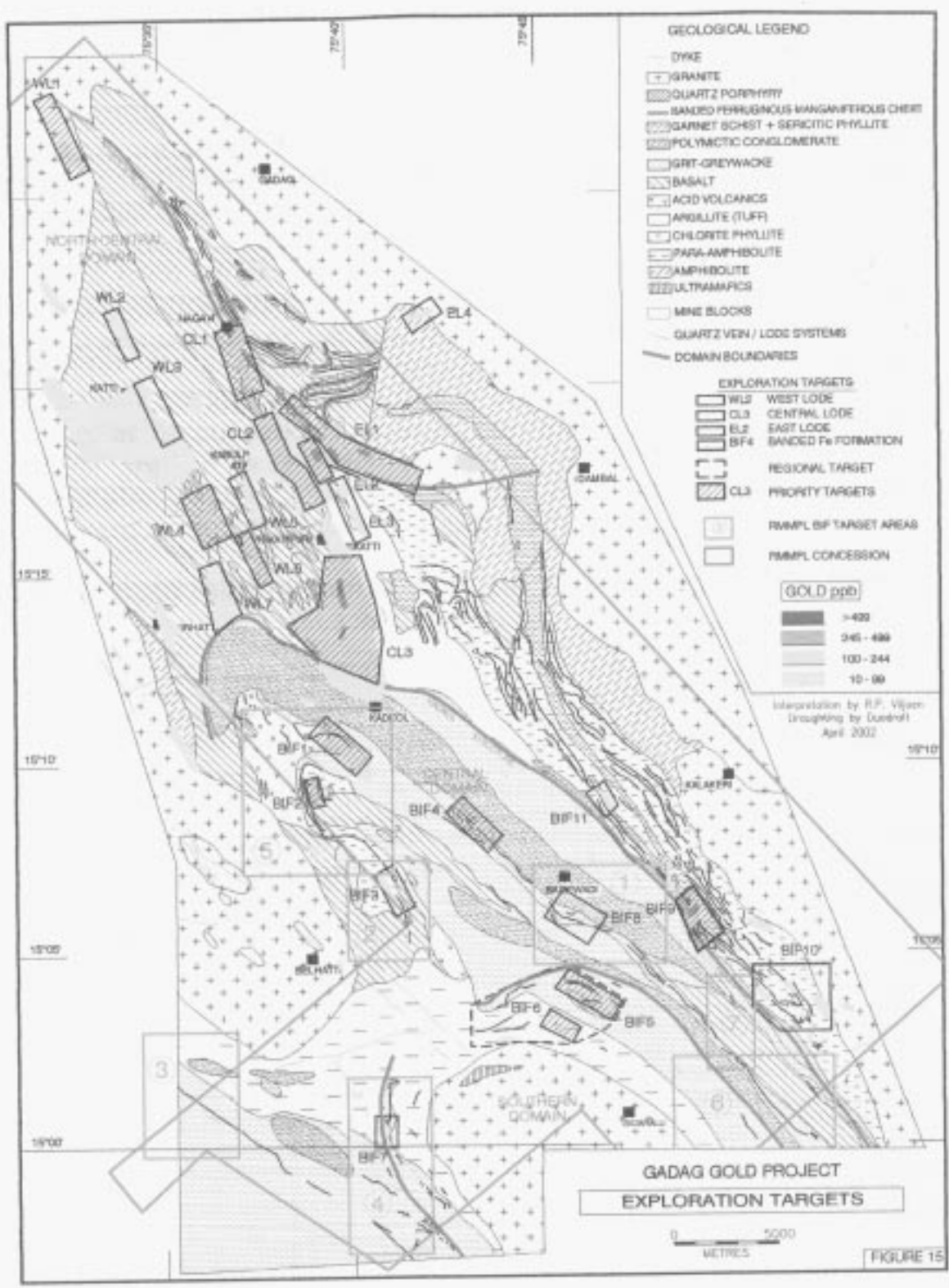
Description of one of the important prospects namely, Sangli Mine block is presented below. Description of other prospects may be found in Curtis L C and Radhakrishna, 1993, Gadag Gold: A Challenging Prospect, Geol. Soc. India, and Min. Res. India. No.6 and Sawkar R H and Shankarappa B S in Mineral Processing Technology, MPT 2007.

Sangli Mine Block: This mine is situated 24km SSE of Gadag city and south of the Mysore mine. It was worked by Sangli Gold Mining Co. Ltd. The main development was carried out on three parallel reefs by two shafts and several adits. Considerable development was carried out to a depth of 152m at various levels. No production details are available.

More recent work has revealed that the mineralisation occurs in three sub-parallel reefs along the sheared contact between the western metabasalt and the eastern greywacke. The three mineralised zones are designated as Western Lode, Temple East lode and New East Lode (Fig.18). They extend for a strike length of 2100m, 820m and 680m respectively, of which the Temple Lode has proved the most promising. The first two mineralised zones are in fine grained banded sediments. The gold bearing vein quartz in the Western Lode forms stock work style mineralization

As indicated above the Sangli prospect has an open pittable reserve of 1.8 million tonnes of ore of an average grade of 2.8 g/t gold and an underground resource of 2.2 million tonnes of 3.7 g/t grade (Fig.19).





THE WORLD CLASS HUTTI GOLD DEPOSIT, IT'S SATELLITE MINES UTI, HIRA-BUDDINI & HIRENAGNUR GOLD PROSPECT

HUTTI GOLD MINES *

This is the most productive gold field in Karnataka located 80km west of Raichur. Mining started at Hutti around 1887 and continued till 1920. during this period about 7.5 tonnes of gold were produced from 385,000 tonnes of ore with an average grade of 19.5 g/t. development was mainly confined to only one reef called the 'Main Reef'. Operations were closed down in 1920 after reaching a depth of 1100 m chiefly because of insufficient funds for further development.

Sporadic mining operations were also carried out at some of the neighbouring properties like Wondalli, Kadoni, Buddini, Topaldoddi, Uti and other places where there were extensive old workings. The grade of ore encountered at these prospects was not remunerative at the then prevailing low price of gold and operations at these mines came to a stop by 1910.

In 1937, the Government of Hyderabad (since at that time the area was under the administrative control of the Nizam's Government of Hyderabad) decided to reopen the hutti gold mines. Partly as a famine relief operation aimed at providing employment to people living in this famine-prone district, although work commenced in 1938, it had to be stopped between 1942 and 1946 because of world War II . from 1948 onwards the mine is in continuous operation, though on a very much smaller scale compared to Kolar. The installed capacity of the mine and plant was increased to 910 tonnes per day under an expansion scheme between 1964 and 1971.

With the reorganization of the states in 1956, Raichur district, and with it , the gold mine at Hutti, became part of Karnataka. The name of the company was changed from the Hyderabad Gold Mines Company Ltd. to The Hutti Gold Mines Co.Ltd. Promulgation of the Gold Control Order and severe restrictions on power supply however, put a halt to the steady growth of mining operations, leading to stagnation and regression.

About 66.78 tonnes of gold have been recovered since 1948 (up to 31st March 2009) from 6 million tonnes of ore at a recovery grade of 6.3g/t.

In recent months the mine has shifted to high production mechanized mining and has also adopted the carbon-in-pulp (CIP) process for recovering gold that has made it possible to treat large tonnages at less cost. The mine is contemplated to increase mine and milling capacity to 3000 tonnes per day. By these cost saving methods the mine is in a position to reduce the cut-off grade to 1.5 g/t thereby adding considerable tonnage to the reserves.

Despite its checkered initial history, the Hutti Gold Mines Co.Ltd. has maintained a steady progress providing gainful employment to a large labour force and contribution substantially to the revenues of both the Central and State Governments. With nine parallel to sub-parallel reefs, the mine has a vast potential for large-scale expansion in gold production in Karnataka. If right policies are adopted and technological skills of the highest

* **Source:** Mineral Resources of Karnataka by B.P. Radhakrishna, 1996, Geol.Soc.India.

order developed, the Hutti mining area and its neighbourhood, including Wondalli, Kadoni, Uti, Mask, Sanbal, and other prospects will once again become a region of intensive mining activity.

GEOLOGY

The Hutti-Maski schist belt is essentially made up of basaltic volcanic rocks of mostly tholeiitic composition with some subordinate felsic volcanic flows. Clastic sediments form a negligible proportion. The rocks have undergone greenschist to amphibolite facies metamorphism. Gold mineralization is confined to several parallel reefs which are apparently shear controlled. Chloritization, biotitization, carbonitization and sericitization are common wall rock alterations (Fig.20).

Gold-bearing Reefs: The Hutti Mining Block is 2.44km long, 2.12km wide (5.172km²) and, to date nine reefs, all gold-bearing, has been identified,

1. Main Reef
2. Prospect Reef
3. Oakley's Reef
4. Middle Reef
5. Zone-1 Reef
6. Village Reef
7. Strike Reef(Hanging Wall)
8. Strike Reef(foot wall)
9. New East Reef

Except Main Reef, Prospect Reef and New East Reef, the rest of the Reefs are under active exploration. The accompanying figures show the surface plan (Fig.21) and a transverse section of the several parallel reefs constituting the Hutti Gold field (Fig.22).

The following table furnishes details of the extent of development carried out of the different reefs within the limits of the leased block up to date.

EXTENT OF MINE DEVELOPMENT AT HUTTI

Reef	Strike (m)	Depth (m)	Extent on Surface(m)
Main	766	1100	2,400
Prospect	232	720	1,100
Oakley's	1864	780	2,500
Middle	1040	840.7	2,500
Zone-I	1392	840	2,650
Village	744	723	1,950
Strike(Hanging wall)	1328	842.5	2,300
Strike(Foot wall)	1288	507	1,050
New East	22	152	2,300
Total	8676		18,750

The Main Reef is the most promising and was the one which was developed during the early years (1895 to 1919). Only the highest grade of quartz ore (+19 g/t) was mined from this reef leaving a good portion of lower grades of quartz and sulphide ore in place. This section of the mine was partially reclaimed to 193m depth, between 1951 and 1957, and some exploratory development and stopping of medium grade ore done. Priority, however, had to be given to the other reefs which could be more rapidly developed under the exploratory development scheme in operation between 1957 and 1964. Further attention could not be bestowed to developing this reef and this section was allowed to become flooded. In the future plans of expansion of the Hutti mains, increased attention will have to be paid to the development of the Main reef over the full surface extent of 2400m.

Production: 11.99 million tones of ore averaging **5.69** g/t have so far been treated yielding **68.25** tonnes of gold up to date (upto 31st March 2009).

Year	Milled (M.T)	Recovery Gm/tonnes	Gold Production in tonnes
Up to 1950	0.059	8.95	0.531
1951-1960	0.724	6.61	4.785
1961-1970	1.073	8.13	8.721
1971-1980	1.630	6.53	10.646
1981-1990	1.599	5.59	8.937
1991-2000	2.631	4.81	12.650
2001-2009	4.271	5.15	21.981
Total	11.987	5.69	68.251

ORE POTENTIAL

A large number samples from wider parts of the reefs- both quartz and wall rock- indicate values ranging from 0.5 to 30g/t over the full width, the maximum exposed width being 41m with a value of 15 g/t . The average width of all the wide reefs is about 9.3 m at a grade of about 8 g/t. although there is no pattern in the distribution of these values in all the reefs, their number and value emphasize the immense potential that exist if the areas of narrow width and lower grade are included.

The reefs have shown little variation or deterioration in value up to 770m, the depth reached by the present workings. There is every likelihood of the reefs continuing in depth and more or less showing the same erratic gold distribution as in the first 1000m. Since gold is of deep-seated origin, very likely the chances of encountering richer shoots are more at depth. The mining lease- hold area is confined to a length of 2.5 km only whereas reefs persist along the strike for several km both to the north and south. These extensions have yet to be fully explored and developed.

Development of the seven reefs, other than the New East Reef and the Main Reef, has exposed a minimum of about 30 million tones of ore to a depth of 750m. At 50% playability, based on the present cut off grade of 2.00g/t, 15 million tones of mineable ore are available. Of this, million tones at an average grade of about 6.3 g/t have already been

mined and a further 6.35 million tonnes is fully exposed at an estimated grade of 6.67g/t. the addition of a further 3 million tonnes at he present cut off grade would bring the average grade to about 5 g/t. these figures are sufficient to indicate the continuity, strength and overall grade of ore available which will be adequate for many years of large-scale production. The mine can safely plan for higher production by expanding the milling capacity to 3000 TPD from the present level of about 800 TPD as already proposed.

Category of reserves	Million tonnes	Grade(g/t)	Gold tonnes
Broken ore up to 721mt depth	0.63	4.83	3.04
Blocked reserve at cut-off grade of 2g/t up to 721mt depth	5.06	6.90	38.64
Additional reserves at cut-off grade of 1.5g/t up to 721mt depth	5.66	2.00	11.32
Total	11.89	4.46	53.00

(Source: Hutti Gold Mines)

Uti Mine (Fig.23): The Uti open pit gold mine is located ~20km east of the main Hutti gold mine. A total resource of 8,39, 500 Mt of ore is estimated up to 90 m depth at an average grade of 2.45 g/t Au (Sangurmah, 2001). The main mineralized zone is confined to metavolcanic amphibolites preferentially to coarse grained variety at the contact with felsic volcanic rocks which is intercalated with carbonaceous andalusite-bearing mica schist (Biswas, S K 1990, JGSI v.36, pp.79-89). Mineralization is associated with intense silicification, biotite-actinolite- and sulfide-rich alteration zones between small anastomosing shear zones. Shearing, concomitant alteration and Au-mineralization took place at post-peak metamorphic conditions. Shear foliation has sinistral sense of movement (Biswajit Mishra et al, 2005 Ore Geology Reviews, 26, pp.1-16). The Uti gold deposit sits directly over the 28km long tectonic discontinuity defined by Vasudev & Chadwick 2008) (Fig.23).

GSI and HGML together have delineated 17 mineralized zones (lodes) over a strike length of 3.5 km on the basis of 8,829m of drilling in 71 bore holes. Individual lodes have strike lengths varying from 50m to 700 m and widths 0.3m to 24 m. The resources estimated are; Lodes 2 & 3: 0.29Mt @ 3.52g/t over 3.2m width and 180m strike; Lode 4: 1.94Mt @ 2.20g/t over 15m width and 700m strike; Lodes 8 & 9 :0.16Mt @ 4.72g/t over 2.23m width and 200m strike. MECL has carried out detailed exploration by exploratory running and deep drilling on lode No 4,2 &3 .This detailed exploration gare scope for the open-pit running . M/S HGML is updating the mining feasibility studies on the present gold date. Out of the 700m strike length of lode-4, 300m has been developed into an opencast mine. The open pittable resource is now nearing exhaustion; the remaining resource is being developed into an underground mine. Ore is being transported to the processing plant at Hutti mine.

Hira-Buddinne gold deposit (Fig.23): Located 19km east of Hutti Mine and just south of Hutti-Raichur road, the deposit has been developed in five underground levels by M/s HGML. Indicated Ore is being transported to the processing plant at Hutti mine. HGML estimated a total ore reserve of exploratory gold ore to 200m depth..The mineralization is confined to 6 km long 3 to 4(m) wide, sill-like body of metamorphosed, intensely foliated

quartz porphyry which has emplaced into pillowed metabasaltic amphibolite. M/S HGML exploratory mining is progressing in fall swing, in the top levels stoping is under progress.

The mineralization is defined by free-milling gold-quartz-carbonate-sulphide disseminated veins, veinlets and ladder works traversing the northwestern h/w contact of quartz porphyry with the amphibolite (Devaraj, N and Ramachandran T.V., 1996, GSI Spl. Publ., No. 40, pp.145-153). The mineralized zone extends for ~600m in ENE direction terminating at the regional tectonic discontinuity. Oblique slip movement along the discontinuity appear to have caused development of the ENE trending fractures hosting the gold mineralization. Thin sheets of K-rich granite have intruded into the quartz porphyry unit at its northern contact with the amphibolite. It is not clear whether gold post-dates emplacement of granite. Sangurmath (2003) proposed that mineralization is hosted by an ENE-trending, ductile-brittle shear zone.

Hirenagnur Prospect (Fig.23):

- a) Footwall magnetite-gold zone:** 500 m long with 7.50 m av. Width (19m max); 3.34 g/t av. gold grade (5.02 max.)
- b) Central magnetite-gold zone :** 280 m long with 6.23 m av. width; (11m. max); 2.12 g/t av. gold grade (3.02max).
- c) Hangingwall sulphidic zone :** 250 m long with 8.63 m av. Width; (16m max); 4.34 g/t av. gold grade (6.38max).
- d) A single intersection lode west of (c):** 25 m long with 6.00 m av. width; 3.52 g/t av. gold grade.

The average grade works out to 3.28 g/t gold for an average width of 8 m. A recent programme of geological mapping to trace the southern extension of the Hirenagnur prospect was successful in tracing the mineralized zone for another 800 m thereby, taking the total strike length of the mineralized zone to 2km. The current reconnaissance drilling has tested the depth persistence of the zones up to 60m from the surface. Extensions of the mineralized zones are open both along strike and depth.

Fig.20. Geological Map of Hutti-Maski Greenstone Belt.

1. Sargur Complex - Metaultramafites (tectonic emplacement); **2.** Peninsular Gneissic Complex - Gneisses, banded gneisses, migmatites; **3.** Hutti Group - Hussainpur Formation. Banded: amphibolites, volcanicwacke; **4.** Hutti Group - 530 Hill Formation: Pillowed metabasalt with lensoids of amphibolite; **5.** Hutti Group - Bullapur Formation: a. Amphibolite with lensoid of metapyroxenite, b. Interaction diorite, c. Quartz sericite schist, d. Quartzite, e. Palkanmardi mixite, f. Quartz-feldspar rock; **6.** Hutti Group - Buddinne Formation: a. Banded Iron Formation, b. Limestone and gritty calcareous quartzite, c. Massive vesicular pillowed metabasalt, coarsegrained metabasalt, local amphibolite and interaction diorite, local carbonaceous phyllite, d. Chlorite phyllite, carbonated metabasalt (Shear zone); **7.** Kavital Granitoid: Grey, biotite - hornblende granodiorite, granite and local tonalite; **8.** Yelgatti Granitoid: Coarse to medium grained pink also grey granite; **9.** Chinchergi granophyre-quartz porphyry; **10-G.** Quartz-gold-sulphide lodes; **11.** Basic dykes; **12.** Deccan Basalt; **13.** Black cotton soil.

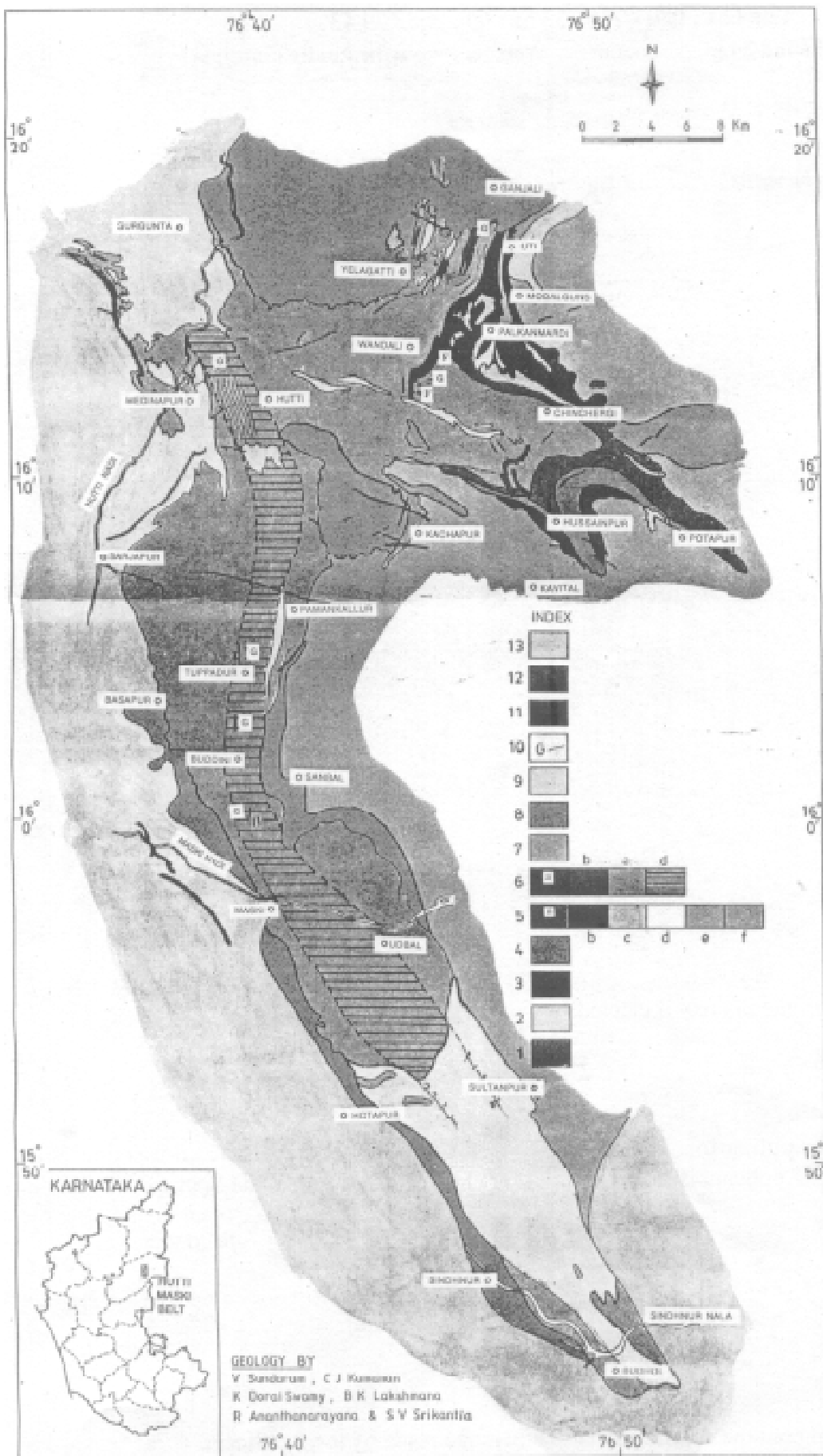


Fig.20.

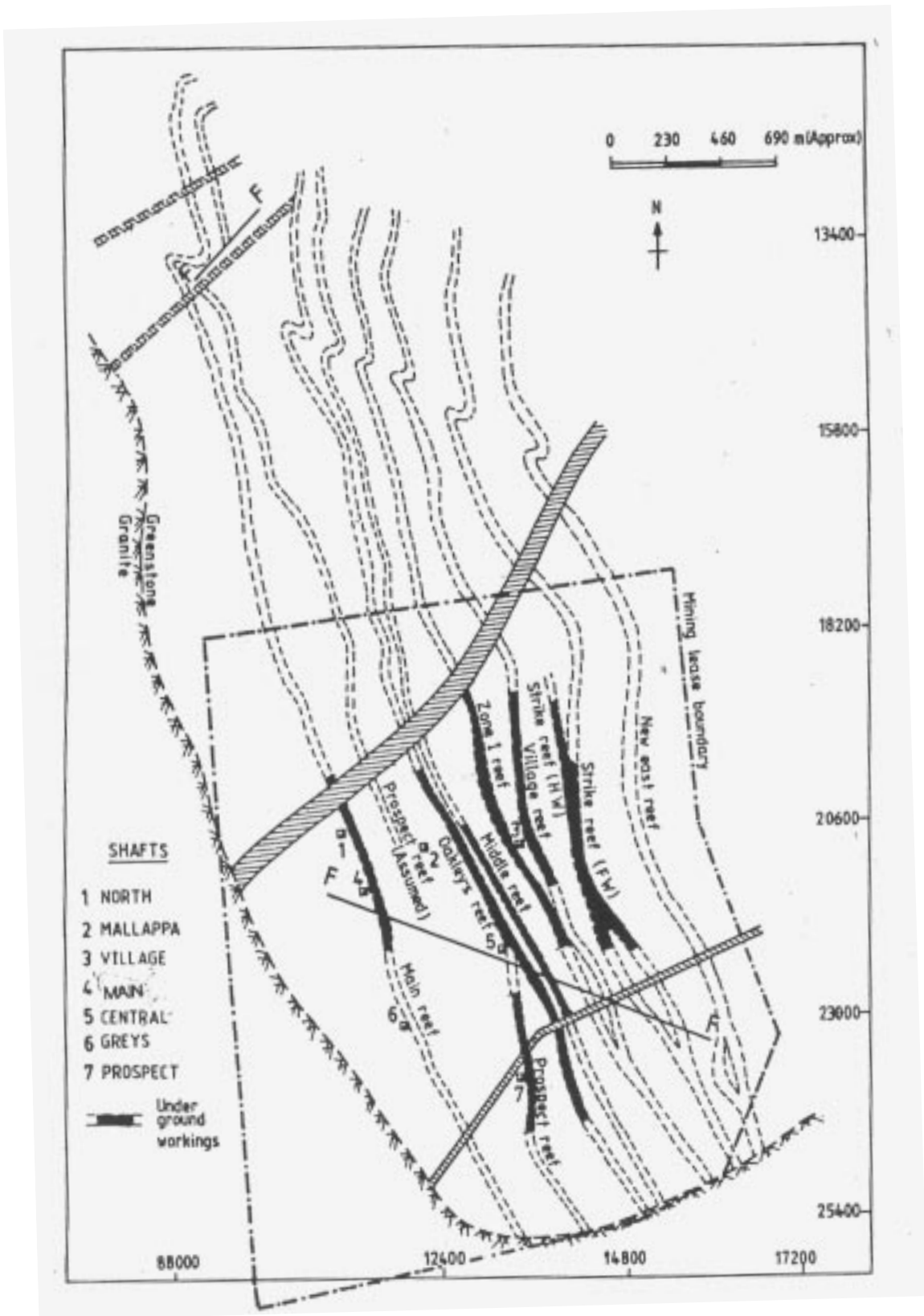


Fig.21. Surface Geological Plan of the Hutti Gold Mines showing several lode zones.

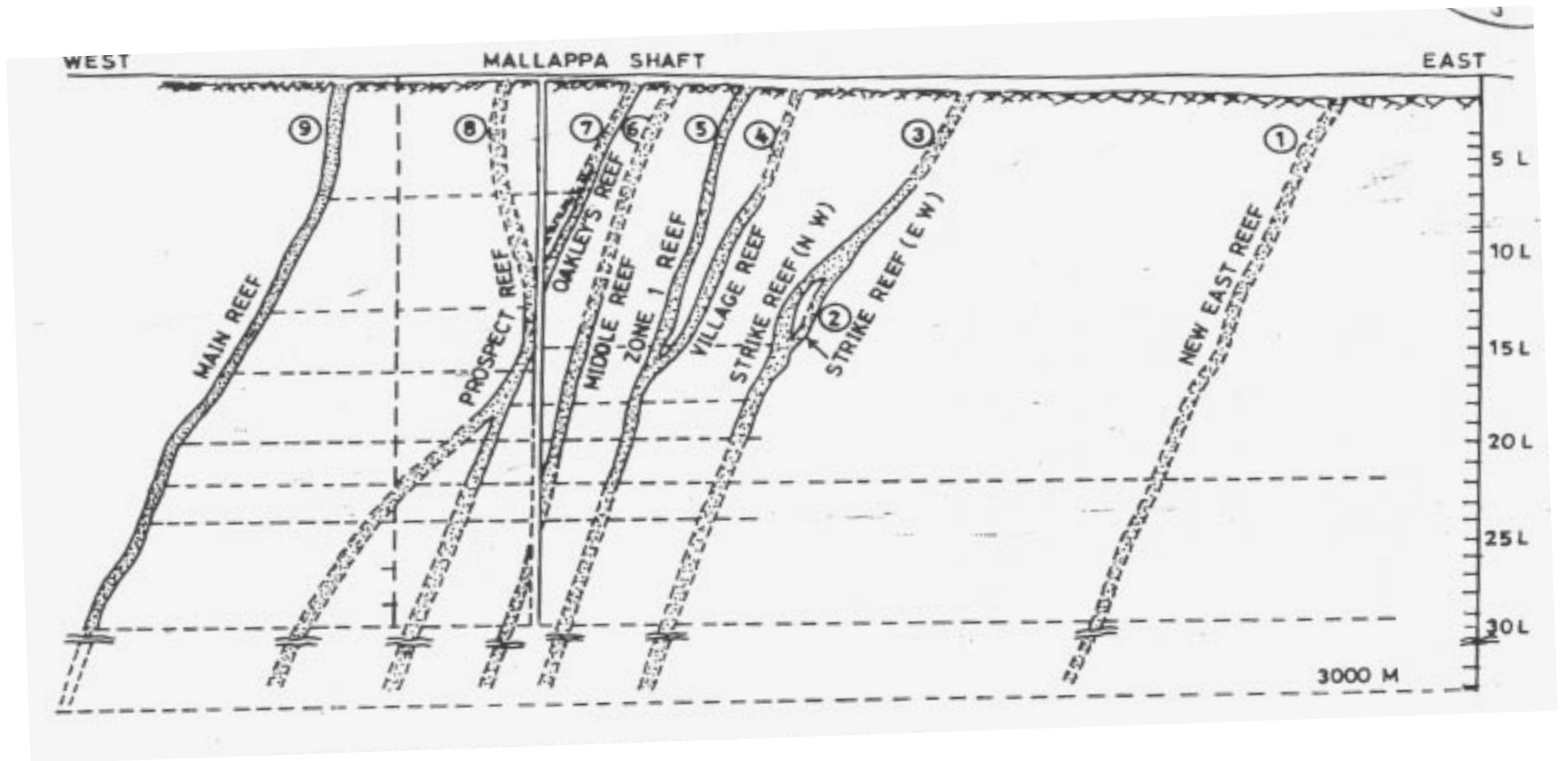


Fig.22. Transverse section of Hutti Gold Field showing disposition of steeply dipping parallel reefs.

Fig.23b.

JONNAGIRI GOLD FIELD

Location: Jonnagiri is located near Gooty in Kurnool district of Andhra Pradesh. The greenstone belt appears as a small enclave (about 180 sq km) amidst granodiorites and granites. Geomysore holds a Mining Lease of 6 sq km area covering all the mineralized zones explored by the GSI. Geomysore also holds a RP block covering the entire Jonnagiri belt. Jonnagiri was a site of ancient open pit gold mining. Innumerable pounding marks are seen around the old pit.

Geology and Mineralization: The area forms part of the Neoproterozoic Jonnagiri greenstone belt in Eastern Dharwar Craton and has all the geological and structural characteristics similar to other gold bearing greenstone belts. The Jonnagiri Greenstone Belt is composed of basaltic and felsic volcanic rocks, meta-gabbro and meta pelitic rocks represented by chloritic and sericitic phyllites intercalated with thin bands of quartz rich metasediments. The rocks are intruded on all sides by granodiorites and alkali feldspar granites and folded into a synformal structure with steep D1 L-S fabrics. A major sinistral shear/mylonite zone marks the eastern margin of the belt. The shear zones host a typical Proterozoic "lode gold" or 'Orogenic style' mesothermal gold mineralization.

Previous Exploration: In late 1914, Oorgaum Gold Mining Co Ltd sunk two shafts at Gavanikonda reportedly without much success. Rock chip samples from ancient workings assayed 3g/t gold. During the early 70s, the GSI carried out reconnaissance drilling over a 7km zone of mineralisation with a number of ancient workings marked by pits. Gold specks were found in panned soil samples.

Exploration by drilling and Resources: Geological Survey of India explored the ground in and around the ancient mining site in the SE of the belt by drilling and defined four gold prospects viz., Dona East Block (450m long x 2m to 20 to 50m wide), Dona Temple Block (650m long x 2m wide 3 parallel vein system), North Block and South Block.

Dona East block: Mineralization is confined to silicified-pyrite disseminated zones in sheared mylonitic, granodiorite. Chlorite and Biotite besides pyrite appear to be products of hydrothermal alteration. GSI has carried out 9,980m of core drilling in 44 holes and estimated a non-JORC compliant resource of 450,000 oz contained in 7.76 million tonnes of ore of an average grade of 2.04 g/t gold at 0.5 g/t cut off.

M/s. Geomysore processed the GSI's drill data using DATAMINE software which indicated an open pitable, 34° shallow dipping, tabular ore body having an average width of 20m, strike length of 200m and a depth extension of ~300m. The first 55m from the base of the ancient pit in a part of the 200m strike appears to be open pitable. However, the GSI estimated resource requires detailed drilling to feasibility.

Temple block: The mineralization is defined by narrow vein quartz in three parallel lodes that appear to be controlled by fractures transecting WNW to NW trending regional D1 schistosity. Mineralization is hosted by metabasalt as well as sheared granodiorite/granite. GSI has estimated a resource of 3 lakh tonnes of ore of an average grade of 4.65 g/t. The

best intersection is found in GSI's deep hole-JDD-1 (930m) which passed through a 41m wide mineralized zone of an average grade of 5.36 g/t. This wide width contains two higher grade intersections viz. **(a) 7.9m of 18.87 g/t and (b) 9.95m of 5.17 g/t**. An attempt is being made to understand the precise structural control of this wide zone.

South block: Gold in this block is in granodiorite. A series of ancient pits dot a 3km long tract extending in WNW-ESE direction. The style and control of mineralization is not known due to lack of contiguous mineralized outcrops. Mineralization appear to be controlled at the junction of two sets of shear fractures viz. (a) NNE trending dextral shear fractures and (b) WNW-NW trending regional schistosity-parallel shear planes. Drilling by the GSI has indicated an intermittent zone of 4km strike length that appears to be parallel to the WNW trending vein type mineralization in Temple block. A detail regarding resources estimated by GSI is not available. Surface rock chip sampling by Geomysore has yielded several high values of gold up to 19 g/t.

Fig.24. Geological Map of Jonnagiri Greenstone belt showing the locations of Dona East gold deposit, Dona Temple and South blocks in the Mining Lease granted to M/s Geomysore Services (India) Pvt. Ltd.

RAMAGIRI GOLD FIELD

Location, Access and History: Ramagiri Gold Field is located at about 160km north of Bangalore on the Bangalore-Guntakal railway line. The Gold Field is well known for its historic (1910–1927) high grade ore production of 176,338 ounces of gold at a recovered grade of 15 g/t from the three main mining ventures existed in a 15km long, N-S trending tract located in the central part of the Ramagiri Greenstone belt (RGB). In addition, substantial unrecorded production has come from ancient workings that have been dated at ~800 B.C. GSI carried out trenching and diamond drilling (over 100 holes) along 5km strike in the central part of the field. They also mapped five auriferous lode systems from north to south, including Chennabhavi lode, Yeppamana lode, Main lode, East lode and Jibutil lode. This work indicated that the grades of the lodges were around 5-8 g/t Au. This was followed up with exploratory mining of the 200ft and 300ft levels in the Yeppamana mine (Ziauddin and Narayanaswami, 1974). The Ramagiri Yeppamana mine was subsequently operated until April 2001 by BGML. After Govt. of India liberalized the mining policy a Reconnaissance Permit was granted to M/s Geomysore Services India Pvt Ltd in year 2001.

Geology and Mineralization: The Ramagiri greenstone belt is dominantly composed of pillowed basaltic rocks, felsic volcanics, volcanoclastites, BIFs, conglomerates, hornfelsed greywacke and phyllites intruded by ultramafic rocks and younger potassic granites and granodiorites. Kimberlite pipe No.7 has intruded into the belt at Venkatampalle in the Penakacherla part of the belt. Mylonite zones mark both the margins of this narrow belt. North of the Ramagiri Gold Field is a 15km long mineralised tract between Atmakur and Kuderu. Further northward, near Penakacherla, three separate prospects - Bhadrampalle, Ramapuram and Venkatampalle have been explored by drilling and identified as having some potential for mining.

The geology of the Ramagiri gold field proper comprises pillowed metabasalts, metaandesite, sheets of gabbro and ultramafics, graphitic phyllites, banded cherty iron formation, felsic volcanics and hornfelsed greywacke. These are intruded by thin sheets of syn to late tectonic potassic granites. The favourable host for gold deposits in the Ramagiri Gold Field is a carbonated and sericitised schistose pillowed metabasalt. The gold mineralisation extends over a length of 15km from Buruju in the north, Ramagiri gold mine in the middle and Jibutil mine in the south. Structurally, the mineralisation is controlled by stacked shear zones within phyllites. The total width of the zone comprising several parallel vein systems is 150–200m. The zone comprises quartz veins of three types viz. (i) white to blue quartz veins, (ii) white brecciated quartz veins, and (iii) black brecciated quartz veins, localized along narrow bands of phyllite. The latter two types are reported to carry much of the gold mineralisation. Individual quartz veins are 30-100m in length and vary in thickness from a few millimeters to 3 metres. About 500m east of the main zone, another quartz vein of quartz ankerite association extends for a considerable distance. The vein zone is 15–28m wide but no details on its gold tenor are known. East of the quartz ankerite zone three bands of gossans occur with a few shallow pits. No details of their gold tenor are known. A brief discussion on the old mines follows.

Buruju Sector (Chennabhavi block): This sector contains 7 shafts developed by Britishers of which Nos 4 & 5 formed the production shafts. The workings reached a depth of 355m in No.5 shaft. The total development consists of 9,296ft with lateral development of 975ft strike length on the 450ft level. One ore shoot (91.4m long and maximum 21m wide) was stoped to 330m depth where it pinched out. This ore shoot produced 125,000 tonnes of ore averaging 23 g/t (2.87 tonnes of gold) quartz-ankerite veins with in quartz-chlorite-sericite schist host the gold. According to M/s John Taylor & Sons, the mine yielded a total of 136,522oz of gold (about 4 tonnes of gold).

Kottapalli Sector: South of the Buruju mine, the sector contains a few old workings confined over a length of 1.2km. No development mining activity or exploratory drilling has been carried out in this sector.

Ramagiri Sector: In this sector, three areas of old workings are known. At the northern end, at Om Partima, three shafts are located, one of which was developed to 90m. The Yeppamana mine consists of two shafts. Three principal ore shoots were named A, B & G on the Yeppamana lode. These were explored in some detail by the Indian Bureau of Mines/Geological Survey of India (IBM/GSI) during 1959-1968. Subsequently BGML started mining operations here in 1984. The mine was closed in April 2001. It produced approximately 1.03t of gold since 1984. The mine is estimated to have a reserve of 0.368Mt of ore at 3.7g/t grade.

North Jibutil sector: This sector contains the Gantlappa mine, Power House mine and Yerrappa mine. The Gantlappa mine was developed to the 700ft level by a shaft of 130m and winzes. The mine produced 12,000t of ore at 8g/t from the 4th and 5th levels. From the records of John Taylor & Sons, it is inferred that out of 13,000t of 17.6g/t of ore, 12,000t of ore was stoped out leaving the balance of 1,000t of ore at 17.6g/t in the mine. Detailed exploratory drilling by IBM/GSI in the late 70s reported the presence of two ore shoots comprising the northerly extensions of the ore shoots from the Gantlappa shaft workings. An inferred resource of 1.5Mt of ore at 6-7g/t to a depth of 300m has been estimated.

The Power House Mine located to the south of the Gantlappa mine, has been developed by 3 shafts, 6 trial pits. About 4000t of ore of 17.6g/t grade is reported to have been produced from the mine. IBM/GSI tested this mine with 12 diamond drill holes, which reported narrow widths of 0.18–0.29m having grades of 8.4 to 52.7g/t.

South Jibutil Sector: Further south of Power House Mine several shafts exist. The main reef in the North shaft was developed to a depth of 12m below the adit level, which yielded 13.6–37.5g/t. Further south in No3 shaft, development reached a depth of 91m. Two levels had been driven at 100 and 200ft on a rich lode with a width of 1.2 to 1.5m. On the Jibutil lode, the south shaft has reached a depth of 335m. There are two ore shoots, which join near the 800m level. The ore stoped out is of the order of 60,000t of 11.2g/t and 6,500t of 35.2g/t. This mine has contributed the main production from this sector.

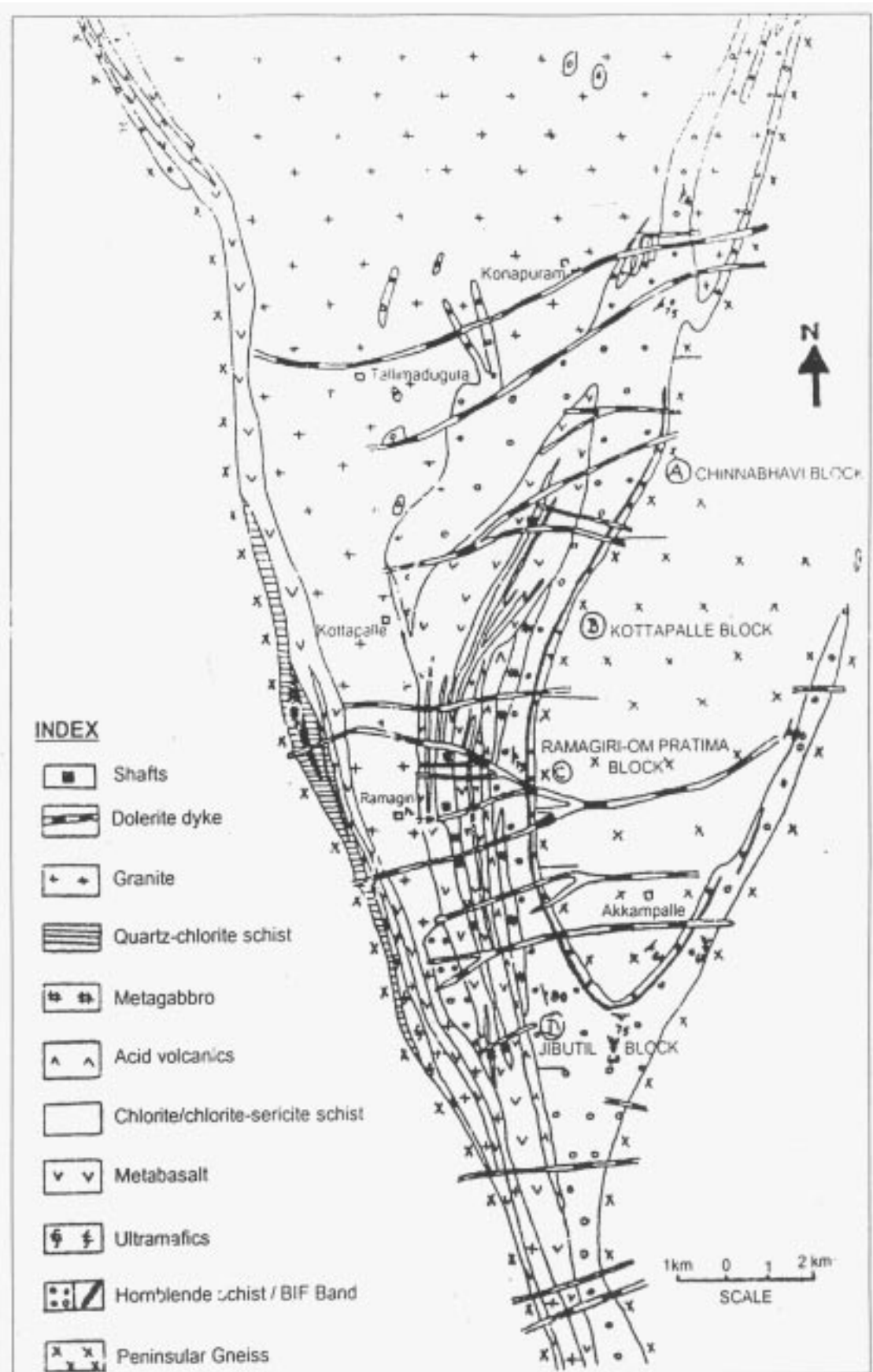


Fig.25. Geological Map of Ramagiri Gold Field, Anantapur District, Andhra Pradesh.