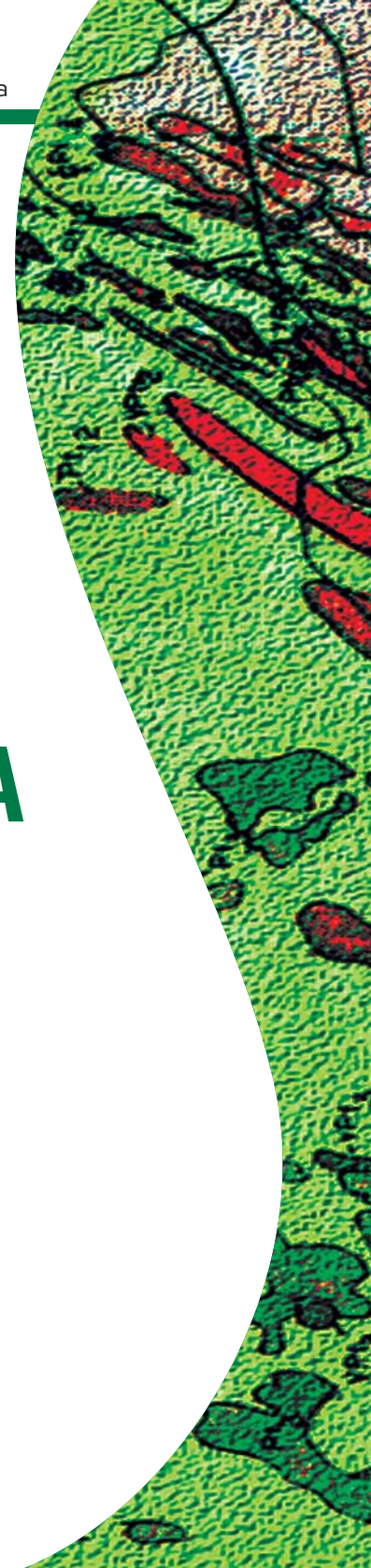

MINERAL RESOURCES OF INDIA

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INTRODUCTION

India has a rich tradition of mineral exploration. Innumerable old workings, mine dumps slag heaps, etc. are the tell tale signs of this glorious tradition. The flourishing diamond trade in the Deccan peninsula, mainly in the Golconda kingdom, had attracted world's attention during historical time. Copper and gold were also used locally since the days of Indus Valley civilizations. East India Company started exploration for coal in the Eighteenth century with setting up of **Geological Survey of India**, the premier Earth science organisation and the second oldest survey of the country, in 1851 for the systematic geological survey and prospecting for coal. India was a notable producer of gold in the early part of twentieth century and major exporter of mica, sillimanite, kyanite, magnetite and chromite. Metallurgical industry started with the setting up of steel plants at Burnpur, Jamshedpur and copper smelter at Ghatsila. Second World War created great demand for various minerals and metals including those of strategic importance e.g., tungsten. Industrial policy, formulated after Independence, brought about a radical change in the mining and metallurgical industry. During the post-Independence period, GSI has embarked upon the exploration for minerals, particularly in favourable geological milieu spread over Dharwar, Bastar, Singhbhum and Aravalli cratons. The investigations carried out since 1960s provide us firsthand information of different mineral occurrences as well as their potential. Keeping in tune with the modern trends of mineral exploration, the GSI oriented its programmes through multidisciplinary surveys. From time to time it equipped itself with state-of-the-art laboratories to back up its various exploration programmes. The efforts have led to discovery of several mineral deposits in virgin areas in different parts of the country. A few other central and state government organisations were also involved in mineral exploration now and then, mostly in collaboration with foreign organisations. The liberalisation of India's National Mineral Policy in 1993 paved the way for the entry of private entrepreneurs, including those from overseas for carrying out mineral exploration. The database developed by GSI has been found very useful for taking investment decisions by the Multi-National Companies.

An ore or mineral deposit represents a geochemically anomalous concentration of elements in a very limited sector of the crust. The crustal elements have to undergo enrichment upto several orders to attain the status of an economic deposit. The concentration of *Clarke* varies from element to element depending on the economic utilisation. The genesis of economic deposits is therefore essentially a question of enrichment. The crustal processes associated with crustal growth and recycling leading to metal concentration and formation of deposits is referred by the term 'metallogeny'.

In the Indian context major metallogenic episodes have taken place during Archaean, Archaean-Proterozoic Transition and Proterozoic proper. Thus large deposits of base metal and basemetal-noble metals, iron, manganese and chromium, etc were formed in distinct episodes mostly from Archaean to Mesoproterozoic.

Crustal evolution during Archaean: The Archaean forms the formative stages of the Earth's history, core segregation, major outgassing, meteoritic bombardment and formation of primeval crust (Piranjo 1992). Archaean heat flow between 3.8 and 2.5 Ga is estimated to have been 2.5 to 4 times its present value. As a result lithosphere was presumably thin and somewhat buoyant. Subduction, if any, was probably little developed and mantle convection gave rise to a series of small jostling lithospheric plates. Initially these were made-up of mafic and ultramafic rocks. Later perhaps in response to partial melting of this lithosphere and the products of erosion of the early consolidated magmas, felsic rocks were formed and accreted leading to the formation of first sialic microplates. The aggregation of these micropltaes could have given rise to Protocontinents, and eventually together near continental size cratonic areas. These cratons were composed of granitic rocks and greenstone belts.

The Proterozoic Eon was the most significant one when intraplate tectonics played a major role in Earth's evolution of magmatism, metamorphism and ore genesis. The Archaean-Proterozoic boundary was a major turning point in crustal evolution and represents a diachronous and transitional period ranging from 3 Ga to 2.5 Ga. Massive crustal growth, lithospheric thickening, decrease in heat flow and a

possible change in mantle convection pattern occurred. The presence of an unconformity is typical separating highly deformed Archaean rocks from the little deformed Proterozoic cratonic sequences. A major intrusive event characterised by large-scale granitic magmatism is identified between 2.67 and 2.5 Ga. The aggregation of a supercontinental mass resulted in the accumulation of heat in the mantle beneath.

Genesis and localisation of economic deposits: The grouping of commercial types of ore deposits is based on a single genetic classification i.e. endogenous, exogenous and metamorphogenic series. The endogenic series incorporates magmatic, pegmatitic, metasomatic greisen type, etc., carbonatite, skarn, plutonogenic hydrothermal, volcanogenic hydrothermal, massive sulfides and stratiform type groups. The exogenic include weathering, placer, sedimentary, mineralised waters and brines.

Endogenic cycle and endogenic deposits:

Magmatic deposits:

Magmatic cycle (both extrusive and intrusives) is responsible for concentration of many important metallic deposits. A genetic connection between both is often difficult to establish because exhalation carrying ore minerals get intermixed with the hydrosphere and atmosphere and are deposited as chemogenic sediments. To this class belong the sedimentary exhalative deposits closely related to time and space with volcanic episodes (e.g. BIF, deposits of stratiform zinc, volcanic hosted massive type sulphide type Pb-Zn-Cu deposits).

Ores may be genetically related to specific intrusives as magmatic concentration and magmatic emanation exuded from magma during its consolidation. Some of them are early magmatic and late magmatic with reference to the intrusion. The podiform chromite mineralsiation associated with ultramafic rocks are examples of deposits of early magmatic concentration.

Hydrothermal origin is attributed to many of the metalliferous deposits of copper, gold, lead etc and fluorite, baryte deposits. The mineral-rich solutions migrating from magma source get precipatetd at different levels in the crust along structurally favourable traps depending on the ambient pressure-temperature conditions of precipitation atthese locales. The following table summarises some empirical data on the igneous rock-ore linkage.

Rock Type	**Associated Ore**
Kimberlite and Lamproite	Diamond
Dunite-Peridotite, Pyroxenite	Chromite, nickel, platinum group
Norite-Gabbro- Anorthosite	PGE, Ti-and V-bearing magnetite, native copper, silver, cobalt, nickel
Dolerite, diorite, monzonite	Magnetite, copper, gold
Granodiorite, quartz monzonite	Porphyry copper, -gold-Mo-Ag-
Syenite	Magnetite, gold
Nephelene syenite	Corundum
Granite and granite pegmatite	Tin-Tungsten, uranium, radium, beryl, tourmaline

Exogenic cycle and exogenic deposits*:*

The mineral deposits formed at deeper zones of the crust under high temperature and pressure conditions are unstable in the interface of atmosphere, hydrosphere and biosphere which are characterised by low temperature, low pressure and abundant water. All these lead to geochemical fractionation of elements, which incidentally leads to formation of a number of mineral deposits. Enrichment of iron, nickel, and aluminium takes place in the weathering cycle under warm tropical conditions in the form of *laterite and bauxite cappings*. This type of deposits is abundant in the Precambrian shield of Indian Peninsula. It represents insitu products of interaction of the stable crustal blocks with the dynamic atmosphere. Mechanical concentration of resistant minerals results in the formation of **placer deposits** of *monazite, ilmenite, garnet*, **gold, cassiterite, diamond, platinum** etc. The dynamic agencies of hydrologic cycle act upon crustal blocks and bring about concentration of heavy minerals. Examples of this type of deposits are the beach placers of *ilmenite-magnetite*-bearing sand placers of Kerala - Konkan Coast, **diamond** placers in Madhya Pradesh and Wairagarh, *Tin* placers of Bastar district, etc.

Another important example of exogenous deposits is **coal**. This is an important source of energy in the country. Large deposits of coal are found associated with Gondwana sediments. These are formed by large-scale deposition of vegetation materials entrapped

in the alluvial sediments brought in by the rivers which during the course of geologic time due to consolidation and lithification transformed into coal beds.

As per the National Mineral Policy, 2008, which emphasized for non-fuel and non-coal minerals, that is, deposits locked at depth, mineral occurrences of India is presented in detail for geologically potential areas in consonance with the national policy goals. Only significant mineralisation with possible economic significance have been described.

DIAMOND

India has the distinction of producing many of the historically famous diamonds like the Kohinoor (186 ct), the Great Moghul (787 ct), the Hope (67ct), Nizam (440ct), Pitt/Regent (410 ct), Orloff (300 ct) and Daryainoor (185 ct). Till the discovery of the Brazilian diamond fields, India was leading in diamond mining.

Diamond occurrences in India are quite widespread. The known areas of occurrences of diamond source rocks are broadly grouped into three diamond provinces, namely the South Indian Diamond Province (SIDP), the Central Indian Diamond Province (CIDP) and the East Indian Diamond Province (EIDP). Each of these Provinces extends approximately over an area of 100,000 km^2 and includes both primary (kimberlites/lamproites) and secondary source rocks (conglomerates and gravels) for diamond.

The SIDP is confined to the Dharwar Craton in the states of Andhra Pradesh, Karnataka and Maharashtra, the CIDP to the Bundelkhand Craton in the states of Madhya Pradesh, Rajasthan and Uttar Pradesh and the EIDP to the Bastar and Singhbhum Cratons in the states of Maharashtra, Chhattishgarh, Orissa, Jharkhand and Madhya Pradesh.

Considering the cratons and presence of diamonds and the source rocks, areas have been prognosticated for kimberlite search in India. They are: (1) South Indian Diamond Province (SIDP) including East Dharwar Craton and adjoining Dharwar Mobile Belt; (2) West Dharwar Province; (3) East Bastar Craton including parts of Eastern Ghat Mobile Belt (EGMB); (4) West Bastar Craton; (5) Southern part of Bundelkhand – Aravalli Craton ; (6) North of Central Indian Suture (CIS); (7) Southern part of Singhbhum Craton including Singhbhum Mobile Belt; (8) Raigarh Mobile Belt; (9) Structural corridor of Son – Narmada rift zone; (10) Structural corridor of Tapti Lineament Zone; (11) Mahanadi Gondwana Graben and (12) Godavari Gondwana Graben.

The SIDP consists of both primary and secondary source rocks of diamond. The kimberlites localised within the Eastern block of the Dharwar Craton are grouped into four kimberlite fields, viz. Wajrakarur Kimberlite Field (WKF), Narayanpet Kimberlite Field (NKF),Tungabhadra Kimberlite Field (TKF) and Raichur Kimberlite Field (RKF).Three N-S zones, viz. (i) the eastern zone of alkaline syenites / alkali granites (1600–1400 Ma) extending from the eastern tectonic contact of EGMB with DC to the eastern margin of CB, (ii) the middle zone of lamproites (~1350 Ma) covering Nallamalai Fold Belt (NFB) and PGC along the northeastern and northern margin of CB, and (iii) the western zone of kimberlites (~1100 Ma) covering PGC to the west of CB, are recognised. The major lamproite dykes occurring along the eastern margin of the Craton i.e. within the Nallamalai Fold Belt (NFB) and close to the northeastern margin of the Cuddapah basin are included in the Chelima- Zangamrajupalle Lamproite Field (CLF) and Jaggayyapeta-Krishna Lamproite Field (JLF) respectively.

Until now, only the WKF is found to contain diamondiferous pipes. Twenty-one kimberlites of WKF are distributed in three clusters viz., Wajrakarur-Lattavaram cluster (Pipe 1-13), Chigicherla cluster (CC 1-5) and Kalyandurg cluster (KL 1-3). There are 34 kimberlite bodies in NKF distributed in Kotakunda (KK1-7), Maddur (MK 1-11), Narayanpet (NK 1-10) and Bhima clusters (BK 1-5 and RK-1). The lamproites are distributed in 12 clusters. Mineralogical composition of WKF indicates their derivation from shallower depths above the diamond window in the inhomogeneous mantle.The diamond incidences (in carat per hundred tonnes–cpht) of Pipe 1 to 13 are 0.3, 3.5, 0.78 to 1, and 7.9 with the high value of 45 in the overburden of Pipe 7.

Secondary sourced diamonds in south India can be traced to the Proterozoic Cumbum conglomerate (Cuddapah Supergroup), Banganapalle conglomerate (Kurnool Group) and Upper-Tertiary Gollapalli/Malavalli conglomerate from the extensive old workings. The Banganapalle conglomerate, explored by various agencies, has incidence of diamond – from 0 to 35 cpht – with average at 2 to 3 cpht. Seventy five percent of the diamonds recovered are of gem variety and the largest one weighed 6 ct. Though this diamond occurrence is rather localised, it assumes significance, in that, many of the world famous diamonds were reportedly recovered from gravels of the area. Another localised occurrence of old mining activity confining to the Mesozoic/Tertiary (?) sandstone is around Mallavelli to the east of Vijaywada and south-eastern side of the Eastern Ghat Mobile Belt.

The basal conglomerate in the Banganapalle Quartzite Formation in the Kurnool Group is the main diamond-bearing stratigraphic unit so far known in the Cuddapah basin (Table 6). The conglomerate occurs as disconnected outcrops in a curved belt 250km long in the western part of the Cuddapah Basin and about 120km long in the Palnad Basin.The conglomerate range in thickness from 1 to 50 cm with an average of 10 cm, with clasts of chert and jasper and subordinate vein quartz embedded in sand-silt matrix.The diamond-bearing conglomerates are subarkose and classified as chert pebble-, oligomictic-, para-, conglomerates. The source of the conglomerates is traced to the west comprising lower Cuddapah sequences, igneous intrusives and the basement. Investigation for diamond-bearing conglomerates has been revived recently from Banganapalle, Vajragiri-Munimadugu, Tammarajupalle and Ramallakota-Viryapalle-Yerubayi.

Alluvial diamonds are known to occur in southern India along Krishna, Tungabadra and Penner rivers. Old workings in Krishna Valleys occur in T_2/T_3 terraces at Panchalingala, Kurnool district near the confluence of Tungabhadra with Krishna river to Paritala down stream in Krishna district, over a distance of >400 kms. The Pleistocene-Holocene gravels of Krishna and Penner rivers have been worked for diamond from different terraces (T_2/T_3 and T_3) with probable primary source from WKF and other unknown sources. The gravels mainly of Krishna river along with those of the Penner river, Sagileru, Kundair, Hundri and Ramileru yielded large quantities of diamonds. Diamond occurrences in the Godavari gravels are sporadic.

The CIDP confined to the Bundelkhand Craton in the states of Madhya Pradesh, Rajasthan and Uttar Pradesh also consists of primary and secondary source rocks. The NE-SW-trending Panna Diamond Belt with established ancient mining activity is located within this province. This is the only belt where active mining for diamond is presently carried out in the country. The National Mineral Development Corporation Ltd is exploiting Majhgawan kimberlite/lamproite, the only diamond producing mine, with an average annual production of 16,000 carats. The lamproite pipe at Hinota has low diamond incidence and is not worked. NMDC also took up mining of a large gravel block at Ramkheria but abandoned the work due to operational difficulties. The extension of Hatupur conglomerate block has been explored by MECL. The occurrence of diamonds over such a long belt viewed in the light of only two known diamond-bearing pipes at one end of the belt strongly point to contribution of diamonds from more pipes.

A little amount of diamond is also being recovered from placer occurrences. The kimberlites/ lamproites (~1100Ma) intruding into the Kaimur Group of rocks are found along the western margin of the Vindhyan basin adjoining the Bundelkhand granite and are included in Majhgawan Kimberlite/Lamproite Field. Kimberlitic rocks discovered in this province are only a few and sporadic and are reported from the Bundelkhand granite terrain.

The main source of diamonds in the country is from Majhgawan with about 10 carats per 100 tonnes within the pipes, which have been producing about 15000 carats per year of which about a third are of the gem quality. The estimated reserve of diamond in this pipe is of the order of 1.3 million carats. The Hinota and Jungel have low incidence of 0.7 and 0.6 carat per 100 tonnes respectively.

The Vindhyan Supergroup of rocks host a major share of diamonds produced from the Panna Diamond Belt in the form of three diamondiferous conglomerate horizons associated with the Itwa sandstone, Jhiri shale and Gahadra sandstone Formations of the Rewa Group of rocks of late Proterozoic age. The conglomerates at Shahidan mine at the base of the Jhiri shale have been worked for a long time and have a higher potential of 26 carats per 100 tonnes.

Diamondiferous alluvial gravels are found mostly along the banks of the Ken, Ranj-Baghain rivers and lateritic gravels over the Baghain and Gahadra Sandstone Formations. The incidence of diamonds in Panna Diamond Belt from gravels of Baghain river (near Ramkheria village) and other streams are good at 23 carats per 100 tonnes. Diamond is also reported from the river gravels and alluvial caps at Chanda, Mahantola Salaia and Urdana.

The EIDP confined to the Bastar and Singhbhum Cratons in the States of Maharashtra, Chhattishgarh, Orissa, Jharkhand and Madhya Pradesh is known for ancient diamond mining activity at a few places only viz., Wairagarh area in Maharashtra, and Hirakud area in Orissa and Koel-Sankh river areas in Jharkhand. Kimberlite discoveries in the province are very recent and investigations carried out in different parts of the Bastar Craton led to

identification of two new kimberlite fields (1) Mainpur Kimberlite Field (MKF) and (2) Tokapal Kimberlite Field (TKF), both in the state of Chhattisgarh. The kimberlites of the MKF intruded into the Khariar group of rocks and those of TKF into the Indravati group of rocks of late Proterozoic age. Some of the kimberlites in the MKF are known to be diamondiferous. Diamond-bearing pipes in the former field have been identified from Payalikhand, Bahradih and Kodomali of Raipur district by GSI, DGM and private entrepreneurs.

The recent discovery of kimberlitic/lamproitic rocks in Nuapada district of Orissa has opened a new area of primary source rocks for diamond. A few lamproite dykes have been discovered recently in adjoining Bargarh district, Orissa. A few of the Cretaceous dykes intruding into the Gondwana sediments of the Damodar valley coalfields and South Rewa Gondwana basin show similarities to that of lamproitic rocks.

Diamonds are also reported in the gravels of Maini, Ib, and Mand rivers in Chhattishgarh and Tel-Mahanadi rivers in Orissa. The ancient workings in Wairagarh area appear to be in the conglomerates as well as gravels. The conglomerates and grit are associated with either the Middle Proterozoic Sakoli Group or the Early Proterozoic Dongargarh Group of rocks.

Meaningful prospecting and exploration for diamond and kimberlites depend much on the right type of prognostication. Prognostication for mineral search is essential at different stages of prospecting from regional operations over large areas to detailed operations over narrowed down target areas.

As a result of GSI's work several prospective blocks have been identified for further investigation. Such blocks are listed below with short descriptions on their status.

A. LAMPROITE/ KIMBERLITES

A.1 MAJHGAWAN KIMBERLITE/LAMPROITE DIATREME

Geographic data:

Location: Majhgawan, Panna district (24°39': 80°02');M.P. Toposheet no. 63O/2

Extent: 515m x 330m diatreme.

Access: Majhgawan pipe is located about 20km south-west of Panna, the district headquarters. Since Majhgawan pipe is a diamond-producing mine, it is connected to Panna by an all-weather road.

Topography: The pipe intrudes into the Baghain sandstone, which forms a flat geomorphic surface with a height of 360m to 400m above MSL. At present, the mine is approximately 80m deep with a number of benches.

Geological set-up:

The Majhgawan kimberlite diatreme identified as lamproite is a downward tapering, cone-shaped body measuring about 515m x 330m in plan. The contact with the host rock dips at fairly constant angle of 70° inwards. The contact between the kimberlite diatreme and the Baghain sandstone is normally sharp. In the western and southern periphery, however, the kimberlite is highly sheared and traversed by a network of calcite veins.

The diatreme contains both cognate and accidental xenoliths. The yellow and blue grounds are well developed with a capping of 5 to 6m of soil. The contact between the yellow and the blue ground is at an average depth of 14 m from the surface.

Exploration:

The exploration programme was aimed at: (1) establishing offshoots of the kimberlite diatreme, (2) deciphering the geometry of the body and study of different petrographic varieties at depth and (3) establishing incidence of diamond in the 'extended arm' of kimberlite on the basis of surface sampling with the help of deep pits.

A total of 2943.70 metres of drilling in 25 boreholes was done to study the pipe. During shallow drilling, two prominent offshoots were delineated upto a depth of 40 m and an additional reserve of kimberlite (0.14 Mt) has been established upto a depth of 40 m.

To study the behaviour of the Majhgawan kimberlite at depth, 5 boreholes were drilled from outside the pipe area. The drilling has established the extension of pipe to a vertical depth of 330 m. The wall of the pipe indicates an inward dip of about 700 to 800. As against the diameter of the pipe, which is about 330 m on surface, it reduces to about 125m at a depth of 330m. The pipe continues to further depth.

Treatment of about 1643.71t of kimberlite from offshoot yielded 14 diamonds weighing 7.20 ct indicating an incidence of 0.43 cpht as against 10 cpht in the main pipe.

A.2 HINOTA KIMBERLITE DIATREME

Geographic data

Location: NNW of Hinota Village, Panna district (24°40': 80°01'), M.P.; Toposheet no. 63D/2

Extent: 200m x 180m diatreme.

Access: Hinota kimberlite diatreme is located about 20km WSW of Panna.

Topography: The pipe is emplaced into the Baghain sandstone which forms a flat geomorphic surface with a height of 360m to 400m. The pipe forms a topographic depression.

Geological setup: The Hinota diatreme is emplaced into the Baghain Sandstone Formation of the Kaimur Group (Vindhyan Supergoup). On surface, the diameter of the pipe is 200 x 180 m with a slight NW-SE elongation. On the aerial photographs, the pipe is recognised by its high density of vegetation and negative topography. It is well recognised on satellite images also. The pipe was discovered as a result of magnetic and electrical resistivity surveys by GSI.

The drilling in the Hinota pipe indicated top 2.5m of detrital material, followed by about 25 m of earthy yellow and greenish clayey matter and then blue ground upto a depth of 60 to 75m ending up in hard kimberlite.

Exploration:

A total of 631.65m of drilling was done in 3 boreholes, which indicated that the body extends beyond 160m in depth. Shaft Sinking: One 18.50-m-deep shaft was sunk in the pipe. A total of 228.40 tonnes of material from the shaft was treated and only two diamonds weighing 1.71 ct were recovered, which shows a very low incidence of diamond.

Recommendations: As diamond incidence is low, further investigation in this pipe is unwarranted.

Caution: The Hinota pipe falls in the Panna National Park area and to obtain prospecting lease, and to carry out large scale operations or even preliminary surveys, a prior permission from the Ministry of Environment, Government of India, is necessary.

B. CONGLOMERATES

B.1 HATUPUR BLOCK

Geographic data:

Location**:** Hatupur, Panna district, (24°48': 80°25'), M.P. ; Toposheet no. 63 D/5

Extent**:** Hatupur block is 3 km x 3 km in extent; Hatupur, Rakhel and Damulua villages are located within the block.

Access**:** The block is located about 23km ENE of Panna on Panna-Paharikhera Road.

Topography: The block fringes at Gahadara sandstone scarps in the southeastern part of the block, with an elevation difference of about 70m. There is a small hill in the eastern part of the block with a height of 440m.

Geological set-up: The Jhiri shales are exposed on the surface in the entire block. At the base of the Jhiri shale, a diamondiferous conglomerate horizon (Jhiri conglomerate), varying in thickness from 4 cm to 54cm, exists. The Jhiri shale is underlain by Itwa Sandstone Formation. Towards the top of the Itwa Sandstone Formation, another diamondiferous conglomerate horizon (known as Itwa conglomerate) exists. The Jhiri and Itwa conglomerates are separated by 2 to 3-m-thick sandstone horizon. The Itwa Sandstone Formation and Jhiri Shale Formation (with conglomerate) show very gentle dip towards SSE. The gradient is 1.5 to 2 m per 100 m.

Exploration:

The area has been mapped on 1:12,500 scale to demarcate conglomerate horizons, diamondiferous lateritic and alluvial gravels and detailed mapping of about 5 sq km on 1:2000 scale.

Drilling: In the western block the grid was laid at 200m intersection and in the eastern block at 250m intersection. A total of 3345.95 m of drilling was done in 108 boreholes. The drill

hole data revealed that the thickness of the Jhiri conglomerate ranges from about 1 cm to 70 cm. The depth of conglomerate varies from 4.55m to 36.35m.The Itwa conglomerate is separated from the Jhiri conglomerate by a non-diamondiferous shale /sandstone horizon, the thickness of which varies from 2 to 4 m. The thicker conglomerate horizons also carry sandstone interbeds. The thickness of Itwa conglomerate varies from 1cm to 2.42m and depth from surface varies from 3.42 m to 62.28m. Core loss has also been recorded in a few drill holes. In view of this, much thicker horizon of conglomerate is expected in the pits than in boreholes.

Isopach map for the Jhiri and the Itwa conglomerates indicates irregular distribution of conglomerate. Both the conglomerates are thicker along palaeochannels than adjoining parts. The palaeochannels are oriented along NE-SW and E-W directions. Isolated patches of thick conglomerate are also recorded. The stratum contour plan of the base of the Itwa conglomerate horizon shows uniform and conspicuous south-easterly gradient.

Thirty six shafts (2.5 x 2.5m), ranging in depth from 5m to 34.75m, were sunk on a grid varying from 100 to 250m to excavate the conglomerates. At the bottom of the shaft, where the Itwa conglomerate was encountered, two east-west oriented drives (1.8m height, 2.1m width and 6m length on each side) were driven to win the requisite quantity of conglomerate. The average thickness of conglomerate in shafts worked out to be 60 cm, varying from 17cm to 1.40m. A total of 4746.92t of conglomerate was obtained from 6494.50 cu.m of excavation, which was treated at NMDC plant, Majhgawan.

Dimensions of explored prospects:

i) Sub-block A: The sub-block (area 0.3 sq.km) was proved to contain conglomerate reserves of about 0.45 Mt with a diamond incidence of 27.91 cpht. This block is open at both ends, indicating the possibility of its further extension towards east and towards south-west. MECL has drilled in the eastern extensions of the block, the results of which are yet to be received.

ii) Sub-block B: These sub-block measures 750m x 500m. Proved reserves of pure and diluted conglomerate estimated are 0.53 Mt and 1.49 Mt, respectively. Treatment results of the samples drawn are not available so far. The depth of the Itwa conglomerate varies from 20.95m to 29.10m.

iii) Sub-block C: The block is along a NW-SE trending channel. Thickness of the Itwa conglomerate ranges from 1.14 to 1.80m and depth varies from 6.45 to 21.65m. On the basis of the data of three pits (P-28, P-35 and P-36) and drives, about 0.31 Mt of undiluted and 0.74 Mt of diluted conglomerate of proved category have been estimated. Probable reserves of 0.60 Mt of undiluted conglomerate and 2.72 Mt diluted conglomerate have been estimated on the basis of drill-hole data. The treatment results are not yet available.

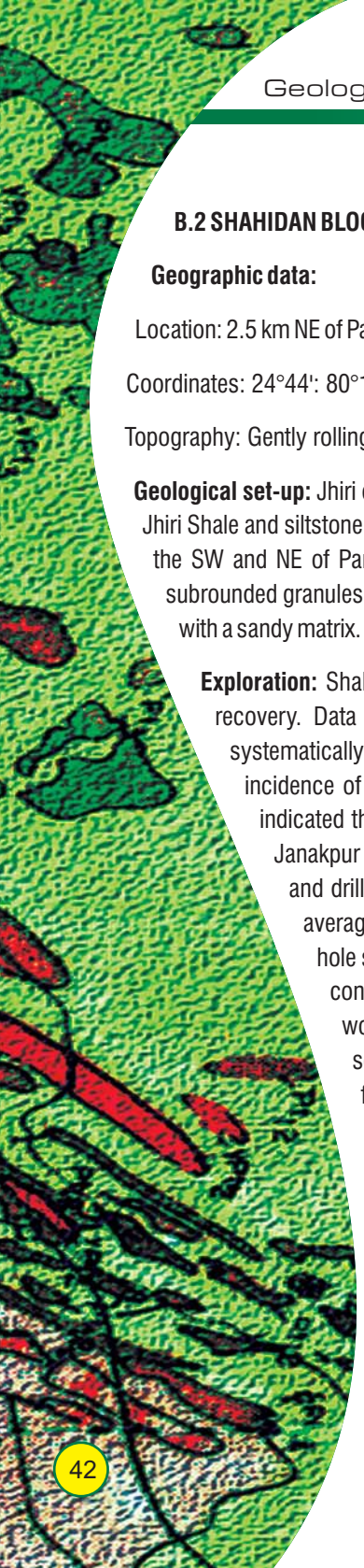
iv) Sub-block D: It is a small block located in the northeastern corner of the Hatupur block. The thickness of the Itwa conglomerate varies between 22 and 30 cm and depth varies from 8 to 8.5 m. Probable reserves of the conglomerate have been estimated at 0.106 Mt for the undiluted and 0.742 Mt for the diluted categories.

v) Sub block E: It is 1km long, trending N-S and defined by drill holes. The thickness of Itwa conglomerate varies from 10 to 77cm and depth from 12.70 to 25.15m. No pits have been sunk in this sub-block. On the basis of the drill-hole data, probable reserves of the conglomerates have been estimated at 0.378 Mt of undiluted and 1.49 Mt of diluted conglomerate.

vi) Sub-block F: It has a dimension of 500 x 500m^2 and is a south-easterly extension of the subblock C. The depth of the Itwa conglomerate varies from 23.40 to 26.05m and thickness from 29 cm to 1.70m. On the basis of the drill-hole and pit data, proved and probable reserves of diluted conglomerate have been estimated at 0.247 Mt and 0.495 Mt respectively.

Diamonds:

The percentage of gem quality of diamonds is very high (55%). Off-colour and industrial diamonds constitute 19% and 26% of the total diamonds. The largest sizes of diamonds recovered so far, during the exploratory operations, are 3.38 ct (industrial variety), 2.27 ct (gem quality) and 1.68 ct (off colour). Average size of gem, off-colour and industrial varieties is 0.6 ct, 0.45 ct and 0.63 ct. respectively.



B.2 SHAHIDAN BLOCK

Geographic data:

Location: 2.5 km NE of Panna, Panna district, M.P.

Coordinates: 24°44': 80°12'; Toposheet no. 63 D/2; Extent : 2700m X 700 m

Topography: Gently rolling terrain.

Geological set-up: Jhiri conglomerate occurs at the base and as interbeds within the Jhiri Shale and siltstone of the upper part of the Rewa Group. It forms escarpment to the SW and NE of Panna. The conglomerate is coarse, pebbly or granular, with subrounded granules of jasper, chert, sandstone and shale. It is rather well sorted with a sandy matrix.

Exploration: Shahidan area has the record of best and larger size diamond recovery. Data computed from the operations of one of the large and systematically managed mines in Shahidan area indicated diamond incidence of 43 cpht. During 1972-74, GSI drilled 20 boreholes which indicated that the cumulative thickness of conglomerate to the SSE of Janakpur is above 30cm. During 1980-85, mapping (on 1:5000 scale) and drilling (62 boreholes by MECL) was done. Drilling showed an average thickness of 20cm of conglomerate. 10 pits sunk at drill hole sites indicated, on an average, 1.7 times greater thickness of conglomerate.The northern part of the area has a number of old workings which are upto 15m deep and waterlogged, causing seepage problem. A part of the northern section is in reserve forest, while the southern part is under cultivation.

B.3 GANJA - SHAHPUR BLOCK

Geographic data:

Location: Near Ganja - Shahpur village, Panna district, M.P. Toposheet: 63 D/5

Topography: Gently rolling terrain.

Geological set-up

Both Itwa and Jhiri conglomerates are encountered in the area. The Jhiri conglomerate is both matrix-as also clast-supported. The matrix-supported conglomerate has 15% to 40% of clasts set in an argillaceous groundmass. The clasts are generally of granule size. These include white quartzite, vein quartz, grey quartzite, green shale, cream quartzite, jasper, pink quartzite and chert.

Exploration: 16 holes drilled in the area encountered Jhiri conglomerate at a depth of 12.15m in the northwest and at 49.30m in the southeast, down the dip. This is in conformity with the regional dip of the formation.The Itwa conglomerate is intersected at a depth of 13.48m in the northwest and 50.50m in the southeast. Thickness of Itwa conglomerate varies from 6 to 70 cm. Drill hole data also indicated that there is a rapid variation in the number of bands of Jhiri conglomerate from 1 to 6. The Itwa conglomerate has generally one or two bands, except for southwestern side where 5 bands are recorded.

Reserve: On the basis of drill-hole data, indicated reserves of the Jhiri conglomerate is about 6.74 Mt and that of the Itwa conglomerate is about 4.44 Mt.

C. RIVER GRAVELS

Geographic data:

Location: Itwa, Brijpur, Ramkheria villages, Panna district, M.P.

Coordinates: 24°47'- 24°49': 80°23'- 80°30'; Toposheet no. 63 D/5

Extent: Gravel zone extends from Ramkheria (24°49': 80°27') in the east to Itwa (24°47': 80°23') in the west.

Access: The area lies about 20 km ENE of Panna and an all-weather road between Panna and Paharikeria runs through the entire length of gravel zone.

Topography: The area is practically flat, with the Baghain river incising into the flood plain deposits.

Exploration : Systematic mapping (1:50,000) of alluvial zone was done as part of regional mapping. The area around and along the Baghain river was mapped on 1 : 12,500 scale as a part of delineation of diamondiferous gravel zones. Geophysical survey of the gravel along the entire river section in Itwa-Ramkheria section was done and the depth of bed rock was demarcated by taking cross traverses.

Dimension of the prospect: The area covers a length of approximately 15 km and width of 1 to 2 km. Diamondiferous gravel is restricted to the basal part of the alluvial pile and its thickness varies from 30 cm to 4 m. It comprises boulders and pebbles of sandstone, shale and laterite, set in sandy matrix.

Diamond Incidence: Bulk sampling by the GSI in 1956 in diamondiferous alluvial gravel of Ramkheria indicated an incidence of 26 cpht. The exploration by NMDC proved a resource of about 1,15,000 ct with incidence of about 16 cpht.

Recommendations : Ramkheria gravel deposits indicate higher diamond incidence with higher percentage of gem-quality diamonds than the Majhgawan kimberlite. This prospect appears to be quite promising provided prior exploration is done in the gravel. A few areas were delineated on the basis of photogeological studies for detailed exploration along the Baghain river.

D. BUNDELKHAND BASEMENT

Several ultrabasic bodies are found in the Bundelkhand granite massif, emplaced after or along with the granitic rocks. Preliminary exploration revealed diamonds, small in size. However, in view of their possible regional relevance in the emplacement of diamond-bearing pipe rocks, short descriptions are given below.

D.1 ANGOR AND BANDHA ULTRABASIC BODIES

Geographic Data:

Location : 0.5 km north of Angor Village (24°44':79°25'; Toposheet no.54 P/6), on the Sagar-Chhatarpur state Highway and 130 km SW of Panna, Chhattarpur district, M.P.

Prospect : Angor Ultramafic prospect

Topography : The granitic country is flat.

Geological set-up : The ultramafic rocks are found in Bundelkhand granite exposed mainly on the eastern side of the road but much of it has been levelled off to form cultivated land.

Exploration :

Geophysical surveys indicated a 450-m-long and 200-m-wide body, trending in NNW-SSE direction and another 170-m-long and 30-m-wide body located 0.5 km NW of the first body. Drilling indicates top 7-12m weathered zones, underlain by brecciated carbonated pyroxenite, underlain by harzburgite. Seven boreholes totalling 792.35m were drilled in the main body, which continues beyond 289m depth. Six large pits reaching to a depth of 10m were put and **two diamonds totalling 0.2 carats** were recorded after treating 937.40 tonnes of excavated material. In course of another excavation, 311.80 tonnes of treated material yielded **five diamonds weighing 3.52 carats**. NMDC treated 1000 tonnes without any recovery of diamond. A similar body occurs near Bandha (24° 392 :79° 19'; 54 P/6) to the southwest of Gulganj. It is a dyke-like body, about 10m wide and covered by soil at both ends. Eighty six tonnes of material treated yielded **two diamonds weighing 1.62 ct (one gem of 0.57ct and one industrial of 1.05 ct).**

Recommendation : In view of the diamond incidence, both the bodies could be subjected to further investigation.

D.2 DONGRAHA ULTRABASIC ROCK

Geographic data:

Location : East of Dongraha (24°51': 80°08'), Panna district, M.P.

Extent: 10m long and 50cm to 1m wide; trends N 30°E - S 30°W.

Geological set-up: The rock is intensely weathered, black in colour and porphyritic with phenocrysts of altered olivine. Groundmass contains calcite and dusty opaques like ilmenite, magnetite and possibly perovskite.

Exploration: No exploration was carried out.

D.3 ULTRABASIC ROCKS OF HARSA

Geographic data:

Location: 1.5 km north of Harsa village (24°46':80°06'), Panna district, M.P.; Toposheet: 63 D/1

Extent: The outcrop measures 1m long and 50cm wide.

Geological set-up: The outcrop shows sharp contact with prophyritic pink granite; the other side is covered by residual soil, rich in carbonate kankars. The rock has been identified as lamprophyre.

Exploration: No exploration for recovery of diamond was carried out.

D.4 ULTRABASIC DYKE NEAR BARIARPUR BARRAGE

Geographic data:

Location: East bank of Ken River, north of Barrage, Panna district, M.P.

Coordinates: 24°51': 80°06'. Toposheet no.:63 D/1.

Geological set-up: A dyke-like body, 5m to 10m wide trending N 50°E -S 50°W, is well exposed more than 1km long in the west bank canal of the barrage, varying in thickness from 5 to 10m and ends covered under soil.The rock is grey, green to greenish brown, showing olivine, reddish mica and opaques. The body cuts through Bundelkhand granite and shows contact metasomatism. The rock is traversed by serpentine, carbonate and quartz veins. It continues under soil cover for 600m, as proved by drilling three holes, spaced 200m apart; further extension possible.

Two pits were sunk in the eastern bank of the Ken River and treatment of 138 tonnes of material from one of the pits yielded one diamond (off-colour) weighing 0.44 ct.

Recommendation: In view of large strike extension and diamond incidence, the body should be further investigated.

D.5 BASALTIC KIMBERLITE OF BIHARPUR AREA

Geographic data:

Location: 0.7 km WNW of Biharpur, Panna district, M.P.

Coordinates: 24°57': 80°31' - Toposheet no. 63 D/9

Extent: 600m long and 1 to 5m wide.

Exploration: Two boreholes, aggregating 298.43m, were drilled. No kimberlite was intersected in any of the holes and it appears that this dyke pinches off at very shallow depth. About 33 cu m excavation was done, and 55 tonnes of material treated but no diamond was recovered.

PROSPECTS IN CHHATTISGARH

The Chhattisgarh State forms a part of Bastar Craton extending west to Maharashtra and on east to Orissa. It is of great significance that the Raigarh Mobile Belt, located between the Bastar Craton on south-west and the Singhbhum Craton on north-east, is manifested by the presence of diamond in all the streams of Ib, Maini, Mand and Sankh and their tributaries. The Archon of Bastar Craton is bordered by Protons of Raigarh Mobile Belt and Eastern Ghat Mobile Belt and this tectonic scenario is important in regional prognostication for diamond and kimberlite in Bastar Craton. In Bastar Craton there has been no major thermal activity after 2000 Ma. Hence, the Proterozoic platformal belts over the cratonic area have been selected as first priority blocks for investigation of kimberlite. The eastern and central parts of the craton are priority areas because they represent the low heat flow and high permeability zones. The area is marked by presence of platform cover sediments which protects the kimberlite diatremes from erosion. The prominent Proterozoic basins are Chhattisgarh basin, Pairi-Khariar basin, Ampani basin, Indravati basin, Sabri basin and Albaka basin. Considering all the positive features, the following target areas have been prognosticated in search for kimberlites:

a) The Pairi-Khariar basin and surrounding granitic terrain, b) the Indravati basin and

adjoining gneissic complex on west and south, c) the Sabari basin and adjoining gneissic

complex, d) Saraipalli area comprising rocks of Chhattisgarh basin and the adjoining granitic terrain, e) the Albaka and Abujhmar basins, f) the southern part of Chhattisgarh basin and adjoining granitic terrain, g) the Raigarh Proterozoic crystallines bordering the Bastar Craton.

A total of 14 priority target blocks have been demarcated of which 11 are in the state of Chhattisgarh and three in Madhya Pradesh. The area of each block has been tentatively kept at 5000 sq. km.

In Chhattisgarh State, so far, two kimberlite fields have been identified which are Mainpur Kimberlite Field in Raipur district and Tokapal Kimberlite Field in Bastar district.

A. MAINPUR KIMBERLITE FIELD (RAIPUR DISTRICT)

The Mainpur Kimberlite Field (MKF) is one of the three established diamond-bearing

kimberlite fields in Peninsular India, the other two being Panna in northern Madhya Pradesh and Wajrakarur (including Chigicherla and Kalyandurg kimberlites) in Andhra Pradesh. MKF is located in the south-eastern part of Raipur district of Chhattisgarh in central India, 135km SE of Raipur city. Exploration activities by GSI and the State Government have led to the identification of five kimberlite pipes (including three diamondiferous pipes) and more than 40 kimberlitic indicator anomaly zones in the MKF, which are likely to be associated with kimberlitic bodies.

Kimberlitic rocks: their occurrence and distribution

Five kimberlitic diatremes have been located in a linear span of 12.5 km in the Mainpur Kimberlite Field. The kimberlitic diatremes are Payalikhand-I (92°10'10": 82°21'00") (100m x 100m), Payalikhand-II (50m x 50m), Jangra((>50m across), Kodomali (300m across) and Bahradih (300m x 200m). Most of the diatremes are circular in plan while Bahradih diatreme is elliptical. Amongst the diatremes only Kodomali exhibits fresh rock exposures while others have been weathered to green earth at the surface.

A. 1. PAYALIKHAND DIATREMES

Geographical data:

Location: Payalikhand (20°10'10": 82°21'00", Toposheet No. 64 L/8), Raipur district, Chhattisgarh; 169 km from Raipur

Topography: 460m above MSL

Geological set-up:

The Payalikhand area comprises a complex lithological assemblage represented by metavolcanics and metasedimentary sequences of Sonakhan Group, rocks of Baya Gneiss Complex, khondalite and charnockite suite of rocks of the Eastern Ghat Mobile Belt, intrusive Bundeli granitoid and the sedimentary cover sequences of Pairi and Ampani Groups and Chhattisgarh Super-group.

Exploration:

Two diatremes have been located along the slope of a foothill of the Khariar plateau.

Characteristics of the diatremes:

Number and name of kimberlite body: **Payalikhand-I,** MKF Field

Dimension: 100m x100m

Emplacement control: Circular within granitoid rocks (64L/8)

Outcrop characteristics: Expressed as a break in slope, highly altered kimberlitic rock (green earth) diatreme facies

Diamond contents/Heavy minerals: **Diamondiferous and garnet, spinel, clinopyroxene**

Number and name of kimberlite body: **Payalikhand-II.** MKF Field

Dimension: 50m x 50m

Emplacement control: Circular within granitoid rocks 64L/8

Outcrop characteristics: Along break in slope, highly altered kimberlitic rock as green earth.

Diamond contents/Heavy minerals: **Diamondiferous**

A. 2. BAHRADIH DIATREME

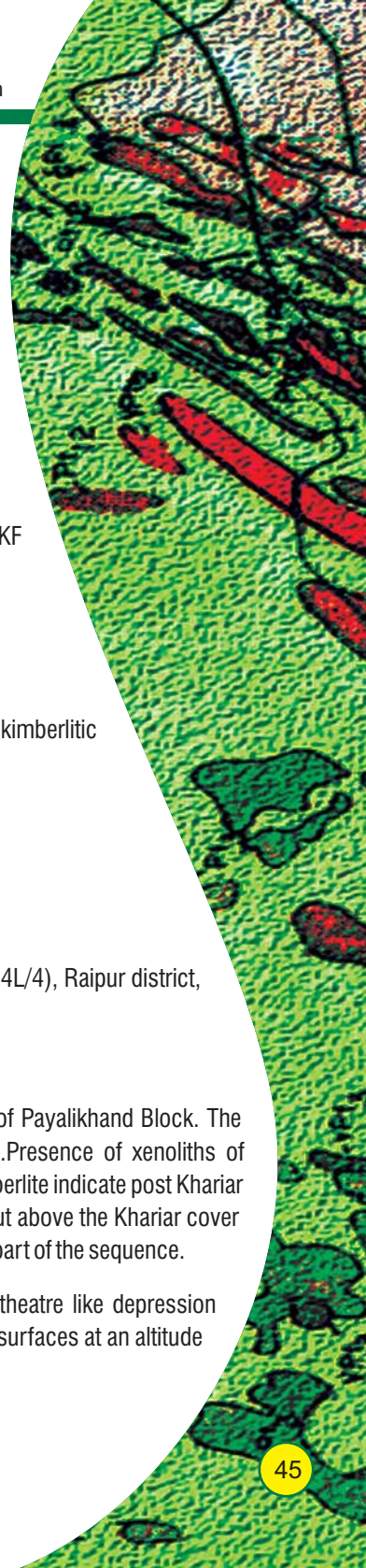
Geographical data

Location: Bahradih (20°12'30":82°12' 00", Toposheet No. 64L/4), Raipur district, Chhattisgarh; 12 km northwest of Payalikhand

Topography: Approx. 300m above M.S.L

Geological Set up: The geological set up is same as that of Payalikhand Block. The kimberlite pipe located at Baharadih is elliptical in shape.Presence of xenoliths of consolidated shale and sandstone within the weathered kimberlite indicate post Khariar age of diatremes. Since the kimberlite pipe does not crop out above the Khariar cover sediments, it is therefore, presumed that it has only intruded part of the sequence.

Exploration: The Bahradih diatreme is located in an ampitheatre like depression surrounded by resistant granitoid rocks. Bahradih diatreme surfaces at an altitude of 560m from MSL.



Characteristics of the diatreme:

Name of kimberlite body: **Bahradih**

Dimension Trend: 300m x 200m;

Emplacement control: Sub circular within granitoid rocks (64L/4)

Outcrop characteristics: Ampitheatrical depression, highly altered kimberlitic rock (green earth), diatreme facies

Diamond contents/Heavy minerals: **Diamondiferous and garnet, spinel, clinopyroxene,**

orthopyroxene, phlogopite

A. 3. JANGRA DIATREME

Jangra diatreme surfaces at an altitude of 500m from MSL.

Characteristics of the diatreme

Name of kimberlite body: **Jangra** (20^0 082 303 : $82^0$19' 40").

Dimension Trend: 50m x 50m

Emplacement control: Circular within granitoid rocks 64L/8

Outcrop characteristics: Ampitheatrical depression within granitoid

Diamond contents/heavy minerals: Not known/garnet and spinel

A. 4. KODOMALI DIATREME

Kodomali ($20^0$11' 10": $82^0$14' 08") kimberlite exposes as a dyke with WNW-ESE trend and is the only diatreme with rock exposure visible at the surface, amongst the five known diatremes in Mainpur Kimberlite Field. Like other diatremes, this diatreme is also surrounded by the granitoids. The near surface alteration as green earth is not much as compared to other diatremes.

Characteristics of the diatreme

Dimension Trend: 300m x 300m

Diamond contents/Heavy minerals: **Diamondiferous garnet, spinel, clinopyroxene, ilmenite and olivine**

Kimberlites of Mainpur kimberlite field have been classified into three volcanic facies,viz. crater, diatreme and hypabyssal. Crater facies material has been preserved as xenoliths within Payalikhand-I and -II diatremes. Bahradih, Payalikhand I & II and Jangra diatremes have been classified as diatreme facies rocks. Only Kodomali rocks are classified as hypabassal facies.

Recommendation: The MKF has scope for further work to establish more kimberlite pipes and evaluation of their diamond potentiality.

B. TOKAPAL KIMBERLITE FIELD (BASTAR DISTRICT)

The regional search for kimberlites in Indravati basin has located kimberlite clan rocks in

Tokapal, Duganpal, Bhejripadar and Parpa-Parakot areas and the Tokapal Kimberlite Field. The area is occupied by the Archaean-Proterozoic rocks of Bastar Craton. The kimberlitic pipes have intruded along NW-SE- trending fracturers exhibited by mafic dyke swarms. The NW-SE- trending dyke swarm as well as major lineaments and faults possibly indicate reactivated mantle permeable zones along which the kimberlitic pipes have been emplaced within the Proterozoic cover sediments.The Indravati basinal area forms the east-central part of Bastar Craton.The Tokapal, Duganpal and Parpa-Parakot kimberlitic rocks probably indicate multiple intrusions from a single or multiple feeders covering an area with 5km length and 1 km width.

The borehole core samples indicate multiple intrusions at different levels with deposition of tuffs in the upper part. The Bastar kimberlites are in the crater facies, without much erosion. It is also interesting to note that in Bastar, there are kimberlitic flows in phases overlain and underlain by Indravati sediments.

B.1. TOKAPAL KCR (KIMBERLITE CLAN ROCK) BODY

The Tokapal rock is exposed in pit section and the rock is greenish in colour and shows

typical kimberlitic clast-matrix texture and flowage structure within sediments (Jagdalpur

Formation) in the form of flows (65E/16). The rock shows crude banding and top portion is lateritised and covered by black soil horizon.

Diamond content: Not known

B. 2. DUGANPAL KCR BODY

The Duganpal kimberlitic rock exposed in the Duganpal *nala* section has been exposed by drilling.

Diamond content : Not known

B. 3. BHEJRIPADAR KCR BODY

The Bhejripadar kimberlitic body is located near village Bhejripadar (65 E/16). The body

is exposed within the sandstone unit of Tirathgarh Formation.

Diamond content: Not known

B. 4. PARPA – PARAKOT KCR BODY

The kimberlitic rock in Parpa – Parakot sector was observed from the borewell cores

drilled by the State Agricultural Department. The crater facies rocks are concealed under the soil and laterite cover of >20m. The borehole data show the presence of kimberlitic tuffs and

pyroclastic rocks below 19.87m from the surface upto 36.67 m. From 36.67m to 62.69m

greenish black massive kimberlite was observed.

Diamond content: Not known

C. EXPLORATION FOR KCR IN RAIGARH MOBILE BELT

The exploration for KCR was also conducted in the Tapti Lineament Zone (TLZ) in parts of Raigarh and Surguja districts of Raigarh Mobile Belt from 1994 to 2000 on the basis of reported diamond incidences in the river gravels of Ib, Maini, Mand, Utial and Talda drainages.A total of 6000 sq km area was covered by PGRS studies and stream sediment sampling, but no primary source of diamond has been located except one grain of chromite falling in the edge of kimberlite field.

D. SARANGARH SECTOR

The Sarangarh area falls in the northeastern part of Chhattisgarh basin. A major part of the area forms a part of Bardwar sub-basin of Chhattisgarh Supergroup. Stream sediment sampling in the area revealed presence of kimberlitic pyrope garnet which are found to be G-9 type of lherzolitic derivative. In addition G-5 garnet has also been discovered from stream sediment samples. Detailed sampling in this area is recommended.

PROSPECTS IN MAHARASTRA

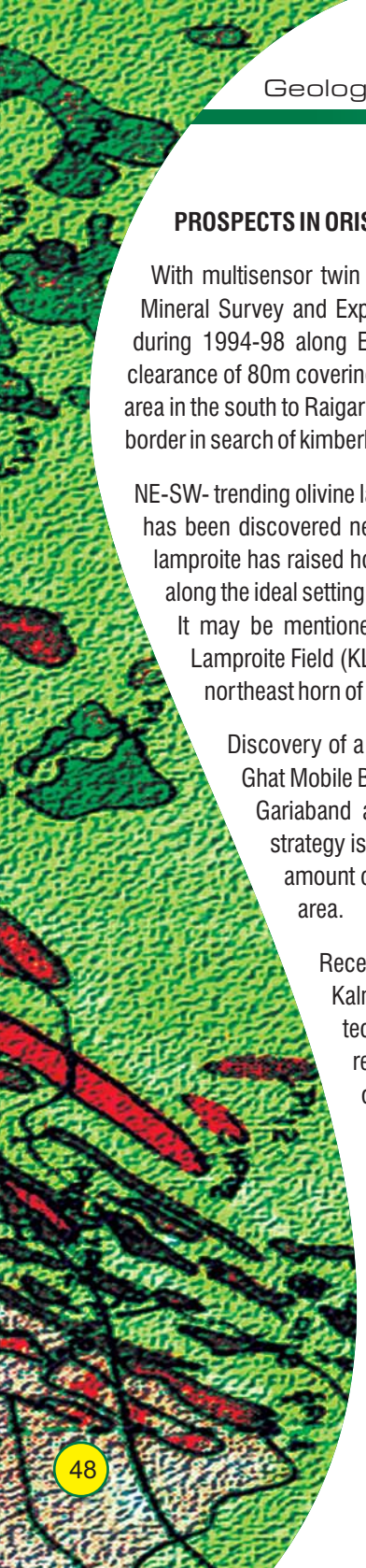
Indicator mineral survey carried out in the western part of Bastar craton, falling in Chandrapur and Garchiroli districts of Maharastra has revealed chrome diopside and G5 garnet. The chrome pyroxenes show some similarity with the pyroxenes from the Monastry Kimberlite Field, South Africa, in terms of their Ca/ (Ca + Mg) and Mg/(Mg + Fe) ratio with chromium.

PALEOPLACER DIAMONDS OF WAIRAGARH, MAHARASHTRA

Diamond incidence is known from conglomerates of Wairagarh area in Maharashtra. The Wairagarh area exposes a narrow stretch of (10km x 6km), NNW-SSE- trending low-

grade, highly deformed metasedimentary belt within Archaean Amgaon Gneiss and forms a part of the western part of Bastar Craton.

An octahedral diamond (3.5mm long and 2.5mm wide, 0.15 carat) was recently recovered during the GSI investigations of the conglomerate unit of WMS. Along with diamond, other heavy assemblages identified include ilmenite, garnet (G-5 minerals, almandine, grossular and andraditic garnets), pyroxenes, amphibole, staurolite, chrome spinel and rare tourmaline. This find has opened up new vistas of diamond search in similar geological milieu in the western Bastar Craton.



PROSPECTS IN ORISSA

With multisensor twin otter aero-geophysical survey carried out by the Airborne Mineral Survey and Exploration Wing (AMSE Wing) of Geological Survey of India during 1994-98 along E-W flight lines at intervals of 500m with a mean terrain clearance of 80m covering an area of about 27,850 sq. km from Mainpur Payalikhand area in the south to Raigarh-Sundergarh area in the north around Chhattishgarh-Orissa border in search of kimberlite.

NE-SW- trending olivine lamproite dyke cross-cutting a NW-SE- trending dolerite dyke has been discovered near Sakri village, Bargarh district, Orissa. Discovery of this lamproite has raised hopes of finding more such dykes and main lamproite bodies along the ideal setting of the contact of Bastar Craton and Eastern Ghat Mobile Belt. It may be mentioned here that this present setting is similar to the Krishna Lamproite Field (KLF) on the eastern margin of Dharwar Craton just outside the northeast horn of Cuddapah Basin in Andhra Pradesh.

Discovery of a lamproite dyke on the margin of Bastar Craton and Eastern Ghat Mobile Belt and incidence of several kimberlite indicators in Mainpur-Gariaband and Khariar road-Paikamal area prove that the integrated strategy is well founded and worth continuing further to utilise the vast amount of aero-geophysical data available with GSI pertaining to this area.

Recently, State DGM has recovered diamond from a pipe in Kalmidadar. The cratonic domain of western Orissa lying in tectonic juxtaposition with circumcratonic EGMB is a promising regional target of primary diamond exploration due to old diamond panning records and recent discovery of kimberlite diatremes in adjoining state of Chattisgarh having identical geological milieu.

A. KIMBERLITES AND LAMPROITES OF SOUTH INDIA

Kimberlites and lamproites are located in about 270 x 180 km area in Wajrakarur-Lattavaram-Chigicherla-Kalyandurg area (WKF) in Anantapur district, Andhra Pradesh (A.P.), Narayanpet Kimberlite Field (NKF) in Mahboobnagar district, A.P.and Gulbarga district of Karnataka and Chelima-Zangamrajupalle area (CZLF) in Prakasam district,A.P. and Jaggayyapeta Lamproite Field (JLF) also known as Krishna Lamproite Field of Krishna and Nalgonda districts of A.P. These kimberlites and lamproites are known to occur only from the Eastern Dharwar Cratonic block.

The WKF (14°05′ – 15°03: 77°18' – 77°23'; Toposheet nos. 57E/8 & F/5) measures 120km x 60km with kimberlites emplaced into the gneisses and schist belt. A total of 21 kimberlites are distributed in 3 clusters, viz,

(i) Wajrakarur–Lattavaram cluster – 13 bodies (pipe–1 to pipe-13)

(ii) Chigicherla cluster – 5 bodies (CC-1 to CC-5)

(iii) Kalyandurg cluster – 3 bodies (Kl-1 to Kl-3)

Majority of the pipes in WKF are diamondiferous.

During 2004, two new kimberlite bodies have been reported from Timmasamudram (TK-1 & TK-2).

The (NKF) is located about 150 km southwest of Hyderabad and 200 km north of the WKF. It measures 60 km x 40 km in extent. The kimberlites of NKF occur in four noticeable clusters, viz.,

(i) Maddur cluster – 11 bodies (MK-1 to MK-11)

(ii) Kotakonda cluster – 7 bodies (KK-1 to KK-7)

(iii) Narayanpet cluster – 10 bodies (NK-1 to NK-10)

(iv) Bhima cluster – 6 bodies (BK-1 to BK-6).

Incidence of diamond has not yet been reported from these bodies.

During 2001-02 in between NKF and WKF three new kimberlite bodies were discovered near Siddampalle village (SK-1, SK-2 & SK-3) in Gadwal district, A.P.

WAJRAKARUR KIMBERLITES

In Wajrakarur area, three kimberlite bodies (pipes 1, 2 & 6) are found over a length of 4 km in an E-W direction. The pipe 6 occurs in black soil area whereas the rest in the residual brown soil area.

KIMBERLITE PIPE 1 (WAJRAKARUR PIPE)

The kimberlite reserves estimated for the southwestern part (400 x 150m) are about 6.94 Mt upto 60m depth with a diamond resource of 52,000 ct. Though the average incidence is less, large majority of diamonds in general are gem quality and diamonds upto 9.45 ct were recovered.

KIMBERLITE PIPE-6 (WAJRAKARUR WEST PIPE)

Location: About 1.5 km west of Wajrararur and 300m north of Kottakunta tank.

Dimension: 260m x 240m– roughly circular in shape

Drilling: Nineteen boreholes, with the deepest borehole going upto 280m depth. The body is completely covered under 1.5-m-thick black soil. Yellow ground occurs upto a depth of 45m, followed by blue ground which extends beyond 280m depth. A granite-kimberlite breccia raft (170m long and 30-80m wide) is found in the centre of the pipe extending upto 35 to 40m depth. The kimberlite resources estimated upto 60m depth are of the order of 5.99 Mt with a diamond resource of 40,000 ct.

KIMBERLITE PIPE -2 (WAJRAKARUR EAST PIPE)

Location: About 2.5 km east of Wajrakarur; Dimension: 380m x 70m.

Drilling: Eleven boreholes; unaltered kimberlite is noticed at surface. The pipe is diamondiferous. Three diamonds were recovered after processing 278 tonnes of kimberlitic material. Diamonds are of gem variety and range in weight from 0.04 to 3.26 ct.

LATTAVARAM KIMBERLITES

Four kimberlites (pipes 3, 4, 8 and 9) are located in a radius of 0.5 km, about 1 to 1.5km east of Lattavaram (14°55´: 77°17´; 57F/5). Outcrops are scanty.

The results of exploration are as follows:

Pipe No. 3: Diamond incidence (cpht) - 0.28

Pipe No. 4: Diamond incidence (cpht) - 0.25

Pipe No. 8: Diamond incidence (cpht) - 0.33

Pipe No. 9: Diamond incidence (cpht) - 0.5

KIMBERLITE PIPE - 5 (MULIGIRIPALLE PIPE)

Location: About 1.5 km east of Muligiripalle

Dimension: 240 x 45m

Sampling five bulk sample pits (3 x 2 x 10m each). 276 cu.m of excavation, 482t of processing. No diamonds recovered.

KIMBERLITE DYKE – 7 (VENKATAMPALLE KIMBERLITE)

Location: About 0.5 km east of Venkatampalle (14°56':77°21'; 57F/5)

Dimension: 1.2 km long x 0.5 to 30m wide – dyke-like body.

Av. diamond incidence (cpht): 44.5

Kimberlite resources: About 0.5 Mt upto 90m depth (for the 600m length of dyke enlargements). About 14000 t of overburden over the dyke enlargement.

Diamond resources: 48000 ct upto 90m depth in the kimberlite and 4700 ct in the overburden over the dyke enlargements.

Diamond characteristics: A large majority of the diamonds recovered from the kimberlitres are of gem quality. Till now, the pipes 1 and 6 and dyke 7 have yielded more number of diamonds. In the pipes 1& 6, about 90% of the diamonds by weight are of gem quality and in the dyke-7, about 60% by weight. The largest diamond recovered from the area is 16.30 ct by weight (from dyke-7) and is of gem variety.

KIMBERLITE PIPE – 10 (ANUMPALLE KIMBERLITE)

Location: 0.75 km west of Anumpalle village (14°59' 4": 77°30'55")

Dimension: 1200m long x 1000m wide pod-shaped body.

Emplaced into the younger granitoids at the intersection of the ENE –WSW fracture with the major NW-SE- trending Singanamala fault. No outcrops, covered by 1.5m kimberlite

calcretre, rafts of granite float in the kimberlite – two linear disconnected satellite bodies noticed to the west of the main body.

Pipe no. – P 10

Diamond recovery No/Wt.Ct.- 48/14.71

KIMBERLITE PIPE –11 (DIBBSANIPALLE KIMBERLITE)

Location: 0.5 km SSE of Dibbsanipalle village (15°02'00" : 77°28'' 00")

Diamond incidence (ct/100t): 0.78

Dimension: 143m long x 82m wide bean shaped

Pipe no. – P 11

Diamond recovery No/Wt.Ct.- 2/2.15

Diamond incidence (ct/100t): 0.78

KIMBERLITE PIPE – 12 (CHINTALAMPALLE KIMBERLITE)

Location: 1 km west of Chintalampalle village (15°02' 00": 77°28' 00")

Dimension: 130m long x 40m wide

Pipe no. – P 12

Diamond recovery No/Wt.Ct.- Nil

Diamond incidence (ct/100t): Nil

KIMBERLITE PIPE -13 (TUMMATAPALLE KIMBERLITE)

Location: 2.5km NE of Tummatapalle village (14°49'55" : 77°41' 00")

Dimension: 125m long x 100m wide

Emplaced into the TGA rocks along a ENE-WSW sinistral fault that displaces the Manutla dome.Melanocratic outcrops and partly weathered and altered kimberlite capped by calcretes.

A.2. CHIGICHERLA AREA (WKF)

Coordinates: 14°3': 77°4'; Toposheet no. 57F/10

KIMBERLITE PIPE CC-1:

Dimension: 315m x 185m – pear shaped. A grab sample of 119 t from a well dump in the body yielded 4 diamonds weighing 0.44 ct. Subsequently 436 tonnes of material has been processed which yielded 5 diamonds weighing 1.31 ct averaging 0.30 cpht.

KIMBERLITE BODY CC-2

Dimension: 200 x 175m

A total of 302 tonnes of kimberlite material was processed which yielded two diamonds weighing 1.02 ct averaging 0.35 cpht

KIMBERLITE BODY CC-4

Location: about 1.75km west of Golapalle

Dimension: 125m x 100m, nearly circular in outline

Incidence of diamond: 15 diamonds weighing 2.17 ct were recovered from 88 tonnes of kimberlite material drawn from 5 trenches, indicating an average diamond incidence of 2.46cpht.

KIMBERLITE BODY CC-5

Location: This kimberlite body is located about 1km NE of Gollapalle.

Dimension: 220m x 70m

Incidence of diamond: Six diamonds weighing 1.38 ct have been recovered from 175tonnes material of pipe CC-5. All are gems ranging in weight from 0.05 to 0.51 ct, the average weight of the stones being 0.23 ct.

A.8. CHELIMA-ZANGAMRA JUPALLE AREA (NALLAMALAI FOLD BELT)

A number of kimberlites/lamproites exists and lie undetected in the soil-covered areas south, west and north of the Cuddapah Basin and within the basin itself. The known source rocks tested so far are not of much economic significance and therefore intensive efforts

are needed to identify additional primary host rocks for diamond.

A.9. JAGGAYYAPETA (KRISHNA) LAMPROITE FIELD (JLF/KLF)

The JLF or KLF falls north of the Krishna River, along the eastern margin of Dharwar Craton (DC) spread over an area of about 160 sq. km. in Krishna and Nalgonda districts and comprises 25 lamproite bodies located just outside the peripheral parts of the north-eastern horn of Cuddapah basin. The lamproites occur as 0.5m – 5m dykes, mostly as clusters and run for lengths of about 1m to 400m in close association with dolerite dykes mostly emplaced along the contacts between granite gneiss and dolerite dykes.

A.10. SIDDAMPALLE KIMBERLITES

During 2001-02 three new kimberlite bodies were discovered near Siddampalle village in Gadwal district, Andhra Pradesh. The first body (SK-1) measuring 100x65m is located about 2km N25E of Siddampalle village and SK-2 measuring 110x50m is located about 1.5km N10W of Mallapuram Tanda. The third body (SK-3) measuring 26 x 14m is exposed in a well section. SK-1 & SK-3 are mainly 'hardebank' variety while SK-2 is a concealed body with calcrete cover.

B. CONGLOMERATES

B.1. BANGANAPALLE - NEREDUCHERLA AREA

Banganapalle - Nereducherla, Kurnool district.

Coordinates : Lat.:15°12' -15°20'; Long.: 77°50'-78°15'; Toposheet no. 57 I/2 & E/16

Extent : 30 km long and 200 m to 2 km wide

Exploration: To assess diamond potential of the conglomerates (mainly basal) exploration was carried out in two phases during 1980-87 by GSI in association with MECL and NMDC, in eight selected blocks in the area, six in the Munimadugu-Allahabad plateau areas and two in the Banganapalle-Rallakotturu-Lingambadi Plateau areas.

MUNIMADUGU BLOCK:

No. of diamonds/weight : 167/84.38 ct

Diamond incidence : 2.26 cpht

Average diamond weight : 0.50 ct

Conglomerate resource : 60, 700 t

Diamond resource : 2,000 ct

An average incidence of 8.32 cpht (spot values upto 35 cpht) was recorded. Average diamond weight from this area is 0.87 ct.

ALLAHABAD WEST AND WEST EXTENSION BLOCKS:

No. of diamonds/weight : 221/71.24 ct

Diamond incidence : 1.48 cpht

Average diamond weight : 0.32 ct

Conglomerate resource : 10,44,000 t

Diamond resource : 15,600 ct

Spot values for diamond are upto 7 cpht.

ALLAHABAD SOUTHWEST AND SOUTHWEST EXTENSION BLOCKS:

No. of diamonds/weight : 298/125.90 ct

Diamond incidence : 2.89 cpht

Average diamond weight : 0.42 ct

Conglomerate resource : 3,94,000 t

Diamond resource : 11,400 ct

An incidence of 8.23 cpht was recorded over a length of 200m (with spot values upto 27.35 cpht)

RALLAKOTTURU - LINGAMBADI BLOCK:

No of diamonds/weight : 104/51.67 ct

Diamond incidence : 2.59 cpht

Average diamond weight : 0.49 ct

Conglomerate resource : 21,37,00 t

Diamond resource : 26,600 ct

Of the total diamonds recovered, gem quality constitutes about 76% while the off colour and industrials 8% and 16% respectively.

B.2. RAMALLAKOTA- YAMBAI AREA

The erratic distribution and lensoid geometry of the conglomerate beds warrant close spaced pitting/shallow drilling to delineate the beds as well as estimate the conglomerate resources.

B.3. UNDUTLA-TAMMARAJUPALLE -CEMENTNAGAR AREA

Area: Undutla-Tammarajupalle-Cementnagar, Kurnool district.

Coordinates: Lat.:15°30' –15°25', Long.: 78°10' – 78°15'

The conglomerates from both the Undutla and Cementnagar Plateau have to be tested for diamond potential.

Search for kimberlite in Buthpur and Achampet block in Mahbubnagar district, Andhra Pradesh, yielded kimberlite specific minerals like picro-ilmenite and chrome-spinel in stream sediment samples from Palkampally, Wattipalli and Kottapalli. Kimberlite-specific minerals like chrome spinel has also been recorded from Kalwakurthi and Charakunda block in Mahbubnagar and Nalgonda districts.

GOLD

India ranked 6th in the world with a gold production of 19.5 tonnes during the year 1905, whereas the production of gold from primary source during the year 2007 is only 2.490 tonnes. Kolar mine has produced more than 800 tonnes of gold before its closure in 2001. Presently gold is produced from three mines viz Hutti, Uti, Hirabuddni (HGML) in Karnataka and as by-product from basemetal sulphide deposits of Khetri (Rajasthan), Mosabani, Singhbhum (Jharkhand) in public sector and Kundrekocha in private sector in the decreasing order. In India, the total gold production in the year (2006-07) was 12.82 tonnes (0.5% of world production), of which 2.36 tonnes is from primary source, 127 kg from basemetal mines as by product, and the remaining 10.34 tonnes recovered from secondary source by smelting of imported copper concentrates by HINDALCO at Dahej in Bharuch district, Gujarat.

Kolar, the second deepest (3200 m) gold mine in the world, survived for 110 years and the Hutti gold field witnessed four periods of widely separated exploration and mining, viz. pre-Asokan (+2000 years old), Nizam period (1886-1920), 1937 to 1947, and the present and most successful from 1947 onwards. The deepest (about 250m in length and over 195m in depth) known old working in the world is located on the Main reef at Hutti gold mines. The advent of worldwide gold rushes in 19th century laid the foundation for present-day mining activity. The gold boom was experienced in India with discovery and mining in Kolar, Hutti, Gadag, Ramagiri, Honalli, Wynad in the south and a few in north, viz. Lawa, Mysara, Pahardia, Kundrekocha, etc. Most of the old workings were closed due to dwindling production and prevailing cost-benefits.

Geochronological data of gold metallogeny revealed major periods of enrichment as Archaean and Proterozoic. Gold occurs in a variety of lithoassemblages, and multiple geological environments / settings such as greenstone belts, mantle-derived intrusions, diapiric juvenile plutons and granulites. In the Indian subcontinent, prominent granite greenstone belts of Peninsular Sheild are located in Dharwar, Bastar, Singhbhum and Rajasthan Cratons. The Dharwar Craton, with two blocks, viz. the eastern and western, hosts the maximum number of gold occurrences. The Eastern block provides an important and favourable lithologic, structural and stratigraphic milieu for gold mineralisation and hosts major deposits like Kolar and Hutti. In the northwestern Indian Shield, gold occurs in association with copper in the Archaean greenstone-like sequence (at Dhani Basri, in Mangalwar Complex) and Proterozoic metavolcanosediments (at Bhukia and Dugocha, in Aravalli Supergroup) with enrichment in the latter. Gold also occurs in Palaeo / recent river alluvium placers, laterite, soil and regolith. Puga geothermal system is a “hot spring” type epithermal gold deposit in the making in the Ladakh region of Jammu and Kashmir.

In the **Dharwar Craton and SGT,** the primary gold mineralisation is recorded in three different geological settings viz. (i) Archaean greenstone belts, (ii) in Banded Iron Formations (BIF) and amphibolite associated with granulites, and (iii) in quartz-carbonate veins related to alkaline magmatism. Among these, the gold mineralisation associated with the greenstone belts is quite significant.

(i) Gold mineralisation in Archaean greenstone belts

Kolar Gold Fields (KGF) had been the primary gold producer in the country. From the position of a large producer in the world (790 tonnes since 1880 from a grade of about 16 gms/t), it became an insignificant gold producer with grades lowered to about 3-4 gms/t to about one tonne per annum in the mine.The KGF comprising the Champion, Nundydoorg,

Mysore and Bisanattam mines is located in the central part of the 80-km-long Kolar Schist Belt. There are two zones of subparallel lodes, sub-conformable to the meta-basite host rock viz., the Champion lode on the east and the Oriental and McTeggart lode on the west. Gold-polysulphide association were identified in Champion Reef and gold-pyrrhotite-arsenopyrite in McTeggart lode with characteristic scheelite. The deposits are vein type with wall-rock alteration, especially in the eastern part of the belt. The economical values of gold ore in the southern end of the Kolar Schist Belt came into limelight at the time the KGF values were uneconomical to mine, and is marked by a number of old workings. Gold mineralisation in the southern belt was established by GSI at Chigargunta, Mallappakonda, Bisanattam, Kudithinapalle and Avulathinapalle. The Chigargunta mineralisation in the south is in non-conformance with that of the KGF to the north and is in distinct tectonised zones and post-dates the major folding and amphibolite-grade metamorphism. The 3-km-long mineralised zone occurs in the amphibolite and Champion Gneiss units as well as on their contacts, confined to shear zones.A reserve of 4.19 Mt with grade ranging from 4.2 to 5.22 g/t of Au over widths ranging from 1.46 to 12.05m was estimated. The deposit is under exploitation by the BGML. In Mallappakonda Block, auriferous zones associated with BIF are lensoid, parallel and en echelon occurring over a strike length of 400m. A reserve of 0.65 Mt of ore with an average grade of 4.3 g/t was established.In Bisanattam Block, both GSI and MECL carried out investigations for gold. The mineralised zones found in fissile amphibolite are lensoid, parallel and en-echelon in disposition and vary in width from 1 to 3 m. About 0.13 Mt of ore with a grade of 5.1 g/t was established. The deposit was mined by BGML and since been closed. In Kudithinapalle Block, located 3 km south of Bisanattam Mine, gold mineralisation in quartz reefs is hosted by both hornblende schist and Champion Gneiss. The quartz reef is about 100m long and 2 to 3m wide. A reserve of 0.48 Mt ore with an average grade of 1.2 g/t was established. Molybdenum is also found in the quartz veins.

Gold mineralisation is reported in the southern extension of the Kolar Schist Belt in Veppananpalli and Bargur sectors in Krishnagiri district of Tamil Nadu. In Veppananpalli sector, the southern continuity of the Kolar Schist Belt is traceable as two narrow linear strips, viz. the eastern Maharajagadai strip and the western Adakonda strip representing synformal keels.

In the Maharajagadai Block, eleven zones of gold mineralisation have been delineated within the silicified zones in quartz-sericite schist (Champion Gneiss) occurring in association with amphibolite. The epigenetic gold mineralisation is mainly confined to the sheared and silicified zones in the quartz-sericite schist. Gold is associated with sulphides, viz. pyrite, pyrrhotite, sphalerite, chalcopyrite, arsenopyrite and galena of which pyrite is most dominant. Exploratory drilling in this block has indicated a potential reserve of 0.07 million tonnes of ore with 1 to 2 g/t of gold upto 75 m vertical depth.

In the Adakonda Block, gold mineralisation is confined to sheared and silicified zone in amphibolite and associated BIF. In this block, gold is associated with pyrite, pyrrhotite, arsenopyrite and chalcopyrite. The surface exploration, by trenching and groove sampling, has indicated gold values ranging from 0.2 to 2.57 g/t with an average width of 1.5 m over a strike length of 450 m.

Near Bargur (15 km SE of Maharajagadai block), gold mineralisation has been recorded in the amphibolite band occurring within the gneisses. The mineralisation is traceable for a strike length of about 75 m over a width of 0.65 to 4.45 m with gold assay values ranging from 0.2 to 0.96 g/t.

In the **Hutti-Maski Schist Belt,** gold mineralisation is localised along the shear zones developed parallel/subparallel to S_1 schistosity in both basic and acid meta-volcanic rocks. The Hutti Gold Mines located in the northern part of the belt produced 1048 kg of gold during 1990-91. Extensive and detailed investigations were carried out by GSI in Hutti mines area, Wandalli, Uti, Hira-Buddini and Maski, proving sizeable gold reserves.

In the **Gadag Gold Fields** of Chitradurga district, ancient workings and mines are seen over an area of 200 km^2. All the known gold bearing lodes are confined to the western limb of an overturned syncline over a strike lenth of 15 km.The prospects explored by GSI are-(i) Western Group comprising Hosur-Champion, Yelishirur and Venkatapur mines hosted dominantly in meta-basalts and meta-andesites, (ii) Middle Group comprising Kabuliyatkatti-Attikatti, Mysore Mine and Sangli Mine, hosted mostly in greywacke, and (iii) Eastern Group comprising Sankatodak Block and a fewer prospects east of Nabhapur and Kabuliyatkatti villages, hosted in greywacke. In addition, gold mineralisation is also known from the area north of Nagavi hosted in BIF in contact with tuffaceous rocks.

In the **Anesidri-Ajjanahalli-Bellara** area, Tumkur district, Karnataka, gold mineralisation is associated with meta-volcanics as well as sulphide-banded iron formation of the Chitradurga Group. In the Ajjanahalli block, 10 parallel zones of mineralisation localised in shear zones in sulphidic BIF along a fold have been delineated by GSI. The strike length of the block is about 1500 m. The estimated reserves at 0.5 g/t cut-off grade are 0.77 Mt of ore.

Very recent exploration for gold by GSI in Ajjanahalli Block-C, Tumkur district, Karnataka on bedrock samples yielded gold value ranging from 0.10 g/t to 4.22 g/t. Analysis of trench samples indicated gold value ranging from 0.36 g/t to 6.0 g/t. In Ajjanahalli block-F, three major auriferous BIF bands have been delineated. Band-I (strike length 300m average width 3 to 4m) has recorded 1.02 to 2.2 g/t gold; Band-II (strike length 200m average width of 2m) has recorded 0.28 to 1.70 g/t gold; Band III (strike length of 700m average width 4m) has recorded gold values from 0.03 to 0.70g/t.

The **Ramagiri-Penakacherla Schist Belt** extends over a strike length of 100 km with a number of gold prospects grouped into two fields, viz. (1) Ramagiri Gold Field (RGF) and (2) Bhadrampalle Gold Field (BGF). RGF has a reserve of 0.7 Mt with an average grade of 7 g/t in the Om Pratima-Gantalappa Block. In Kottapalle Block, north of this mine, a probable reserve of 0.11 Mt withan average grade of 2.65 g/t over an average width of 1.41 m was estimated upto 165 m depth. Auriferous lodes of BGF are of small length. A reserve of 0.023 Mt of ore with an average grade of 4.13 g/t of Au over an average width of 1.21 m upto 75 m depth for the main lode and 0.36 Mt with 2.34 g/t of gold over a width of 1.00 m upto 80 m depth for the northern lode has been estimated. In Ramapuram area, preliminary exploration has led to estimation of 0.07 Mt of ore upto a maximum depth of 70 m for 4 lodes over width varying from 1.29 to 1.56 m and gold content ranging from 1.28 to 1.39 g/t. Ancient mining activity is recorded in both the fields.

Another prominent area of gold mineralisation is located in **Wynad gold field** in Devala-Pandalur, Cherambadi and Kotagiri sectors in Nilgiri district of Tamil Nadu and in the adjoining parts of Kerala.

In Devala-Pandalur sector, gold mineralisation is confined to zones of intense shearing and dislocation which have acted as loci for emplacement of auriferous quartz veins. The host rocks for these quartz veins are biotite gneiss with interbanded hornblende granulite and magnetite quartzite. The gold mineralisation is associated with intense wall-rock alteration in the form of sericitisation and chloritisation. The gold-bearing quartz reefs show a general trend of N-S. Two main types of gold mineralisation have been recognised – one is sulphide-rich and the other is sulphide-poor type.

Alpha-Victoria, Nadghani, Solomon and Hare Wood mines near Devala and Phoenix, Rosedall and Glenrock mines near Pandalur are the important old workings located in this sector. Samples collected from this sector have analysed gold content of 3.06 to 15.2 g/t. The exploratory drilling carried out in some of the old working areas reveal that in Alpha-Victoria mine, the gold mineralised zone is traceable for a strike length of about 1000 m over a width of 1 to 3 m with an average tenor of 1.98 g/t. In Hare Wood mine, the maximum strike length and width of the lode are 116 m and 30 m respectively. In Solomon mine, the lode is having a width of 2 to 5 m for a limited strike length of 40 to 60 m with grade varying from 1.9 to 6.04 g/t.

In Cherambadi sector several old workings for gold are located in Mangorange, Duraiswamikaradu, Went worth-I & II and Cherangode. Auriferous quartz veins occur in sheared biotite gneiss showing intense sericitisation. In Mangorange tea estate, two quartz veins are exposed. The first one occurring in the form of two detached en-echelon reefs trending in E-W direction with 25 to 30º dip towards north. Among these two reefs, the prominent one is having a strike length of over 1.5 km with a width of 2 m. The other reef is measuring 100 m x 2 m. Another quartz vein has been traced for a strike length of 1.2 km with width varying from 1 to 3 m. In Duraiswamikaradu area, a quartz reef with a thickness of 1 to 3 m over a strike length of 0.8 km has been traced. This shows NE-SW trend with southeasterly dip in the southern part and N-S trend with 60º dip towards east in the northern part. In Went Worth-I & II old workings, three quartz reefs are exposed. The width of the individual quartz reefs varies from 20 cm to 5 m and traceable for a length of about 60m. The gold assay values of the samples collected from this sector are not encouraging.

Gold occurrences and ancient mining activities are also reported from Adathurai-Kotagiri sector located in the eastern part of the Nilgiri hill ranges in Tamil Nadu. Preliminary sampling by GSI in the year 1967, from the old inclines, drives and trenches has indicated an average gold value of 2.41 g/t from 61 samples with 18.3 g/t being the highest value. Subsequent detailed studies by GSI (2004-06) have brought out that the Adathurai area is

traversed by a major brittle-ductile shear trending N-S to NNE-SSW. All along the shear/fracture planes, emplacement of auriferous quartz veins is noticed.

Chemical analysis of the trench samples collected from this zone shows an average gold values of 2.26 g/t over 2.5 m width and 6.2 g/t over 1.5 m width in two profiles. Similarly, the samples collected from an gold incline have analysed a maximum gold value of 22.9 g/t thereby indicating that this zone is a promising one for gold mineralisation. Four first-level boreholes drilled in this zone have indicated the depth persistence of the gold mineralised zone at 50 m vertical depth. Although the assay values obtained for the core samples by AAS are not encouraging, selected samples analysed by Fire assay method have indicated gold values upto 5.8 g/t.

In Gopanari-Velliyankadi sector in Coimbatore district, forming the eastern extension of Attappadi valley in Kerala, gold minerlisation is reported within the fractured and sheared quartz veins emplaced along minor shears developed close to the major Bhavani Shear Zone. The general trend of the quartz veins varies from NE-SW to ENE-WSW and occasionally along NNW-SSE to NW-SE directions. The quartz veins occur as small stringers as well as thick veins having a maximum width of about 5 m over 150 m length. The quartz vein contains sulphides which are mostly pyrite and subordinate arsenopyrite. Limonitisation is seen along the fracture planes. A total of five zones of gold mineralisation represented by lensoid auriferous quartz veins have been delineated. These zones vary in length from 7 to 13.5 km. Samples collected from the auriferous quartz veins have shown gold values ranging from 0.03 to 3.5 g/t. This prospect falls within the Gopanari Reserved Forest area.

Old workings for gold are also recorded in Bensibetta-Modikadavur-Inbakombai sector in parts of Erode and Coimbatore districts. Auriferous quartz veins are found within the sheared granitic gneisses which occur in association with charnockite, pyroxene granulite and minor metasedimentaries of Sathyamangalam Group. These lithounits show intense shearing marked by cataclasites, mylonites and phyllonites. Preliminary sampling by GSI has indicated gold values from 0.1 to 0.8 g/t.

Wynad gold field is one of the earliest known gold fields in the country, where gold is found in quartz reefs. Placer deposits of gold are known from Nilambur valley in Malappuram district.

In Kottathara block of Attapadi valley, Palghat district, Kerala, 60,000 tonnes of gold ore with an average grade of 13.6 g/t has been established. In Maruda area of Malappuram district, estimated reserve of 0.55 million tonnes of primary gold ore with an average grade of 4 g/t over a strike length of 350 m upto a depth of 100 m has been worked out by KMEDP.

Preliminary exploration carried out by GSI through test drilling has indicated six parallel lensoid zones in en echelon pattern in Kappil prospect and two lensoid lode zones in Mankada prospect. Gold mineralisation is restricted to the highly sheared and fractured quartz vein within the biotite-hornblende gneiss and amphibolite. The grade of the mineralisation in Kappil prospect ranges from 1.28 to 4.58 ppm and preliminary estimate indicates 0.462 m.t. of ore with a gold content of 1726 kg in Kappil prospect.

Gold mineralisation has been reported by GSI in epigenetic quartz veins emplaced within amphibolite / granite gneiss in Puttumala in Attapadi valley in Palakkad district, Kerala. A structurally controlled mineralised zone with an average width of 1.75 m has been traced with a value of 7.3 g/t gold.

Besides, preliminary gold occurrences are also known in Meppadi, Chundale, Vayittiri, Tariode, Vattam, Kuthimada, Karumsanthod, Thavingal, Venmani, Kakkarikunnu and Manathoddy areas of Wynad district in Kerala. The tenor of gold-bearing reefs in Wynad Gold fields is generally 2 to 3 g/t.

ii) Gold mineralisation associated with Archaean BIF in granulite terrain

Numerous bands of Banded Iron Formation (BIF) occur in association with charnockite and pyroxene granulite within the granulite terrain in northern Tamil Nadu in parts of Dharmapuri, North Arcot, Tiruvannamalai, Villupuram and Salem districts. The BIF shows transition from quartzite (oxide phase), magnetite-orthopyroxene bearing quartzite (silicate phase) to silicified sulphide-rich quartzite (sulphide phase). These BIF show intense shearing, brecciation and minor drag folds. Gold-bearing quartz veins occupy the shear zones and fracture / foliation planes within the BIF.

Preliminary prospecting of the BIF occurring in Melchengam-Attipadi-Thirthamalai belts and in Vediappanmalai-Kavuthimalai-Uchchimalai areas of Tiruvannamalai

district has indicated gold values ranging from < 0.1 to 0.6.5 ppm. Samples collected from Kannakadu Malai and east of Ravathanallur in Villupuram district have assay gold values ranging from 0.28 to 0.6 g/t. The samples collected from the BIF of Nainar Malai, Idaiyappatti, Rasipuram, Kariyampatti and other areas have analysed 0.1 to 0.9 g/t of gold.

The available data indicate that gold mineralisation in BIF is sporadic and the higher values of gold are mainly from the silicified zone in BIF.

iii) Gold mineralisation associated with Neoproterozoic alkaline-carbonatite complex

In northern part of Tamil Nadu, an array of alkaline-carbonatite complexes is found within the major NNE-SSW-trending Dharmapuri shear zone. This zone is marked by intense shearing, hydrothermal alteration of the charnockite and the associated quartzofeldspathic gneiss with profuse development of epidote and carbonates and emplacement of several quartz veins. The Harur-Uttangarai molybdenum prospect is located within this shear zone.

A few occurrences of gold are reported in the quartz veins as well as in the ankerite-siderite-bearing quartzofeldspathic gneiss within this shear zone. The prominent among them are in Nekkundi area near Vaniyambadi and in Andipatti-Elavadai-Ammapettai and Vellakkal west sectors within the Harur-Uttangarai molybdenum belt in Dharmapuri district.

In Nekkundi area, gold mineralisation occurs in the quartz veins emplaced within the sheared epidote-hornblende gneiss containing quartz-carbonate and ultrapotassic veins. The major quartz vein trending in NE-SW direction is traceable for a strike length of about 1 km with a width varying from 1 to 20 m. Chip samples collected from the sheared quartz vein with perthosite have analysed gold values ranging from 0.1 to 4.35 g/t with sporadic high values upto 10 g/t.

In Andipatti area, a major quartz vein is traced for a strike length of 600 m with width varying from, 5 to 27 m. Out of 42 groove samples collected from the entire length of the quartz vein, six samples have analysed 1.05 to 1.25 g/t of Au, fifteen samples showing gold values from 0.2 to 0.8 g/t and five samples giving 0.04 to 0.15 g/t of gold.

In Elavadi area, the auriferous quartz vein is 1km long and 4 to 12 km wide trending in N20°W-S20°E to N-S. Out of 87 groove samples collected from this vein, two samples have analysed 2.46 to 3.10 g/t of gold, eighteen samples have analysed 0.11 to 0.73 g/t and six samples analysed 0.03 to 0.09 g/t. The remaining samples have shown < 0.03 g/t of gold.

The 1.4-km-long quartz vein traced in Ammapettai area shows a general trend of N20°E-S20°W with 20° to 40° dip towards southeast. The width of the quartz vein is 5 to 17 m. It shows intense shearing and wall-rock alteration. Out of 117 groove samples collected from this quartz vein, five samples have analysed 1.1 to 5 g/t of gold and six samples analysed from 0.13 to 0.3 g/t. The remaining samples have shown gold values of <0.3 g/t.

In Vellakkal west area, a feebly carbonated quartz vein is traced for a strike length of 800 m with width varying from 5 to 15 m. Out of 62 groove samples, only three samples have analysed 1.39 to 3.0 g/t of gold. Twenty-seven samples have shown gold values ranging from 0.03 to 0.08 g/t and the rest of the samples give only < 0.03 g/t of gold.

In Velampatti block, the sheared quartz vein have analysed 0.2 to 1.0 g/t of gold in association with molybdenum in several boreholes drilled upto 320 m vertical depth.

Besides these primary gold occurrences, placer gold is reported from several parts of Tamil Nadu in Singiliyankombai and Iswaramurthipalaiyam area in Salem district, Veppanapalli area in Dharmapuri district and in Arakkadavu-Gudaiyur-Velliyankadu-Bhavanisagar sector in Coimbatore and Erode districts.

In the Proterozoic metavolcanosediments of the **North and Northwestern Indian Shield,** the major reserves of gold are from the Jagpura-Bhukia belt in Banswara district of Rajasthan. Five parallel zones extending over a strike length of 2 km is delineated. Minor occurrences are noted in Hinglaz Mata area (Dungarpur district), Ladera area (Jaipur district), and from associated copper ores of the Khetri copper belt. Besides, gold is also noted to occur in Pindwara-Watera belt, which is about 20 km long. On the basis of analytical result, a resource of 22.97million tonnes of gold ore with 1.81 g/t Au has been estimated in Delwara West block, Rajasthan by GSI. The total gold resource of Bhukia gold prospect has been augmented from 60.58 million tonnes to 83.55 million tonnes with average grade of 1.87g/t Au. The stage of exploration corresponds to G-3 of UNFC system.

Primary gold prospects occur in shield areas of Uttar Pradesh in Lalitpur and Sonbhadra districts. A tentative resource of 0.053 million tonnes gold ore with an average grade of 3.03 g/t Au has been estimated in the Proterozoic rocks of Sonapahari area, Sonbhadra district, Uttar Pradesh. The stage of exploration corresponds to G-3 of UNFC system.

Gold mineralisation of Gulaldih:

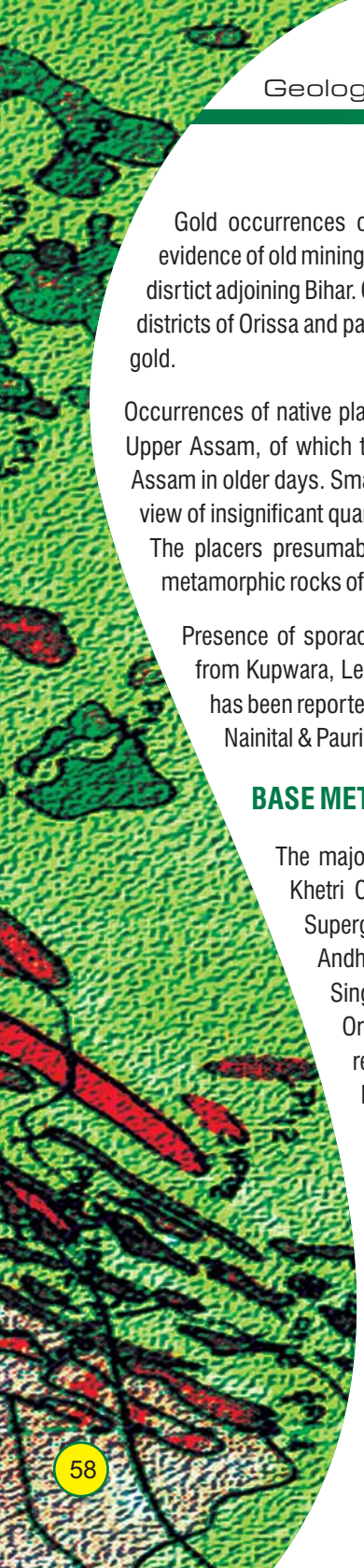
Extensive old workings occur over a strike length of about 10 km from Gulaldih. Detailed geological mapping and examination of old workings have revealed presence of a N85°W-S85°E-trending shear zone in the volcanosedimentary sequence of Agori Formation. The mineralisation occurs in the quartz veins and is associated with sulphides of lead, copper, iron, etc. Clusters of quartz veins form detached lenticular bodies. Gossan zones are well developed and are marked by boxwork with limonitic coatings. The prospect is divided into Bhiwa and Gulaldih block. Prospecting by Geological Servey of India in Bhiwa block indicated that, the shear zones occur in two sub-parallel zones in Agori Formation. The northern zone extends for about 2.4 km with width varying from 0.30 m to 2.0 m. The southern zone is in arenaceous phyllite with width varying from 0.40 m to 2.0 m. Chemical analyses of samples have revealed gold upto 3.87 ppm with background value of 0.3 ppm and threshold value of 1.3 ppm.

The known gold deposits of the **Central Indian Shield** includes Sleemanabad in Jabalpur, M.P., Parsori West, Kitari-Marupar deposits of Nagpur district, Maharashtra, BIF hosted gold deposits of Sonadehi, Bastar district, Pandripani deposit of Raigharh district, Chhattisgarh. The estimated gold resource of the region is of the order of 2.69 mt. This is likely to yield 4.5 tonnes of yellow metal. Investigation for gold mineralisation in Sonadehi gold prospect, Chhattisgarh revealed a resource of 2.28 million tonnes with 0.699 g/t gold. The stage of exploration corresponds to G-3 of UNFC system.

In the **Eastern Indian Craton,** one of the important metallogenic provinces of India, gold is obtained as important by-product during the extraction of copper (and other elements) from the copper ores of the Singhbhum copper-uranium belt. Gold occurs in these ores as discrete grains.

Auriferous quartz reefs are commonly found in the low-grade metasediments and metavolcanic rocks of ultramafic to acidic composition belonging to Iron Ore Group and Singhbhum Group and volcanics of Dhanjori-Dalma affinities. Among the important areas Kunderkocha deposit is considered to be highly potential. Reserve of gold in Kunderkocha as on 1.4.1990 was 0.1 ton. Another prospective area is the Tomka -Daitari region, south of the Jamda - Koira valley. The Lawa-Maysara deposits and quartz-pebble conglomerate located at the base of Dhanjori basin is equally potential in view of its multi-metal association in the latter. Decades back, gold was mined from Lawa and Mysera, north of the Dalmas. The other notable occurrences in this area are Pahardia, Ankua, Sausal, Bhitardari and Digarsai. The one at Sonapet is also quite significant. In north Singhbhum, gold is reported from a number of places located to the north and south of Dalma range. Chaibasa Formation forming the lower part of the Proterozoic Singhbhum Mobile Belt hosts occurrences of gold at Pahardia, Rungikocha, Ankua, Sausal. At Pahardia a gold ore resource of 0.25 mt with 3.85 g/t gold at 1 ppm Au cut-off has been estimated up to 65m vertical depth. At Parasi work by Geological Survey of India revealed an estimated gold resources of 0.11 million tonnes of 3.84 g/t Au (at cut off 3 g/t), 0.62 million tonnes of 1.83 g/t Au (at cut-off 1 g/t) and 1.6 million tonnes of 1.07 g/t Au (at cut-off 0.5 g/t). Recently the intensely fractured quartzite underlying the Dhanjori volcanics and the quartz pebble conglomerate (QPC) have shown significant gold values. The average grade of gold revealed from matrix-supported QPC bands of Haludbani sector is around 0.75 g/t. The bulk sample from Haludbani and Baruniya revealed 1.28 g/t and 0.306 to 0.66 g/t Au respectively. Primary gold mineralisation in reef quartz is noted intersecting pelitic and volcanic sedimentary sequences at Babaikundi and Birgaon along Tamar-Porapahar Shear Zone traversing Chhotanagpur Gneissic Complex. Auriferous quartz vein extending for about 500m shows gold values from 0.30 to 1.54 g/t with thickness varying from 0.15 to 3.0m.

Gold has been traditionally obtained from the sands of the rivers and streams of southern Chhotanagpur. Alluvial gold in Sonapet valley of Ranchi district varies from 0.045-0.68 g/cu.m in gravel. One placer sediment near Ichagarh and another 1.5 km south of Ichagarh indicated 1200 ppb and 555 ppb of gold respectively. Estimated tonnage of gold from placer along Sona *nala* and Karkari *nala* are about 0.4 million tonnes with a maximum tenor of 20 ppb. Placer gold is also known from Ankua. Recoverable resource of gold in Bihar & Jharkhand has been estimated to be 128.88 Mt (IBM, 2005).



Gold occurrences of Orissa are confined to mainly placers, though there is evidence of old mining activity in the northern parts of Orissa, especially in Keonjhar disrtict adjoining Bihar. Occurrence of alluvial gold has been recorded in almost all the districts of Orissa and panning of the stream sediments in the major rivers has yielded gold.

Occurrences of native placer gold have been recorded from a few places in rivers of Upper Assam, of which the Subansiri riverbed was the best gold producing area in Assam in older days. Small grains of native gold were won by panning alluvial sand. In view of insignificant quantity of gold, commercial exploitation of gold, is not possible. The placers presumably have been derived from auriferous quartz veins in the metamorphic rocks of northeastern Himalaya.

Presence of sporadic gold placers, traces of silver and platinum are reported from Kupwara, Leh, Kargil and Doda districts, Jammu & Kashmir. Placer gold has been reported from Bijnor, Gonda, Lalitpur, Moradabad districts of U.P and Nainital & Pauri Garhwal districts of Uttarakhand.

BASE METALS

The major discoveries of copper, lead, zinc deposits of India are in Khetri Copper Belt and in the Dariba-Rajpura area in the Aravalli Supergroup of rocks in southern Rajasthan, in the Cuddapah basin, Andhra Pradesh; in Malanjkhand, Madhya Pradesh; in the Singhbhum Copper Belt, Bihar; in Sargipalli, Sundergarh district, Orissa, and in the Darjeeling Himalaya and other Himalayan regions. Potential occurrences are summarised tectonic betlwise:

Deposits/Occurrences in Dharwar Craton

Two small deposits, one at Ingaldhalu located in the Chitradurga schist belt and the other at Kalyadi located in Dharwar schist enclave within the Peninsular Gneissic Complex of Karnataka are being worked on a scale of about 200 tonnes per day by the Chitradurga Copper Company which is a subsidiary of the Hutti Gold Mines Co. Ltd.

A belt of polymetallic sulphide mineralisation with copper, lead, zinc, antimony, arsenic, gold and silver values has been traced over a strike length of about 40 km along the eastern part of the Chitradurga Schist Belt. This mineralised belt (designated as the Chitradurga sulphide belt) extends from Chikkanahalli (14°26: 76°22') in the north to Yarahalli (14°04: 76°26') in the south. Copper mineralisation mostly occurs in quartz veins emplaced along shear zones occurring within the metavolcanics. Pyrite mineralisation with galena and occasional quartz veins is seen in chert bands and quartz reefs occurring within the metavolcanics.

Copper mineralisation is prominent in the Belligudda-Ingaldhalu-Kunchiganahalu sector over a strike length of about 5 km. Galena mineralisation with silver values is seen in the Kurubamaradikere-Madikeripura area over a length of 10 km. Galena occurrences have also been reported further to the north, near G.R. Halli. In addition, arsenic, antimony, and gold mineralisation occur along the Gonur-G.R.Halli-Chikkananahalli stretch (about 16 km).

Ingaldhalu copper deposit, Chitradurga district:

The Ingaldhalu (14°11': 76°27'; 57 B/8) copper deposit which is now being mined by the Chitradurga Copper Company is located in the Belligudda- Ingaldhalu-Kunchiganahalu sector. This sector has been explored in detail by GSI and the DUG. For purposes of exploration, this sector has been divided into 5 blocks, viz., (from south to north) Ingaldhalu South block - strike length about 1.3 km; Mines block - strike length about 1.1 km ; Ingaldhalu North west block - strike length about 1.8 km ; Ingaldhalu North block - strike length about 750 m and Ingaldhalu Northeast block - strike length about 260 m. The mines of the Chitradurga Copper Company are located in the Mines block and the North block.

The sulphide mineralisation is localised in quartz veins occupying narrow shear zones in the metabasalts and is of polymetallic type containing copper, zinc and lead with some silver and gold values. The principal sulphide minerals are chalcopyrite, pyrrhotite, pyrite and sphalerite with minor galena.

The Mines block has been explored by 45 boreholes drilled by GSI and the Department of Mines and Geology, Government of Karnataka. Mine development has been done to a vertical depth of about 300 m in 12 levels. On the basis of the borehole data, the reserves in the Mine block have been estimated to be 1.4 million tonnes with a copper content of 1.2% of which about 0.27 million tonnes have been blocked out by the mine development. The

silver values in the ore mined ranges from 6 to 85 g/t with occasional higher values of upto 950 ppm. The gold content is generally between 0.1 to 0.2 g/t with occasional values upto 3 to 5 g/t.

The Ingaldhalu North block has been investigated by 24 boreholes drilled by GSI. The mineralisation is similar to that in the Mines block. The copper lodes range in width from 0.44 to 4.3 m (mostly less than 1 m). The grade ranges from 0.75 to 2.25% Cu, mostly around 1%. Appreciable zinc and lead are also present in the mineralised zone. A reserve of about 0.22 million tonnes with an average copper content of 1.46% has been estimated for this block over a strike length of 450 m and a vertical depth of 120 m. The mineralised zone does not appear to persist deeper levels.

The Ingaldhalu Northwest block lies in the area intervening between the Mines block and the North block and has been explored by 37 boreholes drilled by GSI. The total strike length of the block is 1.8 km. Significant concentrations (>0.5% copper) are confined to 4 discontinuous zones varying in length from 70 to 440 m. The cumulative strike length of the 4 zones is about 1380 m. The width of these zones range from 0.35 to 3.03 m (average 1.36 m) and copper content from 0.5 to 1.53% Apart from these, a parallel mineralised zone has also been established over a strike length of about 350 m. The width of this zone ranges upto 1.55 m and copper content ranges from 0.35 to 1.77%.On the basis of borehole data, the reserves estimated in this block are as follows :

Indicated - 77,180 tonnes with 0.95% Cu and 9.31 g/t Ag.

Inferred - 314,150 tonnes with 0.95% Cu and 9.31 g/t Ag.

Total = 391,330 tonnes.

The copper content in the Ingaldhalu Northeast block varies from 1.14 to 3.38%. The reserves estimated in this block are of the order of 0.16 million tonnes with a copper content of 1.79%.

In the Ingaldhalu South block, copper mineralisation has been traced over a strike length of about 750 m. The copper content in the sulphide zones vary between 0.1 and 2.2%. Zinc ranges from 0.32 to 10%, generally between 2 and 6%, and lead from 0.3 to 9%, generally between 0.5 and 2%. Reserves have not been estimated from this block, since the average copper content is <0.5% and the mineralised zones are very narrow.

The overall pattern of the distribution of copper, lead and zinc values indicates zoning of the metals; copper with minor lead and zinc in the central part with the zinc and lead contents increasing laterally both towards south and north of the Ingaldhalu Mines block. On the whole, the gold and silver contents of the mineralised zones in the Belligudda-Ingaldhalu-Kunchiganahalu sector are also quite high. Some boreholes core samples have indicated upto 12.2 g/t gold and 950 g/t silver.

The economic viability of the Ingaldhalu operations can be improved marginally, if the recoveries of gold, silver and zinc associated with the ores can be substantially increased from the present level of less than 50%.

Madikeripura (14°13'30": 76°26'30") - Kunchiganahalu (14°12': 76°27'), Chitradurga district, Karnataka:

Geochemical sampling identified a few parallel en echelon quartz veins showing intense shearing and presence of sulphides such as chalcopyrite,galena, sphalerite and stibnite, malachite and cervantite and indicated multi-elemental anomalies (for lead, zinc, copper, antimony, arsenic and silver) scattered over an area of about 2.5 sq.km. The quartz veins traversing acid and mafic-volcanics have analysed 0.6% Cu, 3.2% zinc, 0.88% arsenic, 0.62% Sb and upto 410 ppm silver and 0.11 to 10.2 g/t gold. A few scout boreholes are being drilled in this block to evaluate the anomalies.

G. R. Halli Northwest block (14°16': 76°25'), Chitradurga district, Karnataka:

This block is located in the northern part of the Chitradurga Sulphide Belt with a well-marked shear zone trending NW-SE over a strike length of about 1 km. Geochemical sampling has indicated anomalous zones with values upto 0.66% copper and 0.30% zinc coinciding with I.P. anomaly zones indicated by geophysical survey. Scout drilling to evaluate the anomaly is in progress.

Kennedlu Southeast block (14°07'45": 76°30'), Chitradurga district, Karnataka:

In this block, regional geochemical surveys have indicated high values of copper, lead and zinc in rock samples. Samples of quartz veins have analysed upto 12% lead, 3-5% copper and 2% zinc. This anomalous zone is also proposed to be evaluated by drilling.

Musturu (14°28': 76°26'), Chitradurga district, Karnataka:

Two brecciated quartzose/cherty zones (250 to 800 m) within the Peninsular Gneissic Complex contain disseminations of sulphides, viz., pyrite, chalcopyrite, galena and sphalerite. Three shallow boreholes intersected only narrow, lean zones of copper, lead and zinc, viz., 0.50 to 1.90 m with 0.16% -0.3% Pb, 0.11 - 0.52% Zn and 0.34 - 1.14% Cu.

Summing up, it can be stated that geochemical sampling and geological work carried out in various parts of the 40-km-long Chitradurga sulphide belt has identified a few small deposits over a strike length of about 5 km. The overall geological setting and indications of mineralisation warrant further detailed work in the other parts of the 40 km long Chitradurga sulphide belt and its possible extensions towards north and south.

The known evidences of mineralisation in Chitradurga Schist Belt are within the volcanic sequence and are mostly proximal to the volcanic sources for emplacement of the metal. The possibility of finding deposits located distally in the overlying metasedimentaries is to be critically evaluated.

Garimanipenta (14°59'30": 79°33'10" - 57 N/9), Nellore district, Andhra Pradesh:

The area exposes gneisses and schists of the Peninsular Gneissic Complex in the eastern part and Dharwar schists in the western part. The rocks trend NW-SE with steep dips (55° to 75°) towards south-west. Copper mineralisation is associated with vein quartz and pegmatites intruding the amphibolites and mica schists. Out of 10 boreholes drilled in the area, only one intersected sporadic copper mineralisation.

Sporadic occurrences of malachite, pyrite and chalcopyrite associated with vein quartz and pegmatites in mica schists and amphibolites have been reported from a number of other locations in Nellore District.

Jonnagiri (15°44': 77°31' - 56 E/11), Kurnool district, Andhra Pradesh:

The area is made up of Peninsular Gneisses, granites, Dharwar schists (chlorite schists and hornblende schists) basic dykes and quartz veins. Old workings with extensive coatings of malachite and azurite are seen over a strike length of 2 km in chlorite schist. Two bands of gossans are exposed along the old workings. Drilling data indicates that the zone of sulphide mineralisation is essentially made up of pyrrhotite and pyrite with subordinate chalcopyrite and sphalerite. The zones of copper mineralisation are narrow with copper contents of 0.1 to 0.5%. Only in one borehole a richer zone of 6.45 m thickness averaging 0.8% Cu and 2.20% Zn was intersected. In one borehole, massive pyrite zone of 9m thickness was intersected. This zone is traceable over a strike length of about 300 m. The average sulphur content is about 23.12% over a width of 5.24 m. Reserves of 0.9 million tonnes of pyrite ore with 2.3% sulphur are estimated down to a depth of 100 m.

Sandur Schist Belt:

Yeshwantnagar (15°32'30' : 76°30'00"), Sandur taluk, Bellary district, Karnataka :

Copper mineralisation occurs in the form of disseminations and stringers of chalcopyrite, chalcocite and bornite associated with pyrite and pyrrhotite, within silicified metabasalts of Krishnanagar formation of Sandur Schist Belt. Integrated surveys by GSI have indicated that the sulphide mineralisation is very poor, highly scattered and erratic in nature. Chemical analysis of the borehole cores from 32 shallow boreholes have given low copper values ranging from 10 ppm to 0.24% Cu, 70 ppm to 0.15% Ni, 20 ppm to100 ppm Co, 10 to 20 ppm Pb and 30 to 100 ppm Zn. The area is largely covered by soil. Evidences for mineralisation are seen in the well cuttings only.

Mailaram (17°43': 80°38') Deposit, Mailaram Belt, Khammam district, Andhra Pradesh:

The area comprises quartz-chlorite schist, biotite gneiss intruded by amphibolite, granite, pegmatite and quartz veins. The schists and gneisses (of the Sargur Supergroup) trend NE-SW and dip at 50° to 85° towards south-east. The quartz-chlorite schists is traversed by numerous veins of black, grey and white quartz. Blue and grey quartz carry sulphide mineralisation, whereas the white quartz is barren. The copper mineralisation is localised in a NE-SW-trending shear zone. Chalcopyrite is the principal ore mineral and is associated with pyrite, pyrrhotite and molybdenite. Sericitisation is developed in the vicinity of the copper mineralisation. The Mailaram block extends over a strike length of 1100 m and has been explored by 20 boreholes drilled by GSI. The deposit is now being mined on a small scale by the Andhra Pradesh Mining Corporation Limited. Exploration by drilling indicates that there are three ore bodies in the area, viz., Main Oreshoot (400 m), Central oreshoot (140 m) and Northern oreshoot (l60 m). The oreshoots are narrow and range in width from

less than a metre to a maximum of 12 m. The average width is around 2 to 3 m. At a cut-off of 0.3% Cu, reserves are estimated to be 0.812 million tonnes with 1.07% Cu.

Deposits associated with sheared quartz veins and metabasic rocks traversing granitoids:

Kallur (16°08'30": 77°12'25"), Raichur district, Karnataka:

The area, mostly under soil cover, comprising granite, diorites and pink porphyritic granite has been investigated by 30 boreholes by the Department of Mines and Geology. The ore body is reported to consist 4 sub-parallel to parallel zones ranging in length from 450 to 1100 m and in width from 5 to 40 m. The ore zones are lenticular with the maximum width in the central part. Copper mineralisation in the area consists of disseminations of chalcopyrite and pyrite, native copper occasionally seen as specks and flakes along joints and associated with specularite and haematite. A reserve of 2.47 million tonnes with 0.85% Cu has been estimated by the DMG.

Machanur (16°15'50": 72°42'30"), Raichur district, Karnataka:

Specks of chalcopyrite associated with malachite and azurite with minor specularite and pyrite are noticed in the shear zone. The area has been explored by 6 boreholes drilled by DMG. These boreholes have tested a strike length of 430 m, the deepest intersection being at about 210 m. On the basis of drilling data, four lodes have been delineated.The lodes range in width between 2 and 30 m with copper contents of upto 3.14%. Majority of the values lie between 0.12 and 0.97% Cu. Reserves of 1.91 million tonnes with 0.95% Cu has been estimated.

Tinthini (16°23': 76°31'), Gulbarga district, Karnataka:

Copper mineralisation is seen in the sheared and brecciated hanging wall contact of the metagabbro dyke over a strike length of 5 km. The mineralised zone extending over a strike length of 1.25 km with width of 4.5 to 14 m contains on an average, 0.15 to 0.33% Cu. The deposit has been explored by 26 boreholes drilled by DMG. Reserves of about 1.84 million tonnes with about 0.6% Cu have been inferred. Subsequently, the deposit was taken up by exploratory mine development by the Hutti Gold Mines Company Limited. A total of 250.80 m of shaft sinking and 1879.60 m of level developments in two levels were carried out over a strike length of 300 m in the central part of the block. The mine development indicated that there is no improvement in the grade at depth. The work was, therefore, concluded in view of the low-grade ore.

The Kallur, Machanur and Tinthini deposits are located close to each other and can probably be worked as a cluster with common facilities for milling, beneficiation, etc. Although the width of these ore bodies and total reserves are fairly large (6.23 million tonnes), the average grade is again marginal (0.80%). The economic viability will depend on the cost effectiveness of the mining and beneficiation techniques.

Sowanahalli (12°08': 76°48' - 57 D/16), Mysore district, Karnataka:

In this area of high-grade granulite rocks, the Konkanhundi layered complex covering an area of about 50 km^2 and consisting of a rhythmic, layered (and concentrically arranged) sequence of gabbro, norite and anorthosite, along with conspicuous non-layered norites occurs as an oval shaped body within the Peninsular Gneissic Complex. Sulphide mineralisation is noticed in the northwestern part of the complex in the form of gossans and malachite encrustations along fractures in a dolerite dyke trending N18°W - S18°E. The gossan zone is traced for a strike length of 400 m intermittently. Old workings are also present. Thirteen boreholes drilled by the DMG indicated mineralisation consisting of veinlets, stringers and disseminations of pyrrhotite, pentlandite, chalcopyrite and pyrite, intersected over narrow widths in 7 boreholes, with copper values of 0.14 to 0.37% over 0.20 to 3.50 m widths and Ni values of 0.10 to 0.42% over widths of 0.20 to 2.9 m..

Kaiga (14°51': 74°26' - 48 J/3) - Mothimakki (14°45: 74°34' - 48 J/9) area, North Kanara district, Karnataka:

The rock formations in this area consist of rnetasediments, ultramafics and metavolcanics of Dharwar Supergroup surrounded by granitic gneisses and traversed by dolerite dykes. Sulphide mineralisation of the disseminated and occasionally massive type is found in the pyroxenite, peridotite and gabbro which constitute the ultramafic complex in the area. Pyrrhotite is the dominant sulphide with pyrite (cobalt bearing) and chalcopyrite in subordinate amounts.Marcasite, pentlandite and bismuthinite and rarely native gold are also recorded.Exploration by drilling in the Kaiga area has delineated a zone of copper mineralisation over a strike length of

300 m. Reserves are placed at 0.32 million tonnes with 1.23% Cu and about 0.2% Ni.

Deposits associated with schist belt enclaves in Peninsular Gneissic Complex:

Kalyadi Copper Deposit (13°14': 76°09' 57 C/4), Hassan district, Karnataka:

The Kalyadi copper deposit is located in a supracrustal Dharwarian schist band relict in the migmatite terrain of the Dharwar Craton. The rock types in the schist belt comprise hornblende schists, quartzites, quartz-sericite schist which are the host rock of the copper mineralisation and ultramafic rocks, quartz diorite and gabbro which occur as intrusives. The mineralised quartzite exhibits sinistral drag folds and is involved in intense shearing, slickensiding and puckering. Copper mineralisation is confined to the sheared and folded quartzite, quartz-chlorite schist and to a minor extent to amphibole-biotite schist. Thirty-four boreholes drilled by GSI and Department of Mines and Geology, Government of Karnataka. indicate that the ore body ranges in width from 5.60 to 26.31 m (average 14.34 m). The average copper content in the various levels ranges from 0.59 to 1.03% with an overall average of 0.89% for the 6 levels. Drill-indicated reserves are placed at 3.8 million tonnes and blocked out reserves at 1.2 million tonnes.

The reserves are adequate to support a 500 t.p.d. mine and the width of the ore body (average 14.34 m) is also adequate to permit larger-scale operations. But the average grade of the ore is marginal, and economic viability will depend largely on the feasibility of major reductions in the cost of mining, milling and beneficiation.

Kalasapura (I3°17': 75°56': 48 O/15), Chikmagalur district, Karnataka:

The area forms the southeastern part of the Chikmagalur Schist Belt and consists of Precambrian metavolcaniclastic suite of rocks belonging to the Bababudan Group. The basal part of the Bababudan group comprises conglomerate (quartz pebble) and current-bedded quartzite and quartz-sericite schist which are the host rocks for sulphide mineralisation. Nine boreholes drilled in the area by GSI have indicated zones ranging in width from 1.10 to 8 m (average 3.27 m) with copper contents of 0.13 to 0.43% (average 0.25%). The mineralisation is conspicuously restricted to the uppermost contact of the quartzite with amygdular amphibolite. Reserves of 0.16 million tonnes with an average grade of 0.25% has been estimated over a strike length of 240 m. Uranium mineralisation is also associated with the quartzite and conglomerate.

It may be worthwhile to explore for mineralisation of the type associated with the conglomerates at Kalasapura.

Aladahalli (13°08': 76°21'; 57 C/8), Hassan district, Karnataka:

This is a narrow NW-SE-trending schist belt within the Peninsular Gneissic Complex. Sulphide mineralisation comprising pyrite, chalcopyrite and pyrrhotite occurs as disseminations in micaceous chlorite schist. Several discontinuous NW-SE-trending gossan zones are seen near Aladahalli, Balehalli, Dasapura, Bhaktarahalli, Mangalapura and Ugranahalli. The gossan zones listed above have been tested by drilling – 20 boreholes in Aladahalli Main block, 17 boreholes in Balehalli East and Main block, 7 boreholes in Aladahalli West block, 10 boreholes in Dasapura block, 3 boreholes in Bhaktarahalli block, 5 boreholes in Mangalapura block and 1 borehole in Ugranahalli block. In Aladahalli Main block, the following reserves have been estimated:

1% cut-off with 1.6 million tonnes with 1.24% Cu.

0.8% cut-off with 1.757 million tonnes with 1.03% Cu.

0.5% cut off with 3.186 million tonnes with 0.75% Cu.

In the Aladahalli West block, two zones of mineralisation are present but no significant sulphide zone was intersected. In the Balehalli block the copper content seldom exceeds 0.1%. The sixth borehole drilled to test the eastern zone intersected a 16-m-wide sulphide zone out of which a width of 2.1 m yielded 0.48% Cu. The ten boreholes drilled in the Dasapura block have reserves of 0.34 million tonnes with a copper content of 0.83% at 0.5% cut-off. The five boreholes drilled in the Mangalapura block also did not indicate any appreciable copper values. Zinc values in the sulphide zones in Bhaktarahalli and Mangalapura East block were found to range upto 1.36% over 4.15 m and 1.04% over 8.8 m respectively.

Exploitation of the deposits in the Aladahalli area can be done on small scale of about 300 t.p.d. subject to economic viability. Occurrences similar to Aladahalli sulphide zone is also recorded from Ramanahalli (13°23':6°20'), Kadikengalbetta (13°20': 76°16'), Hassan district.

Deposits / occurrences associated with ultramafic complexes:

Sulphide mineralisation (pyrite with subordinate pyrrhotite and chalcopyrite) associated with titaniferous magnetite bands is seen near Nuggihalli (13°01': 76°28'), Belagumba (13°14': 76°18') and Tagadur (13°26': 76°26'). In Nuggihalli the average copper in the individual borehole ranges from 0.19 to 0.5% and nickel from 0.17 to 0.2%. In the Belgumba area, the drilling data indicate copper values of 0.3 to 0.48% over widths of 1.8 to 5.8 m in two boreholes. In the Tagadur area, sulphide mineralisation (pyrite, pyrrhotite, pentlandite and cubanite) is indicated in gabbro and titaniferous magnetite bands over an area of 600 m x 200 m. The overall copper content is estimated to be around 0.4% with occasional high values over narrow widths.Occurrences of basemetal mineralisation with ultramafics have also been recorded from Ranganahallibetta (13°03' : 76°26'40''), Idagondanahalli (12°39': 76°19').

Masanikere (13°51': 75°59'), Tavarekere (13°51'30'': 75°57'30''), Magyathhalli (13°53'30'': 75°57'00'') areas (48 O/13), Shimoga district, Karnataka:

In these areas, the metasediments (quartz-chlorite-carbonate schist with quartzite bands) of the Chitradurga Group are intruded by a gabbro anorthosite complex. The basemetal mineralisation (pyrite and chalcopyrite) is seen in the magnetite gabbro occurring in the basal part of the complex. Copper is concentrated in the magnetite gabbro and vanadiferous titaniferous bands. Copper values in these rock types range from 0.3 to 1.56% whereas the copper content in the other rock types is less than 0.1%. A reserve of 6.38 million tonnes of titaniferous-vanadiferous magnetite with a copper content of 0.36% has been estimated on the basis of the 1st and 2nd level boreholes. The copper values were mostly less than 0.1% in the third level borehole. On the basis of drillhole data, reserve of 8.2 million tonnes of vanadiferous titaniferous magnetite with 0.34% Cu has been estimated. The copper content in the ferrogabbro ranges from 40 ppm to 0.18%.

Base Metal Deposits/Occurrences in SGT:

Kollegal (12°09': 76°07') area, Mysore district, Karnataka:

In this area located in high-grade granulite terrain, two types of sulphide mineralisation are noticed ¯ syngenetic, stratabound pyrite and pyrrhotite associated with pyroxene granulite and magnetite quartzite along Talbetta-M.M.Hills Ghat section and M.M.Hills-Palar Ghat section and the second type of mineralisation consisting of pyrite, pyrrhotite and chalcopyrite occurring in the fenitised gneiss and associated quartz veins related to alkali syenite-carbonatite emplacement near Tomyarpalya. Old workings for copper are seen on the northern slope of the ridge near Hadabanatta village.

In SGT of Tamil Nadu, only one basemetal deposit, viz., the multimetal copper-lead-zinc deposit at Mamandur is so far known. In addition, there are a number of reported occurrences of copper and copper-nickel-sulphide mineralisation from a number of locations. These occurrences are mostly associated with calc-granulites, pyroxene granulites, pyroxenites and mafic/ultramafic rocks. Quartz barytes vein with galena and molybdenite have been recorded from the Alangayam area.

Mamandur Deposit (12°02':79°02' - 57 P/4), South Arcot District, Tamil Nadu:

This deposit lies in the Peninsular Archaean complex in the transition zone between charnockites on the west and migmatites on the east. The Mamandur area is made up of migmatites and charnockites with bands of garnetiferous biotite sillimanite gneiss, magnetite quartzite and a suite of ultrabasic rocks comprising pyroxenite, gabbro, norite and anorthosite. The general trend of foliation is NNE-SSW to NE-SW with dips of 60° to 65° towards SE. Galena from the mineralised zone has given an isotope age of 2581 to 2600 Ma.

The Mamandur area has been extensively explored by large-scale geological mapping, geochemical soil sampling, geophysical surveys and drilling by the GSI and the Directorate of Geology & Mining, Government of Tamil Nadu under a collaboration programme with UNDP. Exploratory mining including development of an adit level and the first and second levels have been carried out by the BGML. A total of about 30 boreholes were drilled and 607.46 m of mine development was carried out.

The exploration work has shown the presence of two zones of mineralisation, viz., the multimetal lode with lead-zinc-copper and silver values and a parallel lode on the footwall side with disseminated copper mineralisation. The multimetal lode comprises zinc, lead, copper, silver and cadmium and the other disseminated copper sulphides and is considered to be of the stratiform exhalative volcanogenic sedimentary type. Part of the zinc values in the lode are in the

form of the zinc spinel gahnite. This mineralised zone has been traced over a strike length of 760 m by drilling. Of this, the northern part of about 300 m is relatively better mineralised and the sphalerite-rich ore body extends over a strike length of about 300 m with an average width of 3.15 m and persists to a depth of 280 m in the dip plan ; the southern part being generally poorly mineralised and containing mostly chalcopyrite. The reserves in this ore body are estimated to be 0.66 million tonnes with a metal content 5.53% Zn; 1.15% Pb and 0.45% Cu. The chalcopyrite rich ore body, which extends over a strike length of 180 m with a width of about 7 m and a depth persistence of 34 m, is estimated to contain 0.13 million tonnes of ore with a metal content of 0.62% Cu, 0.69 Zn, 0.12% Pb and 37 g/t Ag. Drilling data indicate that the multimetal ore body does not persist beyond a depth of 280 m. Drilling and exploratory mine development data indicate that the width of the multimetal ore body ranges upto about 9 m in some sections with an average of about 3.15 m.

Exploratory mine development shows continuity of the orebody: the adit level of the BGML exposing the ore zone continuously over a strike length of 182 m. The range in metal contents in the ore body are as follows :

Coppers – 0.17 to 1.04 %

Lead – 0.16 to 1.86 %

Zinc – 2.23 to 14.0 %

The second zone comprising essentially of chalcopyrite is located about 10 to 15 m to the foot wall (western) side of the multimetal lode. It has been traced over a strike length of about 460 m. Appreciable concentration of chalcopyrite of possible economic significance is found only over a strike length of about 180 m. The depth persistence of the lode is also limited to about 35 m below the surface. The average width of the lode is about 8 m. On the basis of the drilling and exploratory development data, the ore reserves available in the ore bodies are estimated to be as follows

A: Multimetal Lode						
	Reserves	Average			Grade	
	(million tonnes)	% Cu	% Pb	% Zn	Ag (g/t)	Cd%
Proved	0.20	0.54	1.13	5.88	39.92	0.13
Probable	0.46	0.37	1.16	5.19		
		0.42	1.14	5.40		
B: Footwall Lode						
	0.13	0.62	0.12	0.69	37.0	

IBM carried out Ore beneficiation tests and showed that the recoveries of metal, particularly zinc are only partial, as part of the zinc is present as gahnite.

Regional geochemical surveys in an area of about 350km^2 falling along the strike extensions of the Mamandur deposit has not brought out any significant mineralisation.

Thus the Mamandur Cu-Pb-Zn-Ag deposit is the only one multimetal deposit, so far known from Tamil Nadu. This also is a small deposit with 0.66 million tonnes of ore averaging 0.42% Cu, 1.14% Pb, 5.40% Zn and about 40 g/t silver. Normally, it should be possible to operate a small-scale mine of about 150-200 t.p.d. on a deposit of this size. But because of the presence of part of the zinc values as gahnite and consequent low recoveries during beneficiation and its isolated location, its economic viability will be adversely affected.

Satyamangalam area (11°15'- 11°28': 76°54'-77°15'; 58 A/15 & E/3), Periyar district, Kerala and Coimbatore district, Tamil Nadu:

In the Satyamangalam Group of rocks lying between the Moyar-Bhavani-Attur lineament in the north and Noyil-Cauvery lineament in the south and forming a part of the Cauvery

suture zone (transform fault?) which extends right across the Tamil Nadu State in an east-west direction from its western border with Kerala to the boundary of the Cretaceous sedimentary basin on the east, Sulphide mineralisation occurs in sheared, silicified zones occurring within the metagabbro or close to the metagabbro/hornblende-biotite gneiss contact. These zones contain pyrite, pyrrhotite and chalcopyrite with some nickel and gold values. In addition, sulphide mineralisation with copper-nickel-cobalt and marginal PGE and gold values also occurs in sheared ultramafic bodies occurring within hornblende gneiss.

During regional geochemical survey and mapping by GSI, numerous sulphides in well dumps with copper-nickel-cobalt values and as many as 15 silicified zones with development of in situ limonite after sulphides have been delineated. The silicified zones range in strike length from 100 - 200 m to about 6500 m, as seen in the Nadukavundanpudur and Ballepalayam and other areas. The width of these silicified zones ranges from 0.5 m to about 8 m. Data of a few boreholes indicate that the sulphide content ranges from sparse disseminations of less than 0.1% to as much as 50% total sulphides in some sections. Analytical data of core samples yielded less than 0.2% Cu and less than 0.1% Ni.

Sulphide mineralisation associated with the ultramafic bands occurring within the hornblende-biotite gneiss country rock is seen in well dumps at several locations in Toposheets 58 A/15 and E/3. Minor chalcopyrite, pyrrhotite and molybdenite occurrences were noticed in pyroxenite and amphibolite near Godepalaiyam and Maranur. Outcrops are rare due to soil cover. On the basis of geophysical surveys and a few boreholes, it is inferred that these ultramafic bands are of limited size ranging in strike length upto 200-300 m and in width from 2-15 m. The well dumps at a few locations indicate appreciable pyrrhotite and pyrite with subordinate chalcopyrite. A few grab samples have analysed upto 2.1% Cu, 0.9% Ni, 0.65% Co, 2 g/t gold and 0.3 g/t Pt. Though the results of exploration so far have not indicated appreciable nickel and copper values in the various silicified zones and sulphide shows in ultramafic fragments from well dumps, the over all geological setting is considered favourable to warrant further search.

A similar geological setting prevails over large areas to the east of Cauvery river in Salem and Tiruchirapalli districts in Toposheet Nos. 58 I/2, 3, 4,6,8,10,12 and 16. In these areas also values of greater than 1000 ppm nickel and copper have been reported in association with ultramafic rocks. Several bands of banded magnetite quartzite and sillimanite-bearing gneisses are also present in these areas indicating that there may be possibilities of locating copper-lead-zinc deposits of the Mamandur type.

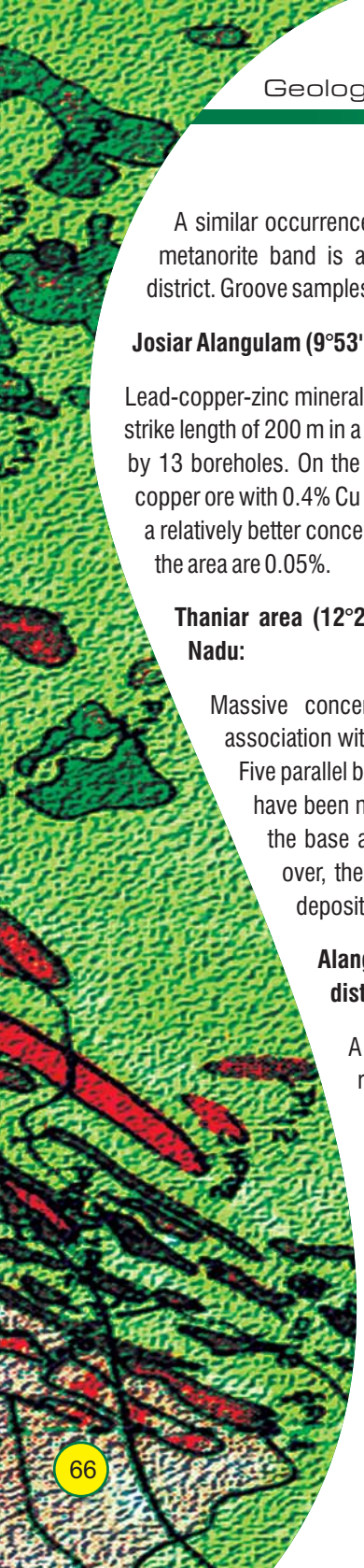
Chalk Hills area (11°43': 78°10'; 58 I/12), Salem district, Tamil Nadu:

Some of the major magnesite deposits of the country are located in this ultramafic complex. Incidence of pentlandite, pyrrhotite and chalcopyrite have been recorded from Chalk hills and Red hills area and the nickel content is fairly high in the limonitised peridotite/dunite suggesting the possibility of locating copper-nickel sulphide mineralisation associated with mafic - ultramafic complexes. No copper deposits of possible economic significance have so far been established in Tamil Nadu. But potential areas for search copper-nickel sulphide mineralisation associated with mafic-ultramafic complexes are large. The possibility of locating Cu-Zn-Pb mineralisation in the alkaline-carbonatite province of northern Tamil Nadu also needs examination.

Arumanullur (8°19'15'': 77°24'35''; 57 H/7) and adjacent areas, Kanyakumari district, Tamil Nadu:

In this area, sulphide mineralisation has been recorded from a number of meta-norite bands occurring in the Arumanullur area and in the areas lying about 3 to 10 km to the north and north-east of Arumanullur.

The occurrence near Arumanullur is by far the best known and contains the maximum concentration of sulphides. Here, the sulphide zone has been traced over a strike length of about 135 m, in a NNE-SSW direction in a shear zone in metanorite. Trench sample data have indicated copper values of 0.12 to 1.94% (average 0.44%) and nickel values of 0.12 to 0.72% (average 0.34%). The drilling carried out by the DGM indicated that the ore body is highly lenticular and discontinuous. The concentration of sulphides in the other metanorite bands ranges from less than 0.5% to about 5% in some bands. Analytical data of samples with fresh sulphides have indicated that the copper and nickel contents are very low; copper upto 0.12% and nickel less than 0.1%. However, gold values of 0.10 g/t to 1.16 g/t with an average of about 0.5 g/t for 7 samples have been recorded from the sulphide zones. The strike length of these bands range from about 50 m to over 500 m and the width of the sulphide-bearing zones from less than a metre to about 50 m (true width about 12 to 15 m as the dips are moderate - about 20° to 25°).



A similar occurrences of pyrite - pyrrhotite – chalcopyrite mineralisation within metanorite band is also reported from Pattankadu (8°37': 77°34'), Tirunelveli district. Groove samples indicated only 0.02 to 0.12% Cu.

Josiar Alangulam (9°53': 77°58'; 58 G/13), Madurai district, Tamil Nadu:

Lead-copper-zinc mineralisation in calc-sillicate rocks was traced over a discontinous strike length of 200 m in a 3-m-wide zone in this area.This strike length has been tested by 13 boreholes. On the basis of the drilling data, resources of 0.36 million tonnes copper ore with 0.4% Cu are estimated. The thickness of the mineralised sections with a relatively better concentration of chalcopyrite ranges upto 4 m. The nickel values in the area are 0.05%.

Thaniar area (12°25' - 12°40': 78°57' - 79°05'), North Arcot district, Tamil Nadu:

Massive concentration of pyrite-pyrrhotite occurs as thick bands in association with the pyroxene granulite and BMQ bands of this SGT terrain. Five parallel bands with thickness upto 7.9 m and strike length upto 3.5 km have been mapped. Since zoning of iron, copper, lead, zinc, with iron at the base and copper-lead-zinc at higher levels is common the world over, the possibility of locating Mamandur type of copper-lead-zinc deposit in this area is considered worth examining.

Alangayam - Harur - Bhavani belt, North Arcot & Dharmapuri districts, Tamil Nadu:

A large number of quartz baryte veins with galena have been recorded from the Alangayam area and galena is a common association with molybdenite-bearing ores which occur along shear zones in a number of areas in this alkaline carbonatite belt. Incidence of pyrite has also been recorded from a number of locations and in association with the quartz-baryte and molybdenite mineralisation. Since copper-lead-zinc-baryte zoning is reported from a number of areas the world over, the possibility of copper zinc mineralisation in the vicinity of quartz-baryte veins and other sulphide mineralisation will be worth evaluating.

Near Narayanapuram in Thiruvallur district, a 380-m-long and 5.2 to 9.1-m-wide quartz vein in a faulted and fissured zone, carrying specks of pyrite, chalcopyrite and pyrrhotite was emplaced along the contact of norite body with country rocks. Chip samples have analysed Cu content between 0.0005 and 0.04%.

Vettilaimalai (10°27': 77°41'; 58 F/11), Madurai district, Tamil Nadu:

In this area, sulphide mineralisation (pyrite, pyrrhotite and chalcopyrite) hosted in pyroxenite has been recorded. The area comprises charnockite with pyroxene granulite, pyroxenite, anorthosite and quartzofelspathic gneiss. The pyroxenite body is about 50m wide and extends for a strike length of 290 m. Trench samples have indicated 0.18 to 0.48% Cu (average 0.30%) and upto 0.37% Ni (average 0.09%).

Base Metal Deposits/Occurrences in Central Indian Craton:

In Madhya Pradesh, basemetal deposits and occurrences have been recorded from Malanjkhand granitoid belt, Bundelkhand granite complex and the Mahakoshal and Vindhyan Groups of rocks. Of these, the Malanjkhand copper deposit is by far the best known. **It is the largest single copper deposit known in Peninsular India.**

Malanjkhand Granitoid Belt:

Malanjkhand copper deposit:

The Malanjkhand (22°02': 80°43' - 54 B/12) copper deposit located in the Balaghat district is presently under exploitation by open-cast mining by M/s Hindustan Copper Limited. The copper mineralisation is localised in the quartz reefs, associated with the granites and also seen within the granites near its contact with the quartz reefs. The ore zone extends over a strike length of about 1.9 km with an average width of about 65 m. On the basis of the drilling carried out by GSI, MECL and the mine development by HCL, reserves available in the deposit upto –8 m R.L.(i.e. about 600m below the surface) at a cut-off 0.45% copper are estimated to be as follows:

Proved: 145.7 million tonnes

Probable: 50.4 million tonnes

Possible: 40.3 million tonnes

Total: 236.4 million tonnes of 1.28% copper.

During open-cast mining, low-grade copper ore beyond the main ore body is also likely to be excavated. The quantity of such ore is estimated to be about 93.03 million tonnes with an average copper content of 0.29% (cut-off 0.2% copper). About 3 million tonnes of oxidised ores with 0.18% copper is also likely to be produced during mining.

Significant molybdenum values are associated with the ore. The copper concentrates are expected to yield 1.24 g/t of gold, 70 g/t of silver and 0.04% molybdenum.

The areas with a similar geological set-up surrounding Malanjkhand copper deposit have been investigated. The work has not brought out any significant copper deposit, but a number of occurrences for copper have been recorded. They are: Bhaunra Pahar (22°04': 80°48') – Taregaon (22°03': 80°51'; 56 B/16) area; Parewa Dongri (22°02'35" : 80°45'30"; 64 B/15); Bodapahadi (22°03' : 80°53"; 64 B/15); Pathratola (22°00': 80°55'; 64 C/13); Manegaon (21°58': 80°48'; 64 C/13); Gidori (21°52': 84°43'; 64 C/9), and Dhorli (21°52': 80°46'; 64 C/13).

Exploration in search of similar type of deposits adjacent to Malanjkhand has indicated only sparse mineralisation. But some of the mineralised quartz reefs have sizeable widths and strike lengths. Considerable scope for further search in the Malanjkhand belt as also other belts exists.

Deposits / occurrences in Mahakoshal Group:

A number of basemetals occurrences mostly localised in the zones of shearing and faulting have been recorded from different parts of this belt.

Imalia (23°36': 80°16'), Bhula (23°37': 80°20'), Nawalia (23°39': 80°28') area, Toposheet No. 64 A/6, Jabalpur district, M.P.:

In the Imalia area 0.075 million tonnes of copper ore with 1.12% Cu over a strike length of 240 m have been estimated. If lower grade ore are also taken into consideration, reserves are of the order of 0.12 million tonnes of 0.82% Cu. In addition, 0.044 million tonnes of lead ore with 1.19% Pb, 6.58 tonnes of Ag metal at an average of 17.32 gm/tonne from 0.38 million tonnes of ore have also been estimated from this zone. In addition, presence of bismuth and arsenic has also been established in the sulphide ores of Imalia block thereby suggesting polymetallic nature of mineralisation. The drilling results have proved the depthwise (60 m) extension of the silver mineralisation with a gradual widening of the zone with depth. Deeper drilling will be necessary to get a complete picture regarding the potentiality of the silver mineralisation.

Bahera - Baheria Shear Zone (24°20' - 24°31': 81052' - 81°56'; 63 H/15), Sidhi district, M.P.:

Sulphide mineralization confined mostly to the silicified shear zones has been intersected below 200 m depth in the boreholes. There are indications of a thin zone of supergene enrichment. Besides copper, lead, zinc, cobalt and nickel occur as traces in the mineralised zone. A few samples gave silver values of 1 to 50 ppm. Only 2 boreholes intersected copper zones averaging 0.50% Cu, viz., SD/1 - 0.50% Cu x 9.0 m and 0.51% Cu x 6.5 m; SD/6 – 0.50% Cu x 2.5 m. The remaining boreholes intersected zones averaging less than 0.2% Cu. The possible strike extension of the zone with +0.5% Cu is about 600 m.

BUNDELHKAND GRANITE GNEISS

Quartz reefs and veins traversing granite bodies revealed sulphide mineralisation, at Salaiya (24°40': 79°45') - Jamtoli (54 P/10, 13 & 14) area, Chhatarpur district, and Antri (26°03' : 78°15') and Bhageh (26°31' : 78°26') - Gijora (26°04' : 78°28') areas, Gwalior district, M.P.

The copper values in the borehole cores varied from 50 to 500 ppm and sporadic galena near Andar (25°42' : 78°06'), Shivpuri district, M.P.

Copper and fluorite mineralisation localised in silicified fault breccia, quartz vein and epidiorite has been recorded from Chichola (21°04': 80°40'), Durg district. Lead-zinc and fluorite mineralisation occurs in quartz veins, silicified fault breccia, pegmatite and epidiorite emplaced along N-S to N10°E - S10°W shear zones in Chandidongri (21°05' : 80°38'), Dura district. The maximum metal contents in core samples were 2.5% Pb, and 1.20% Zn (mostly traces to 0.5% Zn).

Bhawratekra (21°57'40": 78°21' - 78°22'30"; 55 K/5) **Zinc deposit, Multai tehsil, Betul district, M.P**.

Massive sphalerite ore studded with chalcopyrite, galena, pyrite and pyrrhotite occur within the mineralised zone established over a strike length of 265 m. The grade varies from 2 to 16% Zn. Zinc is the predominant metal with minor Cu, Pb, Cd, Ag and W. Cadmium and tungsten values increase with the increase of zinc values

and silver values increase with Pb values and attains maximum of 115 ppm. The reserves estimated at 2% and 4% Zn cut off upto a depth of 180 m are as follows :- 1. At 2% Zn cut-off of 5.10 m average width - 1.58 million tonnes of 4.52% Zn, 85 ppm Cd, and 3.5 ppm Ag. 2. At 4% Zn cut-off of 5.83 m average width - 0.85 million tonnes of 6.48% Zn, 120 ppm Cd and 3.4 ppm Ag.

The Bhawratekra deposit (Reserves 0.85 million tonnes of 6.48% Zn) can perhaps be exploited on a small scale of about 150 – 200 t.p.d. But since a part of the zinc values are in the form of gahnite, ore beneficiation aspects will have to be critically evaluated, before decisions regarding feasibility of mining the deposit can be taken.

Five copper deposits and one zinc deposit have so far been delineated in Maharashtra as summarised below:

Deposit	Reserves (million tonnes)	Grade %	Average thickness (m)
1. Kolari Zone III	8.272	6.79% Zn	51-6.65 m
2. Thutanbori			
0.4% Cut-off	1.909	1.18% Cu	2.03-4.58 m
.0% Cut-off	0.845	2.24% Cu	1.35-3.23 m
3. Ran Mangli			
0.4% Cut-off	0.829	0.81% Cu	1.77
.0% Cut-off	0.344	1.25% Cu	1.73
4. Pular Parsori	0.119	1.76% Cu	
Total 2-4 (1.0% Cut-off)	**1.308**	**1.47% Cu**	
5. Thanewasna	4.7	0.80% Cu	5.0
6. Dubarpeth	1.38	1.19% Cu	3.52
Total 5+6 6.08	**0.89% Cu**		

The Kolari (Zone-III) zinc prospect is located at 2 km S57°W of Kolari village (20°48' : 79°31', 55 P/5) about 75 km from Nagpur on State Highway No.78, in Umrer Tehsil, Nagpur district, Maharashtra.The reserves and grade of ore in the Kolari Zone-III deposit appear to be adequate enough to sustain economically viable operations on a scale of over 500 tonnes per day. Pular (20°51': 79°30'; 55P/9) and Parsori (20°50' : 79°33'; 55P/9) are located about 30 km to the east of Umrer, a Tehsil headquarters of Nagpur district, Maharashtra. Ran Mangli (20°48' : 79°27'; 55P/5) prospect lies at 58 km from Nagpur on State Highway No.78 in Nagpur district, Maharashtra. Thutanbori (20°51' : 79°35'; 55-P/9) prospect is located at about 15 km on the fair weathered road from Pauni, the Tehsil town, Nagpur district, Maharashtra. The Pular-Parsori, Ran Mangli and Thutanbori deposits close to each other and to the Kolari Zone-III zinc deposit. The combined reserve in these deposits works out to 1.308 million tonnes with 1.47% Cu. They can perhaps be mined as a group of small deposits, on a scale of 200 - 300 tpd, if a common infrastructure can be established for all the four deposits, viz. Kolari, Pular - Parsori, Thutanbori and Ran Mangli. The Thanewasna (19°51': 79°44'; 56-M/9, Chandrapur district) and Dubarpeth (19°40': 79°30'; 56-M/10, Chandrapur district) deposits also occur close together in adjacent parallel zones. The combined reserves at 6.08 million tonnes are fairly large, but the grade (0.89% Cu) is marginal. The feasibility of mining them will largely depend on economic considerations.

Base Metals in Eastern Indian Craton

Singhbhum copper belt extends over a strike length of 128 km in the Singhbhum district of Jharkhand. Exploration to-date has established copper mineralisation of possible

economic significance in 3 sectors over a cumulative strike length of about 30 km in the central and eastern part of the belt. They are:

(i) The Turamdih Sector (strike length - 5 km)

(ii) The Tamapahar-Rakha Mines-Roam Sideshwar-Chapri-Kehdadih-Surda-Mosabani-Badia-Mainajharia Sector (strike length - 21.5 km) and

(iii) The Baharagora Sector (Strike length - 3.5 km)

Over 150 occurrences of copper, lead and zinc have been recorded from eight districts of Bihar and Jharkhand, viz. Singhbhum, Hazaribagh, Ranchi, Palamau, Bhagalpur, Santhal Parganas, Shahabad and Gaya. Almost half of them are copper occurrences located in the Singhbhum Copper Belt of Singhbhum district. Some of the deposits in Singhbhum are very large and are being mined since 1908. Till 1970, the Mosaboni Group of mines were the only copper mines in the country. At present, copper mines in the Mosaboni and Rakha-Roam Sideshwar areas are being operated by Hindusthan Copper Limited.

persist without signs of bottoming.

Tamapahar-Rakha Mines-Roam Sideshwar Sector (22°36' to 22°38'50": 86°21'08" to 86°24')

This sector host very significant copper mineralisation.The entire strike length of about 5,400 m is continuously mineralised. The Rakha Mines block was worked by M/s Cape Copper Company between 1908 and 1923. An evaluation of the Mine assay plans, and drilling data of M/s Cape Copper Company, indicated that the Rakha Mines block and adjacent areas constitute a highly potential prospect.

The estimates of in situ ore reserves for the three blocks are furnished below :

Cut-off	Proved		Probable		Possible		Total	
	Reserves	Grade	Reserves	Grade	Reserves	Grade	Reserves	Grade
Grade	(in m.t)	(% Cu)	(in m.t.)	(% Cu)	(in m.t.)	(% Cu)	(in m.t.)	(% Cu)
1.5	14.94	2.24	15.15	2.10	90	1.74	30.99	2.10
1.0	40.17	1.53	35.99	1.54	2.86	1.38	79.02	1.54
0.8	60.55	1.27	49.59	1.33	4.52	1.16	114.66	1.30
0.5	105.16	0.95	85.05	0.99	10.28	0.79	200.49	0.96

Copper-lead-zinc mineralisation appears to be confined to Hazaribagh and the adjacent Santhal Parganas districts. The lead-zinc mineralisation is widely distributed in the western part of Singhbhum district, southern and eastern parts of Ranchi district and in southern Bhagalpur district. Except 2 occurrences of lead with some copper in Palamau district which are associated with sedimentary rocks of Lower Vindhyans, the remaining occurrences are found in Archaean rocks.

In Singhbhum Copper Belt, Chalcopyrite and pyrite are the principal sulphides in the mineralised zone. The copper lodes have been emplaced principally along shear fractures developed within the shear zone.. The Mosabani mines have been developed to a depth of about 1250 m, below the surface. In the Tampahar-Rakha mines-Roam Sideshwar sector the lodes have been tested by drilling to depths of about 600 m and have been found to

Besides copper, a number of other elements such as molybdenum, nickel, etc., are associated with the copper lodes. The average content of these elements in the lodes of the area is as follows:

Nickel	0.80%
Cobalt	0.011%
Molybdenum	0.025%
Bismuth	0.008%
Arsenic	0.007%
Sulphur	2.10%

Selenium	0.0025%
U^{308}	0.02%
P_2O_5	0.55%
Silver	1 g/t
Gold	0.1 g/t

Copper concentrates with over 24% copper with recoveries of +96% were obtained.

The Rakha Mines and Roam-Sideshwar blocks were taken over by M/s.Hindusthan Copper Limited in 1974.

Sideshwar-Chapri-Kendadih-Surda sector:

The ore reserve potential of this sector is very high and is yet to be fully assessed.

Chapri-Sideshwar-Kendadih area:

This area extends over a strike length of 5 km. The potential reserves over the mineralised strike length of 3068 m down to a depth of 300 m is about 8.24 million tonnes with +1.60% Cu. The maximum reserves potential down to 600 m depth at a cut-off of 1% Cu can be of the order of 20 million tonnes per km, i.e. about 100 million tonnes over the 5 km stretch.

In the Chapri area, the ore zones are fairly wide and reserves of 14.71 million tonnes of 0.73% Cu may be available for open-cast mining.

The Sideshwar/Chapri zones have been investigated over a strike length of about 2.3 km by 66 boreholes (total meterage 20703 m) by MECL. These boreholes have tested the depth persistence of the lodes upto 300 m vertical depth. The drilling carried out by the MECL indicates that there are several ore lenses ranging in strike length from 100 to 500 m localised mainly in quartz-chlorite schist. Probable reserves of 7.25 million tonnes with 1.74% Cu have been estimated.

Kendadih mine area:

Several rich lodes have been developed in the mine workings. There are six copper lodes occurring in an en-echelon pattern. The reserves estimated in this area are as follows :

Proved	2.61 m.t.
Probable	1.24 m.t.
Possible	1.47 m.t.

Drilling indicated reserves of 5.32 m.t. with 2.01% Cu

Surda-Mainajharia Sector:

This sector extends in a NW-SE direction over a strike length of about 8.5 km. The Mosaboni, Pathargora, Surda and Badia Mines and Dhobani (old mine) of M/s. Hindusthan Copper Limited are located in this sector. A few other mineralised areas, viz. Tamajhuri, Mainajharia and Chirudih-Somaidih are also present.

Surda (22°33': 86°26') - Pathargora (22°32': 86°27') – Mosaboni (22°31': 86°23') - Badia (22°29': 86°28') - Dhobani (22°31': 86°27') Mines area:

In this sector, the mineralisation is distributed in a much wider zone of shearing (upto 5 km) than in the Rakha Mines sector. The mineralisation is hosted in biotite-chlorite schist occurring in sheared soda granite. A strike length of about 3.2 km has been investigated by GSI. Probable reserves are estimated to be:

At 1% Cu cut-off 0.798 m.t. with 3.13% Cu

At 0.5% Cu cut-off 1.41 m.t. with 2.4% Cu

There is therefore considerable scope for further exploration and increasing the rate of ore production from this 21.5 km stretch of Tamapahar-Rakha Mines-Roam Sideshwar Sector.

Tamajhuri (22°32': 86°26') area:

The area has been explored by 18 shallow series boreholes (total drilling 2,653.6 m) spaced 150-200 m apart drilled by GSI. A number of mineralised zones ranging in width from 0.1 to 2.25 m were met with in most of the boreholes. Probable reserves upto 100m depth are estimated to be:

Cut-off	Reserves	Grade
1.0% Cu	0.27	1.70% Cu
0.5% Cu	0.59	0.91% Cu

Chirudih-Samaidih area:

Nine shallow boreholes were drilled by GSI. These boreholes have intersected several thin zones with 1 to 5% copper alternating with low-grade zones. A probable reserve of 1.47 m.t. with 1.39% Cu has been estimated at 0.5% Cu cut-off. At 1% cut-off, the probable reserve comes to 0.46 m.t. with 2.58% Cu.

Khadandungri (22°26': 86°32') area:

The rock formations in the area belong to the Chaibasa stage. The total length of mineralised zone is about 1 km. The mineralisation is confined to amphibolite. Drilling in the area has established mineralisation over a length of 630 m. The average thickness of the zone is about 1 to 3 m and the average copper content is 1.3%. Molybdenum, vanadium and titanium are seen associated with mineralisation.

Baharagora (22°16'15": 86°43'00") Sector:

This sector lies in the Singhbhum district of Jharkhand near the trijunction of Jharkhand, West Bengal and Orissa States. Copper mineralisation is closely associated with the metabasics and their derivatives and is co-folded with the host basic schists. The area has been sub-divided into six blocks for purposes of exploration.The total strike length of about 3500 m has been investigated by 45 boreholes (total depth 7823.22 m).

Kharkari river - Rajdah Sector:

A cluster of significant copper deposits with an aggregate reserves of about 30 million tonnes and lying close to each other have been identified in this sector. They are :1.Turamdih (22°43'2" - 22°43'53" : 86°10'47" - 86°11'43"); 2.Nandup (22°44'30" : 86°14'15"); 3.Ramachandra Pahar (22°43' : 86°13'); 4.Bayanbil (22°44'00" : 86°14'30"); 5.Dadkidih (22°44' : 86°10'). Of these the Turamdih deposit is the largest. Besides these, a few other significant occurrences are also located in this sector viz., Mohuldih (22°44' : 86°09'); Hitku (22°42' : 86°15'); Rajdah (22°41' : 86°17'); Garadih (22°43' : 86°14') and Keruadungri (22°44' : 86°11'). Uranium and apatite deposits are also found in this sector. The uranium mineralisation occurs on the hanging wall side of the copper lodes in the Turamdih deposit and in the Narwa Pahar (22°42': 86°16').

Turamdih area:

The deposit has been explored in detail by close-spaced drilling and exploratory mine development. Copper mineralisation of varying intensities is seen to persist over the entire strike length of 1320 m explored in detail. Zones of richer concentration constituting the lodes occur as lensoid bodies predominantly within the chlorite-quartz schist. The drilling has established the mineralised zone upto a depth of 200 m.

Turamdih Sector:

(i) A cluster of deposits viz., Turamdih, Nandup, Ramachandrapahar, Bayanbil and Dhadkidih occur close to each other extending over a strike length of about 5 km. The reserves in these 5 prospects at 1.0% Cu cut-off are:

Prospect	Reserves in million tonnes	Grade (% Cu)
Turamdih	17.85	1.59
Nandup	4.00	1.29
Ramachandrapahar	1.70	1.50
Bayanbil	1.36	1.74
Dhadkidih	3.18	1.42
Total	**28.09**	**1.52**

(ii) Of these deposits, only the Turamdih prospect has been investigated.

The deposit has been explored in detail by close spaced drilling and exploratory mine development. Copper mineralisation of varying intensities is seen to persist over the entire strike length of 1320 m explored in detail. Zones of richer concentration constituting the lodes occur as lensoid bodies predominantly within the chlorite-quartz schist. The drilling has established the mineralised zone upto a depth of 200 m.

A summary of the probable in situ ore reserves for different cut-off grades estimated on the basis of drill hole data is as follows:

Cut-off grade	Total Reserves		Reserves in major lodes (Lodes 1A, 2A & 2B)	
	Million	Grade	Million	Grade
	tonnes	% Cu	tonnes	% Cu
1.5% Cu	7.270	2.15	4.371	2.25
1.2% Cu	12.100	1.81	7.434	1.87
1.0% Cu	17.850	1.59	10.992	1.59

A bulk sample drawn by the MEC was beneficiated by the IBM.

The average grade of the sample treated was 1.15% Cu which on flotation yielded a good concentrate analysing 25.11% Cu with a recovery of 90%.

Nandup Prospect:

Inferred reserves of about 4 million tonnes with a copper content of 1.29% have been estimated upto a depth of 200 m, of which 1.77 million tonnes upto a depth of 145 m may be workable.

Bayanbil:

Copper mineralisation occurs in magnetite-bearing quartz-chlorite schist as disseminations, blebs and locally as thin stringers. The zone of intense shearing where ore is localised is about 3m wide.

Probable ore reserves down to a depth of about 140 m (10 m R.L.) have been estimated to be as follows:

Cut-off grade	Reserves in correlatable lodes (lodes 1 and 2)		Reserves in uncorrelatable lodes	
	Million	Grade	Million	Grade
	tonnes	% Cu	tonnes	% Cu
1.5% Cu	0.81	2.12	0.60	2.31
1.2% Cu	1.09	1.90	0.98	1.95
1.0% Cu	1.36	1.74	1.69	1.64

Ramachandrapahar:

Drill indicated reserves in an area of 540 m x 480 m down to a depth of 130 m below the surface are estimated to be 1.7 million tonnes with a copper content of 1.5% at 1% cut-off.

Dhakidih:

The host rock for the mineralisation is quartz-chlorite schist, impregnated with apatite and magnetite. Five lodes with width ranging from 1 m to 5.2 m and copper content from 1.06 to 2.98% have been identified. Inferred reserves upto a depth of 100/120 m are placed at 3.18 million tonnes with 1.42% Cu, 0.03 to 0.08% U3O8 and 0.03% Ni at a cut-off of 1% Cu.

In view of the sizeable total reserves in these prospects and the average grade of 1.52% Cu, it should be feasible to open a group of mines with a total capacity of about 2000 - 3000 tpd in this sector. In case the average grade of 1.52% is marginal, it will be feasible to mine a higher grade at a cut-off of 1.2% or 1.5% Cu.

Galudih:

The host rocks in the area are silicified quartz-chlorite schists. Data of 6 boreholes (total drilling 610 m) indicated that copper mineralisation occurs as several detached en-echelon lenses over a strike length of 160 m. The grade of the individual occurrences ranges from 1 to 15%.

Sankhadih:

The area around Sankhadih-Kharswan is predominantly covered by alluvium. Three of the 11 boreholes drilled to test this zone intersected two en-echelon copper lodes. The mineralised zones intersected vary in thickness from 1 to 2.17 m and in copper content from 0.89 to 2.49%.

Rajdah-Tamapahar Sector:

No significant copper mineralisation has been recorded, but some uranium deposits are located near Bhatin and Jadugoda. Some copper and molybdenum values are associated with the uranium mineralisation.

Hazaribagh district, Jharkhand:

There are many occurrences of copper, lead and zinc in this district. The main zone bearing these minerals extend from Baraganda (24°04': 86°04') to Parasia (24°09': 85°47') over a length of 30 km. Old workings are found at several places between Baraganda and Parsabera (24°04': 86°03').

Charkipahari-Toolsitanr area:

Copper-lead mineralisation extends over a strike length of 4 km in this area and is indicated by the presence of malachite and azurite stains, disseminations of chalcopyrite, chalcocite and galena, old workings and mine spoils. Mineralisation is restricted to lenses of tremolite-actinolite schist within the granite gneiss. The lens dimensions vary from 1 x 0.5m to 22 x 12 m in Toolsitanr area and from 3 x 1 m to 30 x 8 m in Charkipahari area. There are several old workings in the area about 2 km SSE of Bhairukhi village (24°36'00'': 86°36'15''). Small occurrences of copper have been reported at Phaga (24°46': 86°56'), Bhagro-Bajra-Jhibra area (24°48'45'' to 24°49'55'': 86°32'45'' to 86°37'15''), Bhusi-Bhandaria-Duarsar (24°50'20'' to 24°51'40'': 86°35'45'' to 86°39'45'') and Baghmari (24°47': 86°45') in Bhagalpur district.

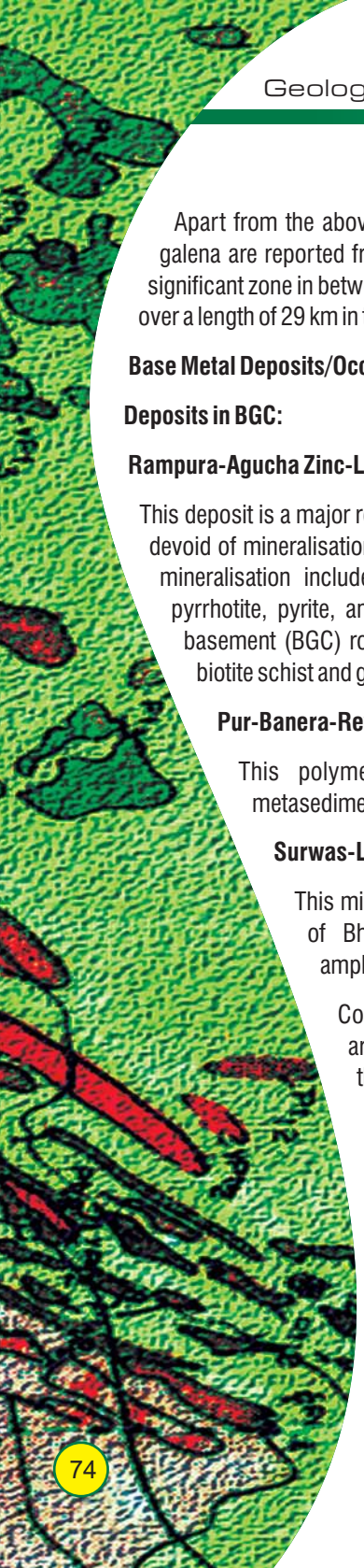
Baghmari mineralised pockets (maximum extent 150 m x 50 m) are associated with dolomite marble and tremolite-actinolite schist. Four boreholes were drilled. The maximum values obtained were only 1.21% Pb x 0.50 m and 0.41% Cu x 0.11 m.

Amjhore Pyrite Mine Area (24°35' - 24°45': 83°50' - 84°00'), Shahbad District, Bihar:

The stratiform Amjhore pyrite deposit (thickness 0.55 to 1.04 m; sulphur content about 40%) occurs in the uppermost part of the Bijaigarh Shale horizon of the upper Vindhyans over an area of about 100 sq.km.The incidence of strata-bound lead-zinc mineralisation in the form of a thin seam varying in thickness from 0.11 to 1.77 m (average 0.77 m) and metal content from 0.22% to 1.17% Pb + Zn (average 0.44% Pb + Zn) has been established by drilling over an area of 5.21 sq.km. This zone occurs about 6 to 10 m above the pyrite horizon and dips northward at low angles.

Two main mineralised belts are known in Orissa. They are: (1) The southern extension of the Singhbhum copper belt (of Jharkhand) for a strike length of about 15 km in the **Kusumbari** (22°04': 86°42'), **Kesarpur** (22°06': 86°41') area of Mayurbhanj district hosting copper mineralisation, and (2) The **Sargipalli** shear zone in the Gangpur basin of Sundargarh district extending discontinuously over a distance of 35 km from Lokdega (22°02': 83°55') in the east to Amatpari (22°12': 83°38') in the west hosting lead mineralisation with subordinate zinc, copper and silver in dolomitic marble and mica schist. The Sargipalli deposit is being mined by M/s.Hindustan Zinc Limited on a scale of 500 t.p.d.

Exploration of the Sargipalli deposit has indicated that these areas mostly comprise iron sulphides.The Kesarpur deposit is of marginal grade and reserves are low (2.81million tonnes with 1.49% Cu at 0.8% cut-off).The Adash prospect in Sambalpur deposit is also a small, marginal one: Reserves 0.93 million tonnes with 1.46% Cu.



Apart from the above mineralised belts, a number of scattered occurrences of galena are reported from Bolangir, Sambalpur and Mayurbhanj districts with one significant zone in between Ampali (20°25' - 83°20') and Chormaria (20°18'- 83°17') over a length of 29 km in the Bolangir district.

Base Metal Deposits/Occurrences in Western Indian Precambrian Shield:

Deposits in BGC:

Rampura-Agucha Zinc-Lead Deposit:

This deposit is a major recent discovery in the basement rocks – the BGC, which are devoid of mineralisation except for these deposits. The stratiform and stratabound mineralisation includes sphalerite and galena as major minerals with minor pyrrhotite, pyrite, and arsenopyrite occurring in the core of a synform in the basement (BGC) rocks. The ore occurs in garnet-graphite-sillimanite- bearing biotite schist and gneiss, calc-granulite and amphibolite.

Pur-Banera-Rewara Copper-Lead-Zinc Deposit:

This polymetallic sulphide deposit of Bhiwara area occurs in metasediments with mineralisation of Cu-Pb-Zn-Fe sulphides.

Surwas-Lakhols-Satdadia Copper Deposit:

This mineralised zone of copper sulphide occurs in metasediments of Bhilwara area with magnetite-quartzite, calc-silicate and amphibolite.

Copper sulphide occurrences in the metasediments of Bhilwara area are known from Wari-Lunera. Other ocurrences include the pyrite-chalcopyrite mineralisation near Bajta, Ajmer district in the Sawar-Bajta metasedimentary belt of Sawar Group of Bhilwara Supergroup and the carbonate-hosted sphalerite-galena mineralisation of Sawar Group.

Aravalli Supergroup

Rajpura-Dariba-Bethumni (Zinc-Lead-Copper) Belt:

This 17- km-long belt of polymetallic sulphide mineralisation in Aravalli Supergroup consists of ores of zinc, lead, copper, silver, cadmium, arsenic, phosperous, fluorite and sulphur with minor gold, molybdenum, indium and mercury.It occurs as a broad conformable Lead-Zinc-Copper sulphide clusters to bedding in graphite mica schists and calc-silicates. Zoned copper-lead-zinc and iron-rich minerals characterise Dariba mineralisation. The major ores are are sphalerite, galena, chalcopyrite, pyrite and pyrrhotite with minor arsenopyrite, cubanite.

Other major Lead-Zinc-Copper mineral deposits in Aravalli Supergroup occur at Mochia, Zawarmala and Borai.The ores are synchronous with the second phase of Aravalli deformation resulting in localising the sphalerite, galena and pyrite mineralisation.

Angeni Copper Deposit, Udaipur district:

The metabasic chlorite schist bands in the basal Aravalli hosts thin discontinuous lenses of chalcopyrite, pyrite, pyrrhotite lenses, upto 5 cm thick with minor covellite and magnetite parallel to pervasive schistosity in a zone of basement-cover interaction. This is characterised as a Proterozoic mélange zone (ductile shear zones).

Delhi Supergroup

The Khetri and Kho-Dariba copper sulphide ore mineralisation and the polymetallic sulphide ore mineralisation along Ajari-Basantgarh-Ambaji-Deri are the two major sulphide deposits.

Khetri Copper Belt

This 100-km-long belt has dominant stratabound copper deposits confined to chlorite schist and amphibolite at Madhan-Kudhan, Kolihan, Akwali and Satkui-Dhanota. Ore minerals are chalcopyrite, pyrrhotite, pyrite, cubanite, magnetite, sphalerite, arsenopyrite, cobaltite, pentlandite.

Massive stratiform copper-zinc ore deposits occur along **Ajari-Basantgarh-Rohera-Pipela** section in southwest fold belt confined to chlorite-mica-quartz schists and amphibolite. The zinc-lead-copper deposits of **Ambaji and Deri** are massive stratiform types located in the southwestern part of the Delhi Fold Belt. Pyrite, sphalerite, galena and chalcopyrite with minor pyrrhotite occur as tabular and lensoid bodies in cordierite-anthophyllite-chlorite rocks and amphibolite.

The basemetal deposits of Gujarat are mainly located in **Amba Mata deposit** in Banaskantha district where the main prospect is 2km long and 600-800m wide with mineralisation of mainly lead and zinc with subordinate copper. The other basemetal deposits are located in Kui-Chitrasani belt falling in Gujarat-Rajasthan.

Base Metal Deposits/Occurrences in Purana Basins:

As many as 70 out of the 84 deposits/occurrences recorded from Andhra Pradesh are located within the Cuddapah Supergroup. The bulk of the basemetal mineralisation is localised in the Nellamalai sub-basin.

At present, only the lead deposit at Bandalamottu in Cumbum formation of the Cuddapah Supergroup is being worked on a small scale by M/s. Hindustan Zinc Limited.

Agnigundala belt:

The Agnigundala belt is located in the north-east corner of the Cuddapah basin. Over 30 copper-lead and zinc occurrences are located in this belt in the calcareous quartzites and dolomites of the Cumbum formation. The only working lead mine of H.Z.L. viz., Bandalamottu deposit (16°13'30" : 79°34'45" - 56 P/12) of Guntur district is located in this belt. This area comprises dolomite and dolomitic limestones interbedded with phyllites and quartzites of the Cumbum Formation of the Nallamalai Group. Zones of lead-copper mineralisation occur mainly in the upper part of the dolomite. The mineralisation is generally poor where the dolomites are associated with chert bands. The regional structure is an anticline plunging at low angles towards north. Concentration of the mineralisation is better along depressions between the anticlines.

Galena is the dominant sulphide mineral with minor chalcopyrite and occasionally sphalerite and pyrite. The deposit has been subjected to 92 surface-and a large number of underground boreholes and mine development by Hindustan Zinc Limited (HZL). The lead orebody is being exploited by the HZL at the rate of 240 tpd.

As a result of the drilling and mine development, the mineralised zone in the Bandalamottu hill has been established over a strike length of about 1200 m with a down dip extension of about 500 m (about 20°dip). Three ore bodies, viz., Main, Eastern and Western have been identified. The Main ore body is developed on the northwestern flank of an anticlinal structure and consists of five overlapping lodes over a strike length of 400 to 600 m. The thickness of the ore bodies ranges from 1 - 11 m and the average thickness of the individual lodes from 1.5 to 6.5 m. The Eastern ore body is located on the eastern flank of the anticlinal structure which extends over a strike length of about 320 m and comprises the No. I lode only. The Western orebody is located to the west of the main ore body. It extends over a strike length of 150 m and comprises only lode No. I. In addition, there is a zone of copper mineralisation below lode No.I of the Main ore body in the lower part of the upper dolomite horizon. This ore body extends over a strike length of about 900 m. The reserves estimated by the GSI for the various ore bodies are as follows:

	Average (thickness) m	Grade Pb %	Reserve (m.t.)
Lead Orebody:			
Main Ore body (Lodes I, II, III, IV, & V)	2.84 to 6.36	4.29 to 8.99	7.899
Eastern Ore body (Lode - I)	5.12	5.58	1.059
Grade - A			
Western Ore body (Lode - I)	3.15	6.45	1.100
Main Ore body (Lode - I)	1.49	3.10	0.650
Grade - B Eastern Ore body	1.60	3.08	0.180
Western Ore body (Dolomite zone)	3.48	3.18	0.571
			11.459
Copper Ore:			
Grade - A Main Ore body	1.5 - 3.0	1.71%	Cu 0.775
Grade - B	0.5 - 1.6		Cu 0.261
		Total	**1.036**

The reserves estimated by the HZL (over a strike length of 700 m) are of the order of only 2.46 million tonnes with an average lead content of 4.98% (at 2% cut-off). The lead deposits are being mined by HZL (about 240 tpd).

Dhukonda (16°13'30": 79°43'30"; 56 P/12) Deposit, Guntur district, Andhra Pradesh:

The geological setting in this area is similar to that of Nallakonda. The rocks are intensely folded. Copper mineralisation is dominant and confined to coarse–grained quartzite. Lead mineralisation is subordinate and is localised in dolomites.

The area has been explored by 79 boreholes. The ore bodies are spread over an aggregate strike length of 2 km in the southern and southeastern slope of Dhukonda peak and adjoining areas. Due to structural complications it has not been possible to clearly establish the exact nature of correlation of the ore bodies. Drilling data indicate that the ore bodies occur as parallel, en-echelon lodes of limited depth persistence and that the ore bodies are repeated due to folding.

The drilling indicated reserves are as follows:

drag fold plunging towards north-east. The deposit has been explored by 72 boreholes drilled by GSI and exploratory mine development at 4 levels by Hindustan Copper Limited (HCL).

The GSI drilling indicated the presence of mineralisation over a strike length of 1300 m and a vertical interval of about 60 m. The ore body appears to have a gentle pitch of about 10 to 15° towards north-east. The downdip extension of ore bodies ranges from 90 m to 400 to 450 m. The orebody comprise a series of parallel en-echelon lodes with sinistral shifts. The lodes pinch and swell both along strike and dip.

Reserves of the order of 3.14 million tonnes with copper content of 1.82% were estimated on the basis of the drilling data by GSI. But the reserves estimated by HCL after exploratory mine development over a strike length of about 150 m are of the order of 0.35 million tonnes with 1.50% copper only. This downward revision of the reserve estimate is mainly attributed to the limited strike and depth persistence of the ore shoots as revealed from exploratory mine development.

Block	Copper ore Reserve (m.t)	Grade % Cu (m.t)	Lead Ore Reserve	Grade % Pb
NE Dhukonda	1.59	1.39	0.22	9.94
SW Dhukonda	0.04	2.60	-	-
Central	0.13	1.48	0.17	8.00
Western Dhukonda	0.40	1.91	0.07	7.06
Total	**2.16**	**1.51**	**0.46**	**8.98**

Nallakonda (16°13': 79°42'; 56 P/12) Deposit, Prakasam district, Andhra Pradesh:

The area comprises chlorite phyllites and grey argillites with intercalations of quartzites and dolomite of the Cumbum Formation. Copper mineralisation is localised in coarse-grained calcareous quartzites. The better zones of mineralisation are seen along the nose of major anticlinal

Vummidivaram (16°09'19": 79°25'3"; 56 P/8) area, Prakasam district, Andhra Pradesh:

The area comprises quartzite and dolomitic breccia intercalated with thick phyllites of Cumbum formation. The beds trend NE-SW with norththwesterly dip of 35° to 60°. Lead mineralisation is hosted in dolomitic quartzite breccia and quartzite. The area is divided into two blocks, viz., Gabbilagavi and Ittammakuvva. The Ittammakuvva block has been explored by 5 boreholes.

Reserves of 0.3 million tonnes with 2.69% lead are estimated. In the Gabbilagavi block, several breccia zones of 0.5 m to 30 m thickness are seen on the surface over a width of 800 m. Exploration by 4 boreholes has not indicated the persistence of breccia zones beyond 70 m depth probably due to pinching/faulting of the mineralised zone. Lead values range between 0.3% and 0.8%, the highest value being 1.40% Cu over 0.77 m.

Karempudi (16°23'30": 79°40'40"; 56 P/11) area, Guntur district, Andhra Preadesh:

The area comprises phyllites interbedded with dolomite and quartzite of the Cumbum Formation. The dolomite host rock is folded into an anticline plunging gently towards east and is partly sheared.The mineralisation is predominantlyin dolomite in the form of veinlets, stringers, pockets and streaks of galena and sphalerite with stray specks of pyrite and chalcopyrite.Fifteen boreholes have been drilled. The mineralised zone has a strike length of 600 m in the northern limb and 200 m in the southern limb. The average width of the mineralised zone is 2.43 m. At a cut-off of 2.0% Pb + Zn, reserves of 0.5 m.t. with 1.38% Pb + 0.96% Zn has been estimated upto a depth of about 150 m. below the surface.

Peddagavalakonda (16°16'30": 79°39'30"; 56 P/11) area, Guntur district, Andhra Pradesh:

The area comprises phyllite, slaty phyllite and argillite with interbeds of dolomitic limestone and quartzite of the Cumbum Formation. The beds strike NE-SW with dips of 40° to 60° towards south-east. Old workings in mineralised dolomite are seen over a strike length of about 1000 m. The area has been explored by 18 boreholes. Four of these boreholes intersected significant zones of lead mineralisation in the lower dolomitic horizon with lead values of upto 8.99% over widths of 1.60 to 3.19 m. These zones do not appear to have dip or strike continuity. Anticipated reserves are of the order of 0.18 million tones with 4% Pb.

Other occurrences in the Agnigundala area:

Veerappakonda (16°12': 79°42'; 56 P/12) area, Guntur district, Andhra Pradesh:

In this area, specks of chalcopyrite and galena are seen in sheared and silicified dolomites of the Cumbum Formation. At the surface a persistent leached zone is seen over a strike length of 400 m. Two boreholes drilled in the area intersected highly limonitised zone with malachite and specks of chalcopyrite.

Papayapalem (16°22': 79°38'; 56 P/12), Guntur district, Andhra Pradesh:

In this area galena mineralisation is seen in brecciated dolomite of the Cumbum Formation. Old workings are seen over 500 m. Out of 8 boreholes drilled, only 2 boreholes intersected mineralised zones: 0.45m x 3.04% Pb and 1.30 m x 2.02% Pb + 0.55% Zn.

Kanchugavi (16°12': 79°24'; 56 P/11), Prakasam district, Andhra Pradesh:

Disseminations of galena are reported to occur in breccia zones inquartzites of the Cumbum Formation. Old workings are seen over a strike length of 150 m.

Other reported occurrences are:

1. Sarikonda (Cu), located 3.6 km NW of Bandalamottu, 2. Balam Devlam (Pb) located east of Bandalamottu, 3. Mella Vagu, 4. Lingalakonda (Cu) located along the northeast continuity of Dhukonda Block, 5. Yerrakuppukonda (16°12': 79°42'), 6. Sakalavonikuvva (Pb-Cu),

7. Currapusala (Cu), 8. Tadivaripalle (Cu-Pb), 9. Ramasamudram (l6°01': 79°24'),

10. Gajjalakonda (15°45' : 79°24') (Cu), 11. Basuvapuram (15°24': 78°38') (Pb),

12. Koilkuntla (15°13': 78°19') (Pb), 13. Chityale (15°28': 77°47') (Pb).

Varikunta - Zangamarajupalle belt:

This belt is located in the south-central part of the Cuddapah basin and stretches over 50 km (N-S). Lead-zinc ores are localised in dolomites enclosed within Cumbum slates. Dips are moderate and rolling.

Zangamarajupalle (14°46': 78°53'; 73 J/13) Deposit, Cuddapah district, Andhra Pradesh:

The area comprises variegated slates and phyllites interbedded with dolomite and quartzite of Cumbum Formation. Dolomite is the host rock. Three dolomite bands are interbedded in the slates. The upper dolomite is 3-8-m-thick with chert band at the top. It is developed all along the strike length of 2 km. The middle dolomite (30 to 70 m) carries the mineralisation and is a fine grained, light to dark grey rock with argillaceous, arenaceous and carbonaceous intercalations. The lower dolomite

(10 to 20 m) is impersistent and merges with the middle dolomite in the southern part. The Zangamarajupalle area forms the western limb of a doubly plunging major anticline. Zones of shearing and brecciation occur in dolomite. The mineralisation is mostly stratiform and confined to the transitional zone between dolomite and chert and the overlying carbonaceous slate. The area has been explored by 22 boreholes at intervals of 200m. On the basis of the borehole data, three better mineralised zone, viz., Central section (400 m), Southern section (600 m) and Northern section (200 m) have been identified. There are 5 lodes (I-V) in the main dolomite and one in the upper dolomite. The lodes I to V in the main dolomite are lead-rich whereas the lode-V in the cherty dolomite is zinc-rich. Subsequently, four series of boreholes spaced at intervals of 50 to100 m along the strike to test the mineralised zones at 50 m, 100 m,150 m and 200 m vertical depths were drilled by the MECL. These boreholes indicated the persistence of the mineralised zone both along strike and depth.

The reserves estimated on the basis of MECL data are as follows:

	Reserves	Grade
At 3% Lead + Zinc cut-off	1.34 m.t.	2.63% Zn 1.91% Pb
At 2% Lead + Zinc cut-off	2.42 m.t.	2.74% Zn 1.3% Pb

Golapalle (14°45'00": 78°54'00"; 57 J/13) Deposit, Cuddappah distict, Andhra Pradesh:

The area comprises greyish green slate, grey dolomite and black pyritiferous carbonaceous slates of the Cumbum formation. Thin chert bands occur interbedded with the dolomite. The mineralisation mostly occurs in the grey dolomite.Sphalerite and galena with minor chalcopyrite occur in association with pyrite at the chert bearing brecciated contact of the dolomite with carbonaceous slates. The sulphides occur as continuous to semi-continuous beds /lensoid bodies in cherty dolomite with finegrained (stratiform) layers of sulphides along bedding planes.

The total strike length of the block is 3.3 km divided into Golapalle East block, Kothapalle block and Chikativaripalle block. 33 boreholes have been drilled in the Golapalle block, 2 in the Kothapalle block and 5 in the Chikativaripalle block. In the Gopalpalle block, continuous mineralisation has been established over a strike length of 1.33 km. The mineralisation is weak in the other two blocks. The reserves estimated in the Golapalle block are as follows:

Cut-off Pb + Zn%	Reserve m.t.	Grade		Width (m)	Total Pb + Zn%
		Pb% +	Zn%		
5	0.46	2.88	2.03	2.55	4.91
4	0.50	3.83	1.87	2.23	5.70
3	1.22	1.61	1.76	3.94	3.37
2	1.89	1.36	1.50	4.30	2.86

The entire deposit falls in the submersion zone of the proposed dam site of Telugu - Ganga project.

Varikunta (15°11': 78°46'; 57 I/16) area, Cuddapah district, Andhra Pradesh:

This area is located along the northerly strike extension of the Zangamarajupalle belt and comprises mainly Cumbum slates interbedded with dolomites and dolomitic quartzites. The strike trend is NNW-SSE with dips of 10° to 35° to east or west. Old workings in the area appear to be along a shear plane in dolomite as also along axes of minor folds in the dolomite. The mineralisation appears to be of e pitches-and-flats type presumably pitching at 10° to 20° towards north, some of the old workings are very extensive with large open stopes. The old workings indicate a series of lenticular ore zones of 100 to 200 m strike length and 5-20 m thickness. Random samples of oxidised zones analysed 0.34 to 3.59% Pb, 0.25 to 0.85% Zn and 0.23 to 0.63% Cu. Two mineralised zones have been identified. An upper zone is associated with cherty dolomite with mostly sphalerite and minor galena and a lower zone of chalcopyrite with minor galena. Six boreholes drilled in the area indicated that the mineralisation is impersistent and lensoid. The metal content in the mineralised zones was found to be less than 2% Pb+Zn (0.88 to 3.72%) over widths of 1.20 to 4 m.

Karredukuppa (14°51'30": 78°49'30"; 57 J/13), Cuddapah district, Andhra Pradesh:

This area is located about 21 km south of Varikunta and has a similar geological setting. Drilling of 6 boreholes indicated only sporadic specks of galena and sphalerite.

Chinnelupatti area, Cuddappah district, Andhra Pradesh:

This area forms the northwesterly extension of the Zangamarajupalle-Kareduppan belt. Galena-sphalerite-chalcopyrite mineralisation within dolomites is noticed over a strike length of about 2.5 km. Geochemical surveys have indicated several linear anomalous zones for zinc and occasional spot values for Pb and Cu.

Ambavaram:

Preliminary geochemical surveys indicate an anomalous zone of Cu-Zn over an area of 200 m x 4000 m. The country rock is green grey shale which carries dolomite lenses and quartz barytes veins with galena.

Gani-kalava belt, Kurnool district, Andhra Pradesh:

This belt extends over 16 km in the northwestern part of the Cuddapah basin. Copper ore occurs in quartz reefs (nearly vertical) cutting through the Tadapatri shales and traps of the Kurnool Formation. The Gani-kalava copper belt comprises Vempalle limestone and Pulivendla quartzites of the lower Cuddapah Supergroup have overlain by Tadapatri shales of the Kurnool Groups. There is a marked angular unconformity between the lower Cuddappahs and the Tadapatri shales. The Cuddapahs and Kurnools in the area are intruded by sills and sheets of metagabbro and metadolerite. Mineralisation is confined to WNW-ESE-trending shear faults occurring in the Tadapatri shales. It is in the form of disseminations, stringers and pockets associated with breccia and quartz vein in traps or at the contact of the trap and shales.

Gani (I5°40'70'': 78°19'57''; 57 I/6) block, Kurnool district, Andhra Pradesh:

The mineralisation in the Gani block consists of an eastern sector of strike length 1100 m and a western sector of strike length 950 m with a gap of about 350 m in between. The mineralisation in the western sector is highly lenticular though old workings are extensive. Some borehole intersections have shown values of 1.31 to 2.7% Cu over 1.25 m thicknesses. But the strike persistence of these values is very limited. Drilling in the eastern sector over a strike length of 500 m has indicated the probability of a significant and persistent zone of copper ore over a strike length of at least 300 m. On the basis of borehole data, reserves of 0.43 million tonnes with1.37% Cu are inferred to be available over a strike length of about 550 m and a depth of 100 m. Copper occurrences have also been recorded from Somayazulapalle (15°35' : 78°11') Kommamarri (15°12' : 77°53') and Gummankonda (I5°38'30' : 78°18'00'') in the Gani-Kalava belt.

Chelima (15°30': 78°40'; 57 I/11), Kurnool district, Andhra Pradesh:

The area is made up of Byrankonda quartzite and cherty quartzites with dolomite, green shales, slaty and phyllitic shales of the Cumbum Formation. These are intruded by dykes of kimberlitic carbonatite. Surface indications of mineralisation are seen over an aggregate strike length of 1 km. The mineralisation is more conspicuous in the nose of the fold where the mineralised dolomite has a thickness of 10 m. Mineralisation is found mostly in the zone of brecciation and dolomites. Three groove samples from trenches indicated values of 2.15 to 6.96% Pb and 6.36 to 8.32% Zn. But drilling of 5 boreholes did not intersect any mineralisation of significance.

Ahobilam (15°08': 78°40'30''; 57 I/12) Kurnool district, Andhra Pradesh:

Copper-lead-zinc mineralisation in this area is hosted in dolomites o the Cumbum Formation. Drilling of 12 boreholes indicated only weak mineralisation with 0.14 to 2.15% Pb, over widths of 0.30 to 4 m.

Pacherla (I5°23': 78°42'; 57 I/11) Kurnool district, Andhra Pradesh:

Galena and sphalerite and occasionally chalcopyrite and pyrite are seen in dolomite intermittently over a strike length of about 2 km. Two samples indicated 3.10% Pb+Zn over 0.97 m thickness.

Basavapuram (15°24': 78°43'):

Lead mineralisation associated with barytes is noticed in quartz veins traversing slaty rocks.

Pulivendla belt, Cuddappah district, Andhra Pradesh:

Copper mineralisation associated with barytes occurring along shear zones in the Tadapatri Formation have been recorded from Venkatapuram (14°24': 78°13'), Vemula (14°22': 78°14') and Midipenta (14°19': 78°19'). The mineralised zone contains barytes, chalcopyrite, pyrite and galena. Six boreholes drilled in the

Venkatapuram area did not indicate any significant zones of mineralisation. Geochemical surveys in the Vemula area indicated an anomaly zone with lead contents of 300 to 1000 ppm. The zones of high values coincide with the known shear fractures in the area.

Mallapuram (15°30'35": 79°10'30"; 57 M/2) (Marakapur belt), Prakasam district, Andhra Pradesh:

The area comprises rocks of the Cumbum Formation, viz., slate, phyllite with quartzite, limestone, dolomite and chert trending NNE-SSW to SW-SW with variable dips of 10° - 80° towards SE. Eleven boreholes have been drilled, of which 3 intersected mineralised zones with upto 3.73% Pb over a width of about 5 m. In a fourth borehole a 0.85-m thick zone with 5.30% Cu was intersected. The strike length of the mineralised zone is about 600 m.

Venkatapuram (17°46': 80°47') area, Khammam district, Andhra Pradesh:

The area comprises phyllite, quartzite, dolomite and ferruginous phyllite of the Pakhal Supergroup. The Venkatapuram block is situated on the western limb of an anticline. The chalcopyrite mineralisation occurs as disseminations and stringers in quartzite and dolomite. Old workings are seen over a length of 120 m. Drilling of 8 boreholes has indicated two en-echelon zones of copper mineralisation with a cumulative strike length of about 150 m. The average grade of the mineralised zone ranges from 1.27 to 1.58% Cu over widths of 1.5 to 5.40 m.

Yellambailu (17°41': 80°40') area, Khammam district, Andhra Pradesh:

This area is located 8 km south-east of Mailaram, and comprises quartz-chlorite schists and biotite gneisses (Sargur Group) intruded by pegmatite and quartz veins and quartzite, tremolite, marble, dolomitic limestone, phyllite and quartz veins of the Pakhal Supergroup. The strike trend is NE-SW with steep dip towards north-west.

Copper mineralisation is seen in quartz-chlorite schist traversed by grey quartz veins and the Pakhal quartzite and dolomitic limestone. Excavations are seen over a strike length of 370 m close to the Archaean and Pakhal contact, but within the Pakhal quartzites and limestones.

Three boreholes drilled in the area indicated two zones of mineralisation, one corresponding to the line of old workings and the other in the underlying quartz-chlorite schists. The zone corresponding to the old workings analysed 1.83% Cu over a width of 0.68 m.

Venkatapalem (17°16': 80°13'), Khammam district, Andhra Pradesh:

This area comprises cherty dolomites interbedded with phyllite and cherts and quartzites of the Pakhal Supergroup. Baryte is often associated with cherty quartzites. Disseminations of chalcopyrite, pyrite and galena are associated with dolomites.

Drilling of 15 shallow boreholes indicated that the mineralisation occurs as lensoid bodies with limited strike and depth persistence. Only three boreholes indicated significant values. They are:

1) 2.68% Pb, 2.88% Zn and 0.38% Cu over 2.24 m.

2) 0.97% Pb, 0.2% Zn and 0.2% Cu.

3) 2.65% Pb, 0.35% Zn and 0.13% Cu.

Ragaboyingudem (17°31': 80°22') Khammam district, Andhra Pradesh:

The area comprises dolomite and phyllite with sheared quartz veins. Three boreholes were drilled, of which only one intersected 0.61% Cu over 2.08 m.

Sarakal (17°43': 80°42'; 65 C/10) :

In this area some old workings in felspathic quartzites and ferruginous quartzites (of Pakhal Group) are seen. Six boreholes were drilled. One borehole intersected oxidised zone with 1.10% Cu over 1.55 m width at 80 m depth. A deeper borehole was negative.

Incidence of copper mineralisation has been recorded from two locations in the Kaladgi basin of Bijapur district. Traces of copper on talcose laminae in limestone has been recorded at Khajjidoni (16°10': 75°31') and north of Gaddankere (16°11': 75°37'), show specks of malachite and occasionally chalcopyrite. Although these two occurrences are of sporadic nature, the possibility of finding economically viable deposits for copper in the Kaladgi basin cannot be ruled out.

OTHER DEPOSITS

In Uttarakhand, base metal mineralisation is located in the large hilly tracts covered by the Garhwal Group of rocks, in the Vindhyans and in the shear zones crossing the Bundelkhand granites. There are a number of reported base metal occurrences in the State, the most important one being the Askot deposit which is described below.

Askot (Copper-Lead-Zinc) Deposit (29°46': 30°20'), Pithoragarh district, Uttarakhand:

The sulphide mineralisation is confined to the northern limb of the Askot syncline near its south-eastern closure. The surface indications of mineralisations are seen in the form of a small outcrop - unaltered, hard, silicified epidote-actinolite-biotite-quartz rock.

The southern ore body (the most important one), which had been explored by GSI through drilling at 50-m strike interval, at two levels (1015 m RL and 985 m RL), covering some 150 m, was opened up by two adits by the MECL at 1015 m RL. The exploratory mining carried out exposed the ore at 985 m level with 1.68% Cu, 4.39% Pb, 4.77% Zn (10.83% TMC) along with 1.68% As, 0.10% Sn, 0.062% Sb. The GSI has estimated reserves of about 0.77 million tonnes of ore averaging 2.32% Cu, 2.64% Pb and 3.95% Zn in the area.

The other explored occurrences are Dudhi (copper-lead-zinc) in Mirjapur district, Khanayun-Galpakot-Kimkhet area (copper-lead-zinc) in Nainital-Pithoragarh districts and Tons Valley in Dehradun district.

Base Metal Occurrences in Himalaya

At the foothills of Himalaya, in West Bengal, only one basemetal deposit has so far been identified, viz., the Gorubathan lead-zinc deposit. The total reserves of 3.70 million tonnes with 3.77% Pb + 3.87% Zn in this deposit may be adequate for opening a small mine of 300 to 500 tpd. But the reserves are distributed over a number of ore bodies in several blocks. These ore bodies have only limited strike persistences of upto 240 m. This is not a very favourable factor, but the average width of the ore bodies (3.27 to 4.30 m) is a favourable factor. However, the fact that magnetite is the principal gangue mineral in the ore bodies can favourably influence the economics of mining. Recoveries of about 90% of the magnetite are reported.

The Sikkim-Darjeeling area is dotted with as many as 40 basemetal occurrences confined essentially to the Daling/Darjeeling Group of rocks with biotitic granites occurring as tongue-like bodies. The important copper-lead-zinc prospects are: Bhotang (Copper-Lead-Zinc) (27°10'30'': 88°32'00''), Rangpo, East Sikkim district ; Dikchu (Copper-Zinc), (27°23' : 88°35'), North Sikkim district; Peshok (Copper) (27°04' : 88°24'), and Pedong (Copper) (27°09' : 88°37'). Drilling encountered poor mineralisation in Bhotang. The IBM estimated following reserves for the Dikchu ore body.

Proved reserves: 1.62 lakh tonnes with 3% Cu and 1.53% Zn

Probable reserves: 1.23 lakh tonnes with 2.91% Cu and 1.59% Zn

Total: 2.85 lakh tonnes with 2.97% Cu and 1.56% Zn (2.90 lakh tonnes)

Peshok (Copper) grades between 0.5% and 2.5% Cu (VE). In Pedong, the richer zones have a grade of about 2.5% Cu (VE).

Palaeo- to Mesoproterozoic Polymetallic Mineralisation : The Bomdila Group of Lesser Himalayan sequence in Ranga Valley of Lower Subansiri district of Arunachal Pradesh hosts polymetallic (Fe, Cu, Pb, Zn with Ni, Co, Sn and W) mineralization of Palaeo- to Meso-Proterozoic age. The mineralisation is confined to the magnetite-bearing schistose units of the Potin Formation. Two copper-rich zones with a possible reserve of 1.55 mt with an average grade of 0.33% Cu with appreciable amounts of lead and zinc have been tentatively estimated in the Ranga Valley (Potin-Yazali area). In the Lesser Himalayan sequence of West Kameng district of Arunachal Pradesh, Proterozoic grey dolomite of Mukatung Formation of of Shergoan Group hosts lead-zinc mineralisation in the form of galena and sphalerite. The mineralised belt extends for a distance of about 9 km on which four exploration blocks are located. The deposit is patchy, highly erratic in depth persistence; but so far as age (*Proterozoic*), host rock (*dolomite*), metamorphic grade (*lower amphibolite*) and character of mineralisation (*stratabound*), etc. are concerned, the deposit is similar to that of Rajpura-Dariba Group of Rajasthan, where more than 300 mt of lead and zinc been discovered by GSI.

Deccan Traps:

Native copper as thin films along joints, vesicular in fillings and disseminated grains have been reported from the Deccan basalts near Handigund (16°25': 75°05'), Belgaum district, Karnataka. Magnetite, haematite and maghemite are other associated minerals.

Nagavand (14°20': 75°35'), Dharwar district, Karnataka:

The metasedimentary-volcanic suite consist of andesite flows, tuffs, carbonaceous shales and ferruginous cherts. Gossanous bands have assayed 0.64 to 12.80% copper. Further exploration is required to assess the nature and intensity of mineralisation.

Late Palaeozoic metallogenic epoch mainly associated with volcanic rocks:

1)*Pb-Cu mineralisation in the epiplatform carbonate sequence around Bora Agar, Rain Agar, Shisakhani and Dhanpur in Uttarakhand Himalaya and Sirban Limestone around Sersandu in Jammu Himalaya.*

Stratabound sulphide occurs in the carbonate rich formations of the volcano-sedimentary sequence of the Garhwal Group in U.K. Himalaya. Though a good concentration for and economic deposit has not yet been demarcated, these occurrences contain a number of old workings

2) *Kwanu lead-zinc-copper belt in Uttarakhand in Deoban Group of rocks*:

The Kwanu lead-zinc-copper belt extends over a strike length of about 1km from Chamri in the southeast to Anyar in the northwest. Amtiyargad and Chamri prospects of this belt are in Uttarakhand, whereas, Anyar is located in the adjoining state of Himachal Pradesh. Old workings, slag heaps and gossans scattered throughout the area are indicative of basemetal mineralisation. The basemetal mineralisation in this area is associated with Sauli Formation of Deoban Group. The principal host rocks for mineralisation are dolomite, shale, carbonaceous and/or calcareous slates and tuffs. Mineralisation occurs mainly in the form of stringers, disseminations, vug fillings, veins and patches of metallic sulphides, mainly pyrite, galena, sphalerite and chalcopyrite. Traces of mercurous sphalerite and argentite are also present. Fractures and shears, parallel to the axial planes of tight folds are the main locales of mineralisation.

BARYTE

The largest baryte deposit in the world with a reserve of 74 Mt is located in Mangampeta in Cuddapah District. This deposit occurs in the Pullampet Shale of the Cuddapah Supergroup.

Baryte occurring as lenses in pegmatites occurs near Kurichchi, Coimbatore District. The mineral is associated with quartz veins near Alangayam, Vellore district, Tamil Nadu. In central India, baryte occurs in the septarian nodules in the concretionary zones overlying the Gunderdehi Shale near Dotapur in Raipur district, Gairi (Dewas District), Dhar area (Dhar district), Sunehra, Manehra (Jabalpur district), SW of Kerua village near Harsi Reservoir (Shivpuri district), Andhiri Kho, Bari (Sidhi district) and around Bhoiron in Tikamgarh district. Baryte veins occur south of Phutana and NNW of Thanewasna, Mahadwari and Dewada areas in Chandrapur district of Maharashtra. In this State, minor occurrences of baryte are noticed near Kopela and Jingaanur areas of Gadchiroli district and north of Ran Mangli in Nagpur district. Barytes occur as very thin vein along foliation planes in Musnota in Mahendergarh district and from Haripur in Ambala district of Haryana. Baryte deposits of the order of 15,000 tonnes are located in Kaami, Tatyana, Batwari and Kheel in Sirmaur districts of Himachal Pradesh and in Kinnaur district, 1425 tonnes of barytes are located in Aarsomang. In Askot copper-lead-zinc deposit, Pithoragarh district, Uttarakhand, the total reserves of barytes have been inferred to be about 20, 0000 tonnes.

PLATINUM GROUP OF ELEMENTS (PGE) AND CHROMITE

The ultramafic – mafic suite of rocks are considered to be the potential host for PGE, nickel, chromium and copper mineralisation.

In the Granulite Terrain of Tamil Nadu, several ultramafic-mafic-anorthosite complexes occur in Sittampundi, Mettuppalaiyam, Torappadi, Manmalai, Tenmudiyanur, Kadavur and Oddanchatram areas. Among these, the major Sittampundi and Mettuppalaiyam

complexes represent layered or differentiated sequences of dunite, meta-pyroxenite / chromiferous meta-pyroxenite, chromitite, garnet-pyroxene granulite, meta gabbro ±garnet, amphibolite, gabbroic anorthosite and anorthosite. These complexes, dated to be ca. 2900 ma, are emplaced within the amphibolite-facies gneisses and the associated supracurstals of Archaean age within the E-W-trending Cauvery Shear Zone.

PGE mineralisation in **Sittampundi Anorthosite Complex** was first identified by GSI in the year 1984 when one of the seven chromitite samples analysed in U.S.G.S. has given 0.929 ppm of total PGE. Close-spaced sampling carried out subsequently has resulted in delineating two zones of PGE mineralisation in the Karungalpatti block – one in the chromitite band No.III with an average grade of 1.56 ppm of Pt + Pd over 3 m width and the other in the chromiferous meta-pyroxenite band no.IV with 2.45 ppm of Pt + Pd over 1.60 m width.

Based on detailed mapping and close-spaced sampling in the adjoining Chettiyampalaiyam block, a significant zone of PGE mineralisation has been delineated for a cumulative strike length of 1.4 km with total PGE values ranging from 1 ppm to a maximum of 18 ppm in the chromitite chromiferous meta-pyroxenite bands. The average grade of PGE mineralisation in this zone works out to be 1.8 ppm of Pt + Pd over 1.5 m width.

In Tasampalaiyam block, located at the western part of the Sitampundi Complex, two zones of chromitite / chromiferous meta-pyroxenite have been delineated. Among these, the western zone shows significant PGE mineralisation with Pt + Pd values ranging from 0.7 ppm to as high as 6.7 ppm over 0.25 to 1 m width, with sporadic high values upto 16.43 ppm of Pt + Pd. The depth persistence of these PGE mineralised zones is being tested by scout drilling.

Similarly, a significant zone of PGE mineralisation (1-4 ppm of total PGE) extending for a strike length of about 1.1 km has been delineated by GSI. in the meta-pyroxenite of Solavanur block in **Mettuppalaiyam Ultramafic Complex.** The PGE mineralisation with an average grade of 1.8 ppm of Pt + Pd over a width of 2.5 m is found within the meta-pyroxenite band showing malachite-azurite encrustations.

In Mallanayakkanpalaiyam area, preliminary sampling of the chromite-bearing meta-pyroxenite band has indicated 0.97 ppm of Pt + Pd.

In Karappadi block, two linear bands of chromitite and chromiferous meta-pyroxenite have been delineated for a cumulative strike length of about 500 m with a maximum width of 3.5 m. Chip samples collected from these bands have shown Pt + Pd values ranging from 0.47 ppm to 1.70 ppm. The depth persistence of these PGE-mineralised zones is being tested by scout drilling.

Recent exploration (2007-2008) by GSI indicated the presence of PGE mineralisation in the form of sperrylite **(PtAsS),** braggite **(PtS)** and stibiopalladinite **(PtAsS)** reported along with pentlandite **(NiS)** and chrome-spinel within the chromitites in Chettiyampalayam block of Sittampundi Anorthoste Complex.

The weathered profile over Bhuvanagiri Ultramafics, Coimbatore district, Tamil Nadu has yielded 0.10 to 0.43% Ni. Peridote / dunite from Chalk Hills, Salem District, Tamil Nadu has yielded upto 0.40% Ni and occasional composite grains of pentlandite + pyrrhotite + chalcopyrite have been recorded from the Red Hills. Nickel values upto 0.12% have also been recorded from the Torappadi ultramafic body, Vellore district, Tamil Nadu.

Chromite:

The region south of the Singhbhum Cu-U belt is very rich in Cr mineralisation. More than 90% of India's reserve of about 150 m.t. of economic grade Cr-ore occurs in this region. The mineralisation occurs in two locales:(1) Jojohatu — Hatgamaria (Singhbhum district, Jharkhand), and (2) Sukinda (Jajpur - Dhenkanal districts, Orissa) - Baula Nuasahi (Keonjhar district, Orissa).Deposits in (1) were much smaller and already mined out. Ore mineralisation at Sukinda is more intense than at Baula Nuasahi.

Important chromite occurrences are reported from Sittampundi and Mettuppalaiayam ultramafic complexes in Tamil Nadu. Several linear parallel bands and lenses of chromitite occur within the anorthosite gneiss in Sittampundi Complex for a total stretch of 12.8 km between Sittampundi in the west and Karungalpatti in the east. These chromitite bands, varying in width from 8 cm to a maximum of about 3 m, are made up of chromite (50-60%), amphiboles (30-35%) and rutile and other

accessories (5%). At places, massive chromitite with 70-80% of chromite showing cumulate texture is also noticed. These chromitite bands analyse 21.72% to 28.20% of Cr_2O_3, 24.04-41.31% of Al_2O_3, 10.20 to 25.59% of Fe_2O_3 and 10.10–13.20% of FeO. The reserves are estimated at 0.221 million tonnes upto a depth of 6 m.

In Mettuppalaiyam ultramafic complex, three occurrences of chromite are reported at Karappadi, Mallanayakkanpalaiyam and Solavanur areas in Erode district of Tamil Nadu. Chromite occurs as bands, lenses and disseminations within the meta-pyroxenite-gabbro-anorthosite sequence extending for a strike length of about 1 km with a width of about 250 m. The chromitite samples collected from Solavanur and Karappadi areas have given Cr_2O_3 values ranging from 20.14% to 30.78% and total iron as Fe-varying from 16.50 to 19.30%.

Only minor chromite mineralisation is reported from central India. The known deposits are in Maharashtra in Sindhudurg and Nagpur-Chandrapur districts. The estimated deposits are of 0.53 m.t. Chromite generally are of podiform nature associated with ultrabasic intrsuives in the gneissic terrain.

Chromite mineralization is reported from Kyun Tso-Shurok Sumdo, Leh district, J&K state and Sanko area. The inferred reserves have been estimated at 14,000 tonnes.

Late Mesozoic Ophiolites of Northeast: The belt with ophiolite suite of rocks extends for about 200 km from Moreh in Manipur, in south to north-east of Chiphur in Nagaland in north. Chromite is the main economic mineral of the 'Ophiolite suite' of rock that is similar to those of the Alpine type in their mode of occurrence, physical (*podiform*) and chemical characteristics [*high Cr_2O_3 content (>45%) and low TiO_2 content*].

Meso-Cenozoic mineralisation epoch associated with Indus ophiolites:

Cr-mineralisation occurs in Ladakh in the form of chromite lenses in ophiolitic suits of rocks represented by basic and ultrabasic rocks which have been emplaced within flyschoid sediments. Copper in the form of disseminated chalcopyrite and native specks is associated with Dras volcanic in Tal and Spiti area.

INDIA'S RESOURCES AND PRODUCTION:

1. Archaean Greenstone Association

a. Sukinda and Nausahi in Orissa

b. Sinduvalli and Byrapur in Karnataka

c. Bhandara and Ratnagiri in Maharashtra

d. Roro and Jojohatu in Bihar

e. Ponda and Dudsagar in Goa.

2. Proterozoic Granulite Association

a. Kondapalli in Andhra Pradesh

b. Sittampundi complex in Tamil Nadu.

3. Tertiary Ophiolite Association

Chromite occurrences of Manipur, Nagaland, Andaman and Nicobar Islands and Jammu & Kashmir.

[Important resource occurrences in India are shown in Plate – 1]

Resources :

Total recoverable reserves of chromite in the country as on 01.04.1995 were assessed at 86.23 million tonnes in which the shares of proved, probable and possible reserves are 30%, 36% and 34% respectively. Over 97% of the total recoverable reserves are found in Orissa State. Out of the total recoverable reserves of all grades, about 34% is of metallurgical grade and 29% is of charge-chrome grade. As per UNFC system, total resources of chromite in the country as on 1.4.2000 are 179 m.t. comprising 47 m.t. of insitu reserves (26%) and the remaining 132 m.t. of resources (74%). Category-wise, grade-wise and state-wise break-up of recoverable reserves are given in following table.

State / Grade	Recoverable Reserves (as on 1.4.2000)		
	Proved	Probable	Total
Metallurgical (>48% Cr2O3)	8072	3464	11535
Refractory (>40% Cr2O3)407	448	855	
Charge Chrome (>44% Cr2O3)	14381	7057	21,439
Low	-	-	-
Beneficiable	5876	6923	12799
BY STATES			
Karnataka	523	648	1170
Maharashtra	2	0	2
Orissa	28227	17263	45490
Manipur	-	-	-
Tamil Nadu	-	-	-
ALL INDIA	**28752**	**17910**	**46,663**

[Source : IBM Year Book, 2004]

B. Production :

Orissa continued to be the leading producing State of chromite, accounting for 99% of

the total production in 2003-04. Production of chromite in Karnataka, Maharashtra accounts for the remaining 1% production. Major share (98.6%) of chromite resources in the country are located in Orissa. The chromite deposits occur in number of localities along NE-SW belt associated with ultramafic complexes of Sukinda, Baula-Nuasahi and similar occurrences of ultramafic rocks at Bhalukasoni and Ramgiri. Chromite occurs as persistent thick bands, seams, lenses within ultramafic complex. Six seams have been delineated with thickness varying from 10 to 50 m. These are friable in nature and described as brown ore. The chromite deposit of Sukinda belt is mainly stratiform type and can be classified into the categories like lumpy ore, granular ore, friable ore, ferruginous ore, disseminated ore and banded ore.

BAULA – NUASAHI BELT:

Nausahi ultramafic complex covers a surface area of 5 sq km and a detached segment occurring at a distance of 50 km to the ENE of Sukinda area. Mining of chromite in Nausahi area started during 1942-43. Ore bodies in Nuasahi sector are spread over a strike length of 3 km in N-S direction.The width of individual band as revealed from borehole data, varies from 15 m to as thin as 10 cm. The Nuasahi ores are inferior charge-chrome grade. Iron and silica are higher than in Sukinda sector. Reserve of 3.40 million tonnes of chromite of all grades have been estimated in Baula-Nuasahi sector. Bhalukasoni chromiferous ultramafic body is the only known occurrence of its kind, east of famous Nuasahi chromite fields. The DGM, Orissa estimated a total reserve of the order of 1550 tonnes for both massive and spotted variety of chromite with Cr_2O_3 content from 25.77 to 54.76%. Ramagiri can be approached from Jeypore, which is connected with NH 43. Five channel samples collected from pits showed the following analytical results :

Cr_2O_3 - 24.07 to 27.49%

Fe(t) - 8.10 to 14.24%

IRON ORE

Major iron ore deposits in India, distributed in five zones designated as Zone – I to Zone-V, have been identified in the country on commercial ground. Zone-I group of iron ore deposits occur on the Bonai Iron Ore Ranges of Jharkhand and Orissa States and in the adjoining areas in Eastern India, Zone-II group comprises iron

ore deposits in the 225-km.-long north-south-trending linear belt in central India comprising the States of Chhattisgarh and Maharashtra (East), Zone – III deposits occur in Bellary-Hospet regions of Karnataka while the Zone – IV deposits cover the rich magnetitic deposits of Bababudan-Kudremukh area of the same State in south India, and Zone – V deposits cover iron ore deposits of Goa. In addition, in south India, magnetite-rich banded magnetite quartzites occur in parts of Andhra Pradesh near the East Coast while in Tamil Nadu good deposits of magnetite occur in Salem district and in neighbouring areas.

Banded Iron Formation of Pre-Cambrian Age:

Extensive outcrops of BIF are found confined to the Precambrian belts in the States of Jharkhand, Orissa, Chhatisgarh, Maharashtra, Karnataka, Goa and Tamil Nadu. The most common names used in India to designate BIF are Banded Haematite Quartzite (BHQ) and Banded Magnetite Quartzite (BMQ). This is a weakly banded magnetite-quartzite forming part of a supracrustal sequence of quartzite, mica schist, marble, metavolcanics and amphibolite completely engulfed in a voluminous mass of a tonalitic gneiss. The formation is highly folded and metamorphosed under granulite facies condition. Typical examples are iron formation from the granulite regions of south India (Tamil Nadu, parts of Andhra Pradesh, Karnataka and Kerala) that is different from those of the Archaean schist belt. Thus the iron ore formation within the Indian shield can be divided into two main types: (i) those lying within the high grade region and (ii) those confined to Archaean schist belt. Among these, the first type occurs as narrow, highly deformed and metamorphosed belt within Archean granulites and gneisses and represents formation of an older age group (>3000 Ma.) formed in distinct tectonic environment and later incorporated within high grade mobile belt.The second and the more extensive type having characteristic of both Algoma and Superior type, is the one confined to the schist belts formed during the period 2900-2600 Ma. These types of deposits are confined to States of Jharkhand, Orissa, Karnataka, Maharashtra, Chhattishgarh and Goa. These form important repositories of rich iron ore deposits in India. The major ore minerals are haematite and magnetite. Important accumulations are in Singhbhum district (Jharkhand), Keonjhar district (Orissa), Bellary district (Karnataka), Bastar district (Chhattisgarh) and in Goa. Magnetite ore deposits are mainly confined to Chikmagalur district in Karnataka, Salem and North Arcot districts of Tamil Nadu and Prakasam district of Andhra Pradesh.

Sedimentary iron ore deposits of siderite and limonitic composition:

These ores are also known as Bog iron deposit. These ores of siderite and limonitic compositions are found associated with the ironstone shales of Lower Gondwana age occurring in the coalfields of Jharkhand and West Bengal and the ferruginous beds in the Tertiary formations of Assam and the Himalaya. In upper Assam, such deposits occur in Lakhimpur and Sibsagar districts and are mainly of two types: clay ironstone and impure limonite. In Ranigunj area of West Bengal, the sedimentary iron ores occur in the form of thin beds of ironstone of variable thickness and frequently in the Ironstone Shale Group of the Damuda Series in Ranigunj coalfield.

Titaniferous and vanadiferous magnetites:

The vanadiferous-titaniferous magnetite deposits of southeastern Singhbhum (Jharkhand), Mayurbhanj and Keonjhar (Orissa) and Hassan districts (Karnataka) are associated with gabbroid and ultrabasic rocks. The larger and rich iron ore deposits are mainly concentrated in Jharkhand, Orissa, Chhattisgarh, Karnataka and Goa. Comparatively small deposits are situated in Maharashtra, Andhra Pradesh, Tamil Nadu, Kerala and Rajasthan.Occurrences of iron ore deposits are also reported from Assam, Meghalaya, Nagaland, West Bengal, Himachal Pradesh, Uttar Pradesh and Jammu-Kashmir. But these deposits are not economically significant. Detail description of the deposits belt-wise and sectorwise has not been enumerated.

MANGANESE

Karnataka has the largest recoverable reserves (64.55 million tones) of manganese ore in the country. Managanese ore minerals occur in close association with haematite and carbonates as stratiform, lenticular, patchy or pockety deposits of varying dimensions, within various greenstone belts. Andhra Pradesh contributes about 90% of the manganese ore production in the country. The manganese ore here is mainly associated with kodurites of the Khondalite Group in Eastern Ghats and Penganga beds in the Pakhal Basin. Orissa accounts for one third of the country's annual production of manganese and possesses the second largest recoverable manganese reserve in the country i.e. 50.36 million tonnes of all grades, next to that of Karnataka. Manganese ores are mined in Singhbhum district in between Noamundi and Gua and from south of Chaibasa. The ore minerals are mostly

psilomelane, braunite, cryptomelane and pyrolusite. Deposits have also been rcorded from Lada Buru and from Lanji. The total recoverable reserve of manganese ore of all grades is estimated to be 2.3 Mt .

Goa possesses 83.1 Mt of manganese which constitutes 22.4% of the total resources estimated for the country.

Madhya Pradesh is India's foremost source of high-grade manganese ore. The largest and richest deposit is located in Balaghat district. Other small deposits and occurrences are in Chhindwara, Jabalpur, Jhabua, Khargone and Seoni districts.Maharashtra possesses about 10% of the country's total estimated resources of Manganese ore, which are of the order of about 22.186 million tonnes. Maharashtra was the second largest producer of manganese ore, sharing 26% of mineral production. The manganese belt in Nagpur and Bhandara districts extends for 100 km from west of Gumgaon to Ghanor in the east and passes through Paraseoni, Kandri, Mansar, Guguldoh, Alsalpari, Dongribuzurg and Chikla with a maximum width of 20 km in the central part, near Mansar. The major share of manganese ore of this sector comes from Sausar Group Manganese ore deposits occurring in the lower part of the Sausar Group. There are about 20 deposits spread over a length of 45 km and with an outcrop width of about 15 km. The ore occurs in two forms viz. (1) as bands intercalated with gneisses, schists and quartzites associated with spessartite-quartzite rock (gondite), rhodonite rock or both and (2) as lenticles of bands of nodules in crystalline limestone. There are as many as 55 known manganese deposits in this district. Manganese ore in Sindhudurg district occurs as secondary enrichment deposits associated with lateritised Dharwarian meta-sediments. Other small deposits and occurrences are in Chhindwara, Jabalpur, Jhabua, Khargone and Seoni districts. Manganese minerals are found scattered on the eastern slope of a hill 1.5 km northeast of Ratanpur near Newasa and Kamarakhol area of Bilaspur district of Chhattisgarh.

MOLYBDENUM

Molybdenite mineralisation occurs in two different geological settings one associated with the alkaline group of rocks occurring at **Harur-Uttangarai Belt,** Dharmapuri district and at **Alangayam,** Vellore districts of northern Tamil Nadu and the other in a graphite pegmatite intrusive into migmatitic gneiss of **Karadikuttam** area of Dindigul district, Tamil Nadu.

In **Harur-Uttangarai Belt,** the mineralisation is confined to the shear zone within which emplacement of quartz and carbonate veins are present. In Velampatti South Block, detailed work was carried out by GSI by drilling upto the fourth level over a length of 1.38 km, which proved the depth persistence of molybdenite mineralisation upto the vertical depth of 320m. The resources estimated in this block are of the order of 2.74 million tonnes with an average grade of 0.102% Mo at 0.03% cut-off or 5.75 million tonnes of ore with an average grade of 0.064% Mo at 0.01% cut-off. In the other blocks of Harur sector, a tentative resource of 12.68 million tonnes of ore with an average grade of 0.032% Mo has been estimated.

In the Velampatti Central Block, the extension of the above said mineralised zone has been proved further north over a strike length of 0.50 km. A reserve of 0.336 million tonnes with an average grade of 0.079% Mo at 0.05% cut-off and 0.723 million tonnes with the average grade of 0.059% Mo at 0.03% cut-off is established. The other nine blocks existing north of Ponnaiyar river in Uttangarai Sector are being explored, some of the borehole core samples show values as high as 2000 ppm of Mo.

The **Alangayam** area falls in the northeastern part of the Gudiyattam Bhavani Belt and mainly consists of epidote - hornblende gneiss occupying the valley between the Yelagiri hills in the west and the Javadi hill range in the east. A number of quartz - baryte vein bearing pyrite, galena and molybdenite and occasional chalcopyrite are emplaced within epidote - hornblende gneiss. Detailed prospecting including scout drilling by GSI has revealed a number of low-dipping parallel quartz veins, some of which assayed significant molybdenum values (0.01% to 0.51%). The maximum thickness of the mineralised zone is one metre. A probable reserve of 86,314 tonnes and possible reserve of 6,33,408 tonnes with the average ranging from 0.0125 to 0.04% of Mo has been estimated.

Near **Karadikuttam** in Dindigul district, molybdenite occurs in the form of disseminated and thin stringers in a graphite pegmatite intrusive into migmatitic gneiss. Exploratory drilling has established about 0.28 million tonnes of ore with an average grade 0.0285% of Mo.

TIN, TUNGSTEN

Extensive deposits of wollastonite are located in Khera Uparla and Bel ka Pahar areas of Pali-Sirohi districts, and in Gola-Alipura area of Ajmer district of Rajasthan. Tosham prospect, Bhiwani district of Haryana contains appreciable

quantity of cassiterite and wolframite with tin ore (0.15% tin) of the order of 30.33 million tonnes. In the State of Chhattisgarh, tin is found in the form of cassiterite occuring in pegmatite and in alluvial soil derived from these pegmatites in Bastar district. Stratiform zinc-scheelite mineralisation in Sakoli belt represents the earliest phase of metallogeny in this belt. In the State of Madhya Pradesh, sporadic occurrences of cassiterite have been noticed within Aravalli Supergroup intruded by granitoid rocks in Jhabua district. Disseminations, streaks and patches of scheelite are seen in the calc-granulite band occurring within pegmatoidal granite/granite body in the Karungalagudi area, Madurai district, Tamil Nadu. Significant concentrations, upto 2% W, are seen near Kambalipatti, Somagiri and Rayarpatti. At Kambalipatti, the mineralised zone has been traced over a strike length of about 270 m with a width upto 40 m. In Somagiri, the mineralised zone occurs with a width of about 40 m or more and is inferred to have a strike length of about 1km. Several ore shoots (at the cut-off grade of 0.05% W) are inferred. On the basis of trench sampling 4 or 5 ore shoots upto 5 m wide are inferred. Ore shoots are estimated to comprise about 20% to 30 % of the total width of the mineralised zone and are expected to have an average W content of 0.10% to 0.15%. In the Rayarpatti area, the mineralised zone extends over a strike length of about 1800 m but the mineral content is rather low, about 200 to 300 ppm. Tin values (upto 1800 ppm) are associated with the mineralised zone in the Kambalipatti. Tin values of 200 to 500 ppm are reported from three grab samples of quartzite from Vaiyampatti, Tiruchirapalli District.Tungsten are known from Pauri & Almora districts of Uttarakhand and Sonbhadra & Hamirpur districts of UP.

URANIUM

Singhbhum district in Jharkhand has so far remained the only place in India, producing *uranium ore*. Uranium in Singhbhum district was first reported in 1921 by GSI. At Jaduguda, uranium occurs associated with hard compact and somewhat mylonitised chlorite-sericite schist and granular metasedimentaries. Indicated ore reserves at Jaduguda have been estimated at 2.8 Mt with an average grade of about 0.08% uranium oxide. Uranium is found associated with copper mineralisation in Chamoli district, Uttarakhand and Lalitpur district, Uttar Pradesh.

BAUXITE

The deposits in AP and Orissa (Eastern Ghats) with a total reserve of about 1650 Mt constitute one of the largest bauxite deposits in the world. Orissa continues to be the leading state accounting for 59% of the total **bauxite** production of the country. **Jharkhand** is also rich in **bauxite** deposits. It occurs in the high hilltops of the Chhotanagpur plateau as residual deposits. Bauxite occurs as segregated sheets, pockets, patches and lenses within laterite cappings over the traps and gneisses. Extensive deposits of bauxite are found in the western Chhotanagpur plateau area falling in **Lohardaga** and **Gumla** districts and adjoining **Palamau** district. The reserves of high-grade bauxite, containing above 50% Al_2O_3 were tentatively estimated to be about 9 mt in the erstwhile Ranchi district and 1.7 mt in Palamau district. The exploration at Amtipani area (23º20' to 23º23' : 84º16' to 84º19') established an estimated reserve of 4.95 mt analysing 48.47% Al_2O_3 and 5.59% SiO_2 in five blocks covering 1.75 sq km. Occurrences of bauxite with laterite in Kharagpur hills, **Munger district** are known since long. Deposits occur on the hills at Khapra (25º10' : 86º27'), Maruk (25º11' : 86º28') and Maira (26º14' : 86º22'), of which the deposit at Maruk is the most promising bauxite occurrences. Bauxites are also reported in the high-level laterite, capping the highly dissected plateau tops of Rajmahal trap rocks in the **Santhal Parganas district**. Bauxite with laterite occurs as capping over the Dhandraul Quartzite of the Vindhyan Supergroup near Adhaura (24º41'15": 83º37') in **Rohtas district** (erstwhile Shahabad district) of Bihar.

The reserves of bauxite estimated from Andhra Pradesh are placed at 565 Mt. Bauxite occurs in association with laterite capping on Deccan Traps on the high plateaus, east of Kolhapur and Satara districts and along the low-lying plateaus of the Konkan terrain in Kolaba and Ratnagiri districts. It also occurs in Kolhapur district, Raigad district, Ratnagiri district, Satara district, Sindhudurg district and Thane districts of Maharashtra. The important occurrences of bauxite are located in Rakti Dadar, Nanhu Dadar, Jamuna Dadar (Mandla) , Tikuri and Tikaria (Jabalpur), Mundi Dadar, Touri Dadar, Kauwajhar Dadar (Balaghat) and also in Shahdol, Rewa, Satna, Guna, Shivpuri and Vidisha districts of M.P. High grade bauxite occur between Keshkal and Amabera (Bastar district), Phutka Pahar (Bilaspur district), plateau laterite in Khuria (Raigarh district), Bodai, Daldali, Kesmarda (Rajnandgaon district), atop Deccan trap in Mainpat-Jamirapat and Joka-Luchupat (Surguja district) and also in Durg district of Chhattisgarh State. Bauxite occurs as irregular lenses / pockets and high-level laterite cappings over charnockite in the Nilgiri Hills, Shevroy Hills, Kollimalai Hills, and the Palani Hills of Tamil Nadu. Significant bauxite occurrences are also present in several other States, notably in Madhya Pradesh and Gujarat.

The diasporic bauxite is extensively found in Jammu region. It belongs to Jangalgali Formation. The aggregate reserves of 13.40 million tonnes were estimated for these deposits. In recent years GSI has investigated bauxite deposits of (1) Triyath-Krul, Ransuh-Khori areas of Chakkar (192,000 tonnes bauxite, 345600 tonnes alumunous clay), (2) Saro-da-Bas-Malhad area of Sangarmarg (1,326,430 tonnes pisolitic/non-pisolitic bauxite, aluminous clay and kaolinite), (3) Panhasa area (total 2,432,000 tonnes) (4) Heimna-Gura area (219,980 tonnes) and (5) Karthal-Simnigali-Lodra, Jangalgali, Sukhwalgali, Chhaparbari, Kotla areas and Mohogala areas (1.33 million tonnes).

NON-METALLIC AND INDUSTRIAL MINERALS

Magnesite

Prominent deposit of magnesite is located on Chalk Hills as criss-cross veins traversing dunite / peridotite in Salem District, Tamil Nadu with estimated reserves of 44 million tonnes. High-grade magnesite reserve of 2.5 million tones occurs in Paintahl, near Katra while 45,330 tonnes of magnesite occur in Kyun tso-Shurok, Leh district. Several magnesite deposits have been reported from the Uttarakhand Himalaya, viz. 3.48 million tonnes magnesite reported from Agar – Girechhina deposit, Almora district with 38% MgO; 7.9 million tonnes from Dewaldhar deposit with 38% MgO; 6.7 million tonnes from Kanda – Masauli deposit with 39.67% to 44.50% MgO; 0.01 million tonnes from Areapani prospect; 43.45 million tonnes of grade-1 magnesite deposit and 3.14 million tonnes of grade-II magnesite from Pithoragarh district. A reserve of 9.2 million tonnes with MgO from 37% to 44% has also been reported from Bora – Agar, Pithoragarh district, UP. In Alaknanda valley, a possible reserve of 2.65 million tonnes with MgO between 38% to 41.61% from Dwing – Tapowan deposit; 6.45 million tonnes with MgO more than 43.5% from Gulabkoti- Pagnao- Mamolta- Molta deposit; 1.38 million tonnes with MgO from 38% to 43.5 % from Helang deposit; 1.54 million tonnes with MgO from 38% to 43.5% from Palla – Jhakhola – Kimana deposit; 1.31 million tonnes with MgO 42.348% to 45.96% from Mandra – Taraktal deposit and in Mandakini valley area 5.45 million tonnes with MgO 38% to 43.5 % from Ramini deposit have been reported.

Limestone

Extensive deposits of cement-grade limestone occur in the Himalayan states. Huge deposits of limestone of differenet industrially exploitable grades occur in Jammu and Kashmir. Extensive deposits of limestone occur in various parts of the State. Reserve in these districts are : Anantnag – 671 million tonnes, Baramulla – 180 million tonnes, Srinagar – 7.5 million tonnes, Ladakh – 0.53 million tonnes, Kathua – 45.45 million tonnes, Rajouri – 12.26 million tonnes (probable reserve), Poonch – 6.5 million tonnes and Udhampur – 3.03 million tonnes. Cement-grade limestone reserve of 117 million tonnes (CaO: 45.22 to 47.80% and MgO: 0.91%) occur in Jamkhal and Gangta Hill in Bilaspur district of Himachal Pradesh (H.P.). In Kangra district, H.P., 3 km north of Dharamshala, 17.6 million tones of cement-grade-limestone of CaO 42.52% and MgO 2.04% are reported. In Mandi district, 550 million tonnes reserve of cement-grade limestone with CaO 34.40 to 52% and MgO 0.2 to 9.1 % are reported. In Shimla district, H.P., tentative reserve of 1020 million tonnes is estimated in Drawal, Kariali, Jutog, Thench and Suma. Cement-garde limestone deposits of the order of 50.25 million tonnes are located in Ambala & Mahendergarh districts of Haryana. From Rihuita, Kolgadaiya, Sidhpur & Hanuman dhara blocks, Banda district, U.P., limestone reserves to the tune of 66 million tonnes are reported. From Barkot – Nutiya, Lambidhar- Hathipawn and Song valley deposits, Dehradun, limestone reserves of 38.2 million tonnes, 7 million tonnes and 146.4 million tonnes respectively have been estimated. From Deoban- Bazmara area, Chakrata tehsil, Uttarakhand, a probable reserve of 478.43 million tonnes with 45% to 46% CaO has been estimated. In Deoban sector, Durari Dhar deposit has 80 million tonnes with CaO ranging from 51.38 % to 53.34%, Kanasar deposit 62.5 million tonnes with CaO from 47.08% to 53.05%, Deoban deposit 125 million tonnes with CaO from 45.91% to 51.22%, Aun chak deposit 98.43 million tonnes with CaO from 49.33% to 53.1% and Osmar deposit 18 million tonnes with CaO 52.53%. In Bazmara sector, Bazmara deposit has 50 million tonnes limestone with CaO from 50.56% to 53.17%, Bazmara Lani deposit has 25 million tonnes with CaO from 52.27%to 53.04 %. In Pithoragarh district, Dharchula deposit has cement-grade limestone of 6.591 million tonnes with CaO from 40.97% to 49.75%, Gangolihat deposit 91.89 million tonnes with CaO from 46.80% and 46.40%, Rorgaon deposit 7.8 million tonnes with CaO from 39.38% to 51.43%. In Nainital district, Betalghat – Jaurasi deposit has a reserve of 10 million tonnes with 44% CaO. A large deposit of limestone has been reported near Nagni in Tehri Garhwal district and 3.6 million tonnes cement-grade limestone around Garur chatti area, Pauri Garhwal district. A reserve of 161.22 million tonnes with 60 million tonnes of

cement-grade and 30 million tonnes of blast furnace-grade limestone has been reported from Kajrahat limestone belt; 48.90 million tonnes with CaO from 38.1% to 48.3% from Gurmah – Patwadh block, Rohtas limestone belt; 49.60 million tonnes with CaO from 42% to 45% from Kanach block, Rohtas limestone belt; 26 million tonnes with CaO from 42.23% from Susnai Mahona block and 70.90 million tonnes with CaO from 43% to 44% from Chandi – Basuhari block, Sonbhadra district, U.P.

Limestone deposits in Bihar and Jharknand are mainly associated with two different groups of rocks, viz., Vindhyan rocks in Rohtas and Palamau districts, and Chhotanagpur Gneissic Complex in Hazaribagh, Ranchi, Munger and Palamau districts. Besides, some fine-grained, non-crystalline limestone is also found within the rocks of Kolhan Group in Singhbhum district. The total recoverable resource of limestones of all categories and all grades has been estimated to be 1450.84 million tonnes in the whole of Bihar & Jharkhand.

Substantial limestone deposits occur in Tamil Nadu both as crystalline and non-crystalline (amorphous) varieties besides corals. The bulk of limestone deposits are mainly distributed in parts of Salem, Tiruchirapalli, Karur, Madurai, Virudhunagar, Ramanathapuram, Nagapattinam, Tirunelveli, Tuticorin and Coimbatore districts. The total reserves of crystalline limestone amount to 200 million tonnes of 'Proved' category and about 25-30 million tonnes of 'Inferred' category. Non-crystalline limestones are located in parts of Tiruchirapalli, Tirunelveli and Tuticorin districts with reseve base of about 670 million tonnes of both 'proved' and 'inferred' categories. Coral limestone is found in a series of islands in Gulf of Mannar, Palk Bay and Rameswaram.

Apatite and Rock Phosphate/Phosphatic nodules:

Apatite is found in East and West Singhbhum districts (Jharkhand) as veins emplaced in the Singhbhum Shear Zone and also as a constituent associated mineral in mica pegmatites of Bihar Mica Belt, in parts of Gaya, Hazaribagh and Munger districts. In Singhbhum district, apatite occurs in a 60-km-long belt in the eastern part of shear zone, between Ichagarh (22º45':85º42') and Khejurdari (22º41' : 85º34'). A total possible reserve of 178 million tonnes (Mt) apatite of all grades in the whole of Singhbhum Shear Zone has been estimated by IBM (1998). In Pathargora, a reserve of 0.45 mt of apatite with 15% P_2O_5 was estimated in 1989 by IBM. However, later work in (1992) Pathargora has indicated a possible reserve of 3.73 Mt of apatite with average grade of 11.89% P_2O_5 at 4.0% P_2O_5 cut-off. Recoverable probable reserve of apatite in Jharkhand has been estimated as 7.27 Mt.

Small crystals of apatite have been noted in hybrid rocks (syenite-pyroxenite) in the Hogenekal area, Dharmapuri district, Tamil Nadu. In the carbonatite near Sevattur, Vellore district, apatite crystals are disseminated and a reserve of 190,000 tonnes of apatite has been estimated with P_2O_5 content of 27.48 per cent.

Phosphatic nodules occur in association with gypseous clay and shale of Karai Formation of Uttattur Group of Cretaceous age, along a belt extending from Neykulam to Siruganpur covering an area of 27.5 km in Tiruchirapalli district, Tamil Nadu. A total probable reserve of 127,000 tonnes of these nodules upto a depth of 15.24 m was estimated. The P_2O_5 content of the nodules varies from 21.14 to 26.50%. Upto 1960, about 100 to 150 tonnes of nodules were produced annually, but no production is reported at present.

Asbestos

Asbestos occurrences in Jharkhand are almost entirely confined to the East and West Singhbhum districts and are associated with Precambrian basic and ultrabasic rocks, especially where the latter have been serpentinised. Although both crysotile and amphibole varieties are found, the majority of the occurrences are mainly of amphibole variety. Tremolite type being the most common crysotile variety occurs at Roro (22º39'30":85º30'30"), Nurda (22º20':85º44'), Kalimati (22º16'00":85º35'30"), Bichaburu (27º17'30":85º48'00") and Manpur (22º36':86º16'). A total reserve of all categories of asbestos in whole of Jharkhand has been estimated to be of the order of 0.155 Mt.

Amphibole asbestos has been noted near Bargur and Muddampalayam in Coimbatore district, 13km south of Namakkal and Allanganathan in Namakkal district and at Kargudi in Karur district of Tamil Nadu. Asbestos occurs at Goreghat (Balaghat District), Badagaon and Khemra (Betul district), Dhantalab (Dewas district), Abdia (Hoshangabad district) and in minor quantity in Mandsaur, Narshingpur, Schore Sconi and Sidhi district of Madhya Pradesh. Minor occurrences of asbestos have been reported near Kolgaon in Sindhudurg district; near Tumkhera khurd in Bhandara district, near Wenganur and Kandodi in Gadhchiroli district of Maharashtra.

Borax

The net reserves of crude borax in Puga valley have been estimated at 5,423 tonnes. Other occurrences of borax have been noted at Chumathang, Chusul, Yang and Mahe areas of Leh district.

Stibnite

Stibnite reserve of the order of 10,582 tonnes (1.65% Sb) occurs at Bara Shingri in Lahaul & Spiti districts of Himachal Pradesh.

COAL, LIGNITE, OIL and GAS (FOSSIL FUEL)

Jharkhand, the leading State in the Indian subcontinent in respect of its solid fossil fuel content, exhibits classical development of the Permian **coal** measures. Out of different Gondwana basins of Peninsular India, the newly defined Jharkhand State carried out of erstwhile Bihar occupy the most important Damodar-Koel valley basin belt along with a subsidiary basin chain to the north of it and the Rajmahal group of basins (a part of Rajmahal-Purnea master basin). The coalfields like Raniganj (western part, to the west of Barakar river and a small area in trans-Ajay part), Jharia, Bokaro, Ramgarh, Karanpura, Auranga and Hutar from east to west are included in E-W-trending Damodar-Koel valley basin belt. Coal resources of Bihar is 160 million tonnes and that of Jharkhand is 74313.64 million tonnes as on 01.01.2007.

Raniganj coalfield of West Bengal holds the laurel of being the earliest known coalfield of the country. During the last 10-12 years, the Birbhum coalfield has been discovered. Besides these two large coalfields, there are a few minor coalfields and/or outliers of coal-bearing rocks, like Darjeeling, Barjora, Hetampur and Tangsuli in West Bengal. Till date, Raniganj coalfield is the only coal-producing area of the State. The total coal resource of West Bengal is estimated at 28334.84 million tonnes.

Important coalfields of central region include coalfields of Mahanadi basin, Satpura-Son basin, and Wardha valley basin. The coal is generally non-coking and high in moisture. The important coal fields are 1) Wardha Valley Coalfield (Chandrapur District) and Kamthi-Saoner Coalfield (Nagpur District) of Maharashtra State; 2) Korba Coalfield, Hasdo-Arand Coalfield, Sendurgarh Coalfield (Bilaspur and Korba districts), Mand-Raigarh Coalfields (Raigarh-Jashpur districts), Sohagpur Coalfield, Chirimiri Coalfield, Jhilmili Coalfield, Sonhat Coalfield (Koriya district) and Bisrampur Coalfields, Lakhanpur Coalfields and Tatapani Coalfields (Surguja district) in Chhattisgarh State; 3) Pench-Kanhan-Tawa Coalfields in Betul-Chhindwara and Hoshangabad districts, Mohpani Coalfield, Johilla Coalfield, Umaria and Korar Coalfields of Narsinghpur district, Singrauli Coalfield of Sidhi district in the State of M.P. Semi-anthracitic coal deposits are located in various parts of Udhampur and Rajouri districts of Jammu region. Estimated reserve are: at Jangalgali (4.7 million tonnes), Chinkah (3.9 million tonnes), Metka (2.25 million tonnes) and Jigni-Kura (0.18 million tonnes). A few deposits of lignite of the order of 7.26 million tonnes are reported in Nichahom and Chowkibal, Baramulla district.

Recently, Geological Survey of India carried out an exercise for prognostication of possible gas-in-places (**Coal Bed Methane**) reserves in selected areas of a few coalfields containing high rank coal under cover of younger sediments. An attempt was made to make the estimate more realistic by reconciling empirical calculations of methane content with actual gas emission, gas desorption data, published or otherwise, wherever available. Thus prognosticated gas-in-place reserves of 281 billion cubic metre (BCM) (at equilibrated pressure under saturated reservoir condition) were derived from prospective areas of Bihar and Jharkhand coalfields.

The lignite belt in the Cauvery Basin of Tamil Nadu, about 130km long and 5 to 15km wide, extends from Bahur in the north, through Neyveli, Srimushnam, Jayamkondacholapuram and up to Mannargudi in the south, falling in parts of the Union Territory of Puducherry and Cuddalore, Perambalur, Nagapattinam and Thanjavur districts of Tamil Nadu. The lignite occurs as a sub-crop at depth ranging from 50 m to 500 m below ground level. Down-dip extension of this lignite zone is reported from ONGC boreholes from 500m to 1800m depth in Tiruvarur, Kamalapuram, Kovilkalappal and Mayiladurai. Lignite zone is 1 to 25m thick with an average of 12 m, north of Kollidam river whereas, 1 to 90m thick (cumulative thickness) in the Mannargudi area, south of Kollidam river. The estimated reserve of lignite is about 6,500 million tonnes and 18,000 million tonnes in the area north and south of Kollidam river, respectively. It is being mined by Neyveli Lignite Corporation Limited and the mined lignite is utilised in thermal plants I&II, which has 600 and 1470MW generation capacity respectively.

Rajasthan has good deposits of lignite in Bikaner, Nagaur and Barmer districts. Substantial deposits of lignite occur in the Tertiary formations of Middle Eocene

area in the Barmer – Jaisalmer, Palana and Nagaur basins of Barmer/Jaisalmer, Bikaner – Nagaur districts. Exploration of these deposits are being carried out by GSI, NLC, MECL & DMG Rajasthan. Major occurrences of lignite in Gujarat are in the Panandro lignite field and adjoining areas of Kacchh district and in the Bhuri – Rajpandi area of Bharuch district. The lignite occurs within Tertiary formations of Eocene age. Exploratory work by ONGC indicated possible occurrences of lignite at 800m – 1400m depth level in the Kalol basin. Sizeable deposits of lignite are reported from Hundwara tehsil of Baramulla districts. GSI has proved 4.5 million tonnes of lignite reserves upto a depth of 36.5 m in Nichahom and Chowkibal areas of J & K.

Significant prospects of oil and natural gas have been identified over an area of about 40,000 km^2 on-shore and off-shore in the Krishna-Godavari basins in parts of East and West Godavari and Krishna districts.

GRAPHITE

Graphite occurrences are reported from Sindhudurg, Bhandara and Gadchiroli districts of Maharashtra. In the Bastar district of Chhattisgarh state, graphite occurs associated with quartzite and diopside gneiss on the west bank of Sabari river. Specks of graphite are reported from Palachelama and Bote Tongu and as lenses in association with quartzites and schists at Kennapara, Manikpur, Kobi and Tolkipara areas of Surguja district. Flaky graphite has been noted near Borakonde and Kamaram in Bastar district, Kartpadar and Limpara in Raipur district of Chhattisgarh State. Graphite occurrence is located in Puvandhi in Sivaganga district, Kurinjankulam in Tirunelveli district, Palakottai Hill and near Pudupalaiyam in Vellore district and Tirumangalam, Ponnamangalam in Madurai district of Tamil Nadu. Reserves are estimated at over 0.6 million tonnes of graphite concentrate in Tamil Nadu. In the State of Madhya Pradesh, graphite is found associated with graphite schist and phyllite at Tikari, Maramjhiri, Chiklar, Gauthana, Bhopali, Junawani and Golighat areas in Betul district, in the graphite schist from Jobat, Tampura, Jowari Moti and Kalapan areas of Jhabua district and in carbonaceous shale of Morar Formation near Chalgaon and Chattgurhi near Behat of Gwalior district.Graphite also occurs in Doda and Baramula districts (probable reserve of 16 million tonnes) of J & K. Graphite is reported from Almora and Pauri Garhwal districts in Uttarakhand Himalaya and Hamirpur district in Uttar Pradesh. From Kalimati and Sirar areas of Almora district, a possible reserve of 10.7 million tonnes of graphite has been estimated upto a depth 3 m.

Ilmenite, Rutile, Monazite and Garnet sands

Tamil Nadu has major heavy mineral deposit (ilmenite, rutile, monazite and garnet sands) associated with the beach sands spread along its vast coastal tracts; major concentration of these heavy minerals occur along east coast between Kolachal and Kanyakumari in Kanyakumari district with reserves of 45,75,605 tonnes, as reported by Atomic Minerals Division (AMD). Apart from these, 93,60,093 tonnes of heavy mineral deposit have been estimated between Periaswamipuram and Vembar Naripaiyur in Ramanathapuram district of Tamil Nadu. In the Union Territory of Puducherry, ilmenite and garnet sands occur along the coast of Karaikal with reserves of 17,26,862 tonnes (Source : AMD).

The heavy mineral deposits of Kerala are mostly dominated by ilmenite and monazite confined to sandy beaches of coastal stretches of Varkala and Chavara in Kollam district. The Chavara heavy mineral deposit extends in the north to sandy beach west of Nirkunnam to south of Trikkunnapuzha in Alappuzha district. These deposits are being worked by the Kerala Minerals and Metals Ltd. and Indian Rare Earths Ltd. In Malappuram district, the coastal tract between south of Ponnani to Balangod is endowed with 9,15,000 tonnes of ilmenite, 1,80,000 tonnes of magnetite, 2,30,000 tonnes of garnet and 4,000 tonnes of zircon. The deposit of ilmenite and monazite in beach sands of Thiruvananthapuram district are found in Vizhinjam, Kovalam and near Veli and Varkala. The AMD has estimated a reserve of 3.33 million tonnes of heavies from these areas out of which ilmenite constitutes a reserve of 2 million tonnes. Apart from these, GSI has proved the probable resources of ilmenite-0.9 million tonnes, rutile- .07 million tonnes, zircon-0.06 million tonnes and sillimanite-0.3 million tonnes in the inner shelf areas of Kollam-Varkala sector.

Gypsum

Rajasthan accounts for about 90% of total production of gypsum in the country, and it is located mainly in Bikaner district (Jamsar, Dhirera, Kaoni, Bharru, Lunkaransar areas), Nagaur district (Bhadwasi, Dhakoria areas), Barmer (Utarlai, Kavas, Thob, Chittar ka Par areas), Jaisalmer (Sri Mohangarh, Hamirwali Wadi, Lakha, Nachna, Bhaddara, Phalsund, Satta Sunde and Nokh areas), Sri Ganganagar district (Siramsar, Mahala, Pallu, Borasar

Malkisar, Karnisar, Raghunathpura, Suratgarh, Desli, Hanumangarh areas), and Churu district (Bhallan, Deogarh, Shethon areas) of Rajasthan. Large gypsum deposits of the order of 100 million tonnes occur between Liwa Thach and Kapus in Kinnaur district of Himachal Pradesh. Gypsum deposits are located in Uri, Baramulla district (63.83 million tonnes), and Ramban-Batote–Assar belt (41 million tonnes) of J & K. Gypsum reserves of 15.60 million tonnes are reported from Perambalur in Perambalur district and Lalgudi Taluk in Tiruchirapalli district, Tamil Nadu. Gypsum occurs as lump in Ambala district, Haryana. Gypsum deposits are known from Dehradun, Nainital, Pauri Garhwal and Tehri Garhwal districts of Uttarakhand as well as Hamirpur and Jhansi districts of Uttar Pradesh. Gypsum reserve from Manjhara area (13,209 tonnes), Dehradun district, upto a depth of 15 m, Kharari chatti area (1.585 lakhs tonnes), Pauri Garwhal district, Uttarakhand, Garur chatti area (1.066 lakhs tonnes), Tehri Garhwal district, Uttarakhad, Gugthani (5,080 tonnes), Mahipur (2,032 tonnes) and from Rangargaon (30,481 tonnes) have been estimated.

Apatite

The important apatite occurrences are located in Beldih and Mednitanr in the western part and Chirugora, Purtaha Kutni and Dandodih-Gamardih in the western part of West Bengal. At Beldih reserve of 4.56 million tonnes of ore containing an average grade of 13.17% P_2O_5 has been estimated up to a depth of 150 m which includes high-grade reserve of 1.56 million tonnes of ore with an average grade of 21.62% P_2O_5. The apatite ore contains high Nb-content which may be recovered as by-product. The lensoid apatite zone has been delineated over a strike length of 350 m in Mednitanr. Apatite-quartz rock occurs on surface only as float ore boulders. A probable reserve of 0.19 million tonnes of ore with an average grade of 7.00% P_2O_5 has been estimated for a vertical depth of 50 m. At Chirugora, a reserve of 1,862 million tonnes of ore with an average grade of 10.58% P_2O_5 has been estimated up to a vertical depth of 50 m and in the eastern sector 0.521 million tonnes of ore with an average 7.33% P_2O_5 has been estimated up to a vertical depth of 100 m. At Purtaha, a probable reserve of 0.74 million tonnes of ore with an average grade of 7.26% P_2O_5 has been estimated up to a vertical depth of 50 m. This reserve also contains 0.25 million tones of ore with an average grade of 10.39% P_2O_5. In Kutni, a total of 4.26 million tonnes of ore with an average of 8.87% P_2O_5 have been estimated up to a vertical depth of 100 m. In Dandodih-Gamardih, a total of 4.48 million tonnes of ore with an average grade of 8.04% P_2O_5 have been estimated up to a vertical depth of 50 m. The reserve also includes 1.29 million tonnes of ore with 12.22% P_2O_5 and 0.11 million tonnes with 25.04% P_2O_5. Along the North Purulia Shear Zone, apatite-magnetite-quartz rock is reported to occur at Pankridih in the northern part of Purulia district. The apatite mineralisation appears to extend over a strike length of around 300 m.

Precious and Semi-precious Stones

A number of occurrences of precious and semiprecious stones are known from gemstone belt in the Eastern Ghats, distributed in East Godavari, Visakhapatnam and Vizianagaram districts.

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Location Index

Location	Latitude	Longitude
Ada konda		
Adhaura	24˚41' 15"	83˚37'
Ahobilam	15˚08'	78˚40'30"; 57 I/12
Ajjanahalli	13˚45'30"	76˚44'00"
Aladahalli	13˚08' :	76˚21' ; 57C/8
Amatfari	22˚12'	83˚38'
Amjhore	24˚35'-24˚45'	83˚50'-84˚00'
Ammapettsi		
Amtipani area	23˚20' to 23˚23'	84˚16' to84˚19'
Andar	25˚42'	78˚06'
Andipatti	09˚56'	77˚38'
Anesidri	13˚37'	76˚46'
Angor Village	24˚44'	79˚25'
Antri	26˚03'	78˚15'
Anumapple	14˚59'40"	77˚30'55"
Arumanullur	8˚19'15"	77˚24'35"; 57 H/7
Askot	29˚46'	30˚20'
Attikatti	15˚16'15"	75˚39'15"
Avulathinapalle	17˚34'00"	82˚05'
Badia	22˚29'	86˚28'
Baghmari	24˚47'	86˚45'
Baharagora	22˚16'15"	86˚43'00"
Bahera-Baheria	24˚20'-24˚31'	81˚52'-81˚ 56' ; 63H/15)
Bahradih	20˚12'30"	82˚12' 00"; 64 L/4.
Bandalamothn	16˚13' 30"	79˚34'45"- 56p/12)
Banganapalle-Neruducherla	15˚12'-15˚ 20'	77˚50'- 78˚15'; 57 I/2 & E/16
Baraganda	24˚04'	86˚04'
Bargur	11˚49'	77˚33'

Location	Latitude	Longitude
Bariarpur	24˚ 51'	80˚ 06'
Basavapuram	15˚24'	78˚43'
Basuvapuram	15˚24'	78˚38'
Bayanbil	22˚44'	
Belagumba	13˚14'	76˚18'
Bellara	13˚37'	76˚40'30"
Bhageh	26˚31'	78˚26'
Bhagro-Bajra-Jhibra	24˚48'45" to 24˚49'55"	86˚ 32'45" to 86˚77' 5"
Bhairukhi	24˚36'00"	86˚36'15"
Bhaunra Pahar	22˚14'	80˚48'
Bhawratekra	21˚57' 40"	8˚21'-78˚22'30"; 55K/5
Bhejripadar, Bastar Dist.	19˚03'	81˚50' (65 E/16)
Bhotang	27˚10'30"	88˚32'00"
Bhukia	23˚20'	22˚35'
	74˚00' (46I)	76˚55' (55B)
Bhula	23˚37'	80˚20'
Bhusi-Bhandaria-Duarsar	24˚50'20" to 24˚51'40"	86˚35'45" to 86˚39'45"
Bichaburu	27˚17'30"	85˚48'00"
Biharpur	24˚ 57'	80˚ 31'
Bisanattam	12˚50' 30"	78˚15' 00"
Boarder		
Bodafahadi	22˚03'	80˚53'-64B/15
Chalk Hills area	11˚43'	78˚10' (58I/12)
Champion Reef	12˚55'	78˚15' (57L)
Chandidongri	21˚05'	80˚38'
Chelima	15˚30'	78˚ 40' (57 I/11)
Cherambadi	11˚30'	76˚15' (58A)
Chichola	21˚04'	80˚40'

Location	Latitude	Longitude
Chigicherla	14˚31'	77˚41' (57 F/10)
Chikkanahalli	14˚26'	76˚22'
Chingargunta		
Chintalampalle Village	15˚02'00"	77˚28'00"
Chityale Lead	15˚28'	77˚47'
Chormaria	20˚ 18'	83˚17'
Dadkidih	22˚44'	86˚10'
Delwara	22˚45	85˚06
Devala	11˚25'	76˚20'; 58A
Dhani Basri		
Dharmapuri	12˚02'	78˚29'
Dhobani Mines area	22˚31'	86˚ 27'
Dhorli	21˚52'	80˚46'; 64C/13
Dhukonda	16˚13'30"	79˚43'30"; 56P/12
Dibbsanipalle	15˚02'00"	77˚28' 00"
Dikchu	27˚23 '	88˚35'
Dongraha	24˚51'	80˚ 06'
Dubarfeth	19˚40'	79˚30'; 56M/10
Dugacha		
Dugapal , Bastar Dist	19˚00'	81˚50' ((65E/16)
Elavadai		
G.R.Halli	14˚16'	76˚25'
Gadag	15˚25'	16˚00'
	75˚35'; 48M	76˚50'; 56G
Gajjalakonda	15˚45'	79˚24'
Gani	15˚40'70"	78˚19' 57" (57 I/6)
Ganja- Shahpur	24˚45'	80˚30'; 63 D/5
Garadih	22˚43'	86˚14'

Location	Latitude	Longitude
Garimanipeta, Nellore Dist.	14˚59'30"	79˚33'10"; 57 N/9
Gidori and	21˚52'	84˚43'; 64C/9
Gijora	26˚04'	78˚28'
Golapalle	14˚45'00"	78˚54'00"; 57 J/13
Harur-Uttangarai, Dharmapuri dist.	12˚40'	12˚00'
	12˚00'	77˚05'; 57H
	78˚25'; 57L	78˚25'; 57L
Hatupur	24˚ 48'	80˚ 25'
Hinglaz Mata, Dungarpur dist. Rajasthan	22˚05'	72˚05'; 46B
Hinota	24˚ 40'	80˚ 01'
Hirabuddni, Karnataka	16˚12'	76˚49'15"
Hitku	22˚42'	86˚15'
Hondlli	18˚40'	77˚10'; 56F
Hosur-Champion	12˚50'	12˚50'
	77˚50'; 57H	78˚00'; 57L
Hutti	16˚10'	76˚35'; 56D
Ichagarh	22˚45'	85˚34'
Idagondanahalli	12˚39'	76˚19'
Imalia	23˚36'	80˚16'
Ingaldhalu	14˚11'	76˚27'; 57 B/8
Itwa Village	24˚47'	30˚23'
Jagpura Bhukia, Banswara dist. Rajasthan	23˚50'	74˚20'; 46I
Jangra	20˚08'30"	82˚19'40"
Jonnagiri	15˚44'	77˚31' (56 E/11)
Josiar Alangulam	9˚53'	77˚58'; 58G/13
Kabuliyat katti		
Kadikengalbetta	13˚20'	76˚28'
Kaiga	14˚51'	74˚26'; 48 J/3

Location	Latitude	Longitude
Kalasapura	13˚17'	75˚56'; 48 O/15
Kalimati	22˚16'00"	85˚35'30"
Kallur	16˚08'30"	77˚12'25"
Kalyadi Copper deposit, Hassan dist.,	13˚14'	76˚09'; 57 C/4
Kanchugavi, Prakasam Dist.	16˚12'	79˚ 24'; 56 P/12
Kappil		
Karempudi	16˚23'30"	79˚40'40"; 56 P/11
Karredukuppa	14˚51' 30"	78˚49'30"; 57 J/13
Kennedulu	14˚07' 45"	76˚30' 00"
Keruadurgri	22˚44'	86˚11'
Kesarfur area Shahbad dist.	22˚04'	86˚42'
Khadandungriarea	22˚26'	86˚32'
Khajjidoni and north of Goddankera	16˚10' to 16˚11'	75˚31' to 75˚37'
Khapra	25˚10'	86˚28'
Khejurdari	22˚41'	85˚34'
Khetri		
Kitari-Marupur, Nagpur dist. Maharastra	20˚55'	20˚20'
	79˚45'	79˚45'
Kodomali	20˚11'10"	82˚14'08"
Koilkuntla	15˚13'	78˚19'
Kolar	12˚56'30"	78˚16'00"
Kolari village	20˚48'	79˚31'; 55 P/5
Kollegal area, Mysore dist.	12˚09'	76˚07'
Kommamarre and Gummankonda	15˚38'30"	78˚18'00"
Kottathara block, Attapadi valley, Palaghat dist. Kerala	11˚00'	76˚30'; 58A
Kotyagiri, Nilgiri dist. T. Nadu	11˚20'	76˚50'; 58A
Kudithinapalle		
Kunchiganahalu	14˚12'	76˚27'

Location	Latitude	Longitude
Kunderkocha, Dhanjori	22˚27'	86˚15'
Kusumbari	22˚04'	86˚42'
Ladakh	24˚25'	77˚45'; 52F
Ladera, Jaipur dist., Rajasthan.		
Lalitpur	24˚40'	78˚25'; 54L
Lattavaram	14˚55'	77˚17'; 57F/5
Lawa	23˚01'	86˚05'
Lokdega	22˚02'	83˚55'
Machanur, Raichur dist.	16˚15'50"	72˚42'
Madikeripura	14˚13'30"	76˚26'30"
Magyathhalli	13˚53'30"	75˚57'00"; 48 O/13
Maharajagadai	12˚35'	78˚15'; 57L
Mailaram Deposit	17˚43'	80˚38'
Mainpur, Paliakhand (Raigarh- Sundergarh, Chhattisgarh Orissa	20˚17'	81˚23'
Maira	26˚14'	86˚22'
Majhgawan, Panna dist.	24˚39'	80˚02'
Malanjkhand	22˚02'	80˚43'; 54B/12
Mallappakonda,	12˚46'	78˚14'
Mallapuram (Marakapur belt) Prakasam Dist.	15˚30'35"	79˚10'30"; 57 M/2
Mamandur defosit South Arcot dist.	12˚02'	79˚02'; 57 P/4
Manegaon	21˚58'	80˚48'; 64C/13
Mangalwar		
Manpur	22˚36'	86˚16'
Maruk	25˚11'	86˚28'
Masanikere	13˚51'	75˚59'
Maski.	18˚55'	15˚55'
	77˚00' (56F)	76˚35' (57A)

Location	Latitude	Longitude
Masturu	14˚28'	76˚26'
Midipenta	14˚09'	78˚19'
Mohuldih	22˚44'	86˚09'
Mosabani, Singhbhum (Jharkhand)	22˚30'	86˚30' (73J)
Mosaloni	22˚31'	86˚23'
Mothimakki	14˚45'	74˚34'; 48 J/9
Maysara	23˚03'	86˚00'
Mysore	12˚15'	76˚40' (57D)
Nagavand, Dharwar Dist.	14˚ 20'	75˚35'
Nanduf	22˚44'30"	86˚14'15"
Narwa Pahar	22˚42'	86˚16'
Nawalia	23˚39'	80˚28'
Nekkundi	12˚05'	12˚35'
	77˚55' (57H)	78˚35' (67L)
Nuggihalli	13˚01'	76˚28'
Nundydoorg		
Nurda	22˚20'	85˚44'
Pacherla	15˚23'	78˚42'; 57 I/11
Pahardia	22˚30'	85˚12'
Pandalur	11˚25'	76˚20' (58A)
Pandripani, Raigarh dist., Chhattisgarh.	23˚30'	83˚30'
Papayapalem area	16˚22'	79˚38'; 56 P/12
Parakot, Bastar Dist	19˚00'	81˚50'; 65E.
Parasia	24˚09'	85˚47'
Parewa Dongri	22˚02'35"	80˚45'30"; 64 B/15
Parsori	20˚50'	79˚33'; 55 P/9
Passabera	24˚04'	86˚03'
Pathargora	22˚32'	86˚27'

Location	Latitude	Longitude
Pathratola	22˚00'	80˚55'; 64C/13
Payalikhand	20˚10'10"	82˚21'00"; 64 L/8
Peddagavalakonda area	16˚16'30"	79˚39'30"; 56 P/11
Peshok and Pedong	27˚09'	88˚37'
Phaga	24˚46'	86˚56'
Pindwara- Watera Belt, Rajasthan	24˚45'	73˚00'; 45H
Pular	20˚51'	79˚ 30'; 55P/9
Ragaboyingudem	17˚31'	80˚22'
Rajdah	22˚41'	86˚17'
Ram Kheria,	24˚49'	80˚27'
Ram Mangli	20˚48'	79˚27'; 55 P/5
Ramachandra Pahar	22˚43'	86˚13'
Ramagiri	14˚18'	77˚33'
Ramanahalli	13˚23'	06˚20'
Ramasamudram	16˚01'	79˚24'
Ranganahallibetta	13˚03'	76˚26'40"
Roro	22˚39'30"	85˚30'30"
Sakri Village, Bargarh dist., Orissa.	21˚20'	21˚35'
	82˚00'; 64K	82˚10'; 64K
Salaiya	24˚40'	79˚45'
Sangte Mine		
Sarakal	17˚ 43'	80˚ 42'; 65 C/10
Sarangarh Sector, N-E of Chhattisgarh basin	21˚35'	83˚05'; 64O
Satyamangalam area, Periyar and Coimbatore dist.	11˚15' -11˚ 28'	76˚54' 77˚15'; 58A/15 & E/3
Sawanahalli	12˚08'	76˚48'; 57 D/16
Sleemnabad, Jabalpur, M.P	23˚35'	80˚15'; 64A;
Somayer Zulapalle	15˚35'	78˚11'
Sonadehi, Bastar dist.,Chhattisgarh.	22˚25'	2˚20'; 64J;

Location	Latitude	Longitude
Sonbhadra districts, U.P.	24˚40'	83˚00'; 63P)
Surda	22˚33'	86˚26'
Tagadar	13˚26'	76˚26'
Tamapahar-Rakha Mines-Roam Sideshwar sector	22˚36' to 22˚ 38' 50"	86˚21' 08" to 86˚24'
Tamajhuri area	22˚32'	86˚26'
Taregaon area	22˚03'	80˚51'; 56 B/16
Tavarekere	13˚51'30"	75˚57'30"
Thanewasna	19˚51'	79˚44'; 56 M/9
Thanian area	12˚25'-12˚40'	78˚57'- 79˚05'
Thutanbori	20˚51'	79˚ 35'; 55 P/9
Tinthini	16˚23'	76˚31'
Tokapal, Bastar Dist.	19˚01'	81˚53'; 65 E/16.
Tomka- Daitri.	27˚25'	90˚35'
Tummatapalle	14˚49'55"	77˚41'00"
Turamdih	22˚43'02"-22˚ 43'53"	86˚10' 47"- 86˚11'43"
Undutla- Tammarajupalle- Cementnagar	15˚30'-15˚25'	78˚10'-78˚15'
Uti	16˚16'30"	76˚47'00"
Varikunta area	15˚11'	78˚ 46'; 57 I/16
Veerappakonda	16˚12'	79˚42'; 56 P/12
Velampatti	12˚05'	78˚27'
Vellakhal	12˚40'	12˚10'
	78˚40' (57L)	78˚25' (57L)
Vemula	14˚22'	78˚14'
Venkatampalle	14˚ 56'	77˚21'; 57F/5
Venkatapalem	17˚16'	80˚13'
Venkatapura	15˚43'22"	75˚31'15"
Venkatapuram	14˚24'	78˚13'
Venkatapuram	17˚46'	0˚47'

Location	Latitude	Longitude
Veppanapalli, Kolar	12˚45'	78˚15'; 57L/2
Vettilaimalai	10˚27'	77˚ 41' (58F/11)
Villupuram, Salem dist., T.Nadu	11˚55'	79˚30' (58M)
Vummidivaram	16˚09'19"	79˚25'03"; 56P/8
Wairagarh, western part of Bastar Craton,	20˚25'	80˚05' (64D)
Maharashtra		
Wajrakarur- Kalyandurg (WKF)	14˚05'	15˚ 03'
Wandalli	16˚10'	15˚50'
	76˚40' (56D)	76˚20' (57A)
Yarahalli	14˚04'	76˚26'
Yelishirur	15˚16'30"	76˚36'00"
Yellambailu	17˚41'	80˚40'
Yerrakuppukonda	16˚12'	79˚42'
Yeshwantnagar	15˚32'30"	76˚30'00"
Zangamarajupalle	14˚46'	78˚53'; 73 J/13