

EXPLORATION & DEVELOPMENT



# Indian Minerals Yearbook 2015

(Part- I : General Reviews)

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**EXPLORATION & DEVELOPMENT**

(FINAL RELEASE)

**GOVERNMENT OF INDIA  
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## GOVERNMENT'S POLICY

The National Mineral Policy, 2008 for non-fuel and non-coal minerals, introduced by the Government in replacement of the National Mineral Policy 1993 lay enormous thrust on the various aspects of mineral industry, such as regulation of minerals, role of State in mineral development, survey and exploration, database of mineral resources and tenements, strategy of mineral development, etc. Among other things, strong emphasis is laid on the following:

- \* To exploit judiciously and utilise the country's mineral potentialities, systematic regional and detailed exploration will be carried out using state-of-the-art techniques in a time bound manner. Zero-waste mining will be the national goal and mining technology will be upgraded to ensure exploration and utilisation of entire run-of-the-mine.
- \* To make regulatory environment conducive to private investment, procedures for grant of mineral concessions, such as Reconnaissance Permits, Prospecting Licences and Mining Leases shall be transparent and seamless with security of tenure guaranteed. Prospecting and mining shall be recognised as independent activities with transferability of concessions playing a key role in mineral development.
- \* To attract large investments and high technology, a new concession, namely, a Large Area Prospecting Licence (LAPL) will be introduced. Duration of all concessions will be rationalised and areas of operations enlarged suitably, within each State.
- \* IBM will maintain a digitised database comprising a Resource Inventory and a Tenement Registry. The Tenement Registry will give information of leasehold and freehold areas in terms of greenfield, brownfield and relinquished areas, etc.

Data filing will be rigorously applied and concession holders will be monitored. Lock-in arrangement will be assured and the data will be released to prospectors after integration.

- \* Prospecting being a high-risk venture, access to risk funds from capital markets will be facilitated.

This policy initiative is expected to encourage greater involvement of private sector in survey and exploration of minerals.

The High-Level Committee constituted by the Government of India which brought out the National Mineral Policy, 2008 has recommended amendments to the MMDR Act, 1957 with the purpose of providing necessary initiatives to attract investment and participation of private and public sectors in areas of exploration and exploitation of minerals.

Subsequently, the Mines and Minerals (Development and Regulation) Amendment Act, 2015 has been notified on 27<sup>th</sup> March, 2015 to amend the MMDR Act, 1957. The Amendment removes discretion in the grant of mineral concessions. Henceforth, all mineral concessions will be granted by the respective State Governments only through auctions, which will bring greater transparency and remove discretion in allocation of mineral resources. There would be no renewal of any mineral concession. The tenure of mineral concessions has been increased to 50 years compared to earlier provisions of 30 years. Thereafter, all mining leases would be put up for auction. Establishment of District Mineral Foundation in any district affected by mining related operations and National Mineral Exploration Trust for the purpose of regional and detailed exploration has also been incorporated in the Act.

## ORGANISATIONS INVOLVED

GSI, AMDER, DGMs of various states, public sector companies like NMDC, MECL, MOIL, etc. continued their efforts in respect of surveying,

mapping and exploration of new deposits and re-assessment of old deposits/mines during 2014-15.

In oil sector, ONGC, OIL and a few joint venture and private companies were engaged in exploration of onshore and offshore areas.

## IBM

IBM, as a facilitator to the Mineral Industry, (a) provides technical consultancy services for conducting feasibility studies, environment impact assessments, environment management plans, etc; (b) carries out mining research project on need-based aspects of mining; (c) conducts mineral beneficiation studies, including mineralogical testing and chemical analysis and (d) prepares mineral maps.

During 2014-15, IBM prepared 100 multi-mineral leasehold maps with forest overlays on 1:50,000 scale in respect of Andhra Pradesh, Bihar and Kerala states. Forest overlays are prepared in collaboration with Forest Survey of India.

During 2014-15, IBM conducted 58 ore dressing investigations, chemical analysis in respect of 34,660 radicals, and 2,244 mineralogical studies.

Indian Bureau of Mines undertakes preparation of National Inventory of mineral resources on a quinquennial basis. Under this programme, implementation of UNFC system was adopted in 2002 replacing the earlier resource classification based on Indian system. Subsequently, NMI as on 1.4.2005 and 1.4.2010 were updated. An intermediate updation of the NMI of mineral resources in respect of 25 selected minerals as on 1.4.2013 has been completed in 2014-15. Presently, updation of NMI as on 1.4.2015 has been taken up.

## GSI

GSI pursued its systematic geological mapping in 2014-15 and had completed 5,450 sq km large-scale mapping, 73,543 sq km detailed mapping and 87,465.87 m drilling as against preceding year's achievement of 5,264 sq km large-scale mapping, 62,525 sq km detailed mapping and 68,037 m drilling. Out of the total mappable areas of 3.14580 million sq km of the country, 3,09935

million sq km has been covered so far by systematic mapping bringing the total coverage to 98.52%.

## Reserves Established

Resources augmented by GSI during 2014-15 are furnished below:

i) Total 155.34 million tonnes (Fe:50.40-62.11%) of iron ore resources in Sundargarh distt., Odisha and Kabirdham distt., Chhattisgarh.

ii) Total 21.023 million tonnes (Cu: 0.22-0.76%) of copper ore resources in Alwar, Banswara & Sikar districts, Rajasthan.

iii) Total 5.895 million tonnes (Au: 0.88g/t - 1.78 g/t) resources of gold ore in Tumkur distt., Karnataka and Banswara distt., Rajasthan.

iv) Total 635.30 million tonnes (K<sub>2</sub>O:4.8%) of glauconite (Potash) resources in Sonbhadra distt., Uttar Pradesh.

v) Total 250.773 million tonnes of limestone (CaO: 43-46%) in Guntur distt., Andhra Pradesh; West Siang distt., Arunachal Pradesh and Jaintia Hills distt., Meghalaya.

vi) Total 4.73 million tonnes of graphite (FC: 9-11.68%) in Betul distt., Madhya Pradesh and

vii) Total 24.2 million tonnes of andalusite resources in Sonbhadra distt., Uttar Pradesh.

## Survey

### Marine Survey

GSI continued its offshore geoscientific studies both in Exclusive Economic Zone (EEZ) and Territorial Waters (TW) along the East and West Coasts of India. Survey in the near-shore zones (0 m - 10 m isobaths) were carried out using hired small mechanical boats.

During 2014-15, a total of seventeen cruises were undertaken using three vessels.

The following marine geoscientific surveys were carried out during 2014-15 Field Season:

### R.V. Samudra Ratnakar

SR-001A (SR): Study of tectonic setup of northern Andaman Sea by systematic multichannel 2 D seismic survey.

SR-003 A: Multichannel bathymetric survey on the eastern extension of Sewell Rise and southern extension of West Andaman Fault- Part II.

SR-004 : Sea bed mapping, morphometry, sediment composition and sediment transport in the continental slope, off Cochin, Kerala.

SR-005: Multibeam bathymetric survey and exploration for Mn micronodules in EEZ of India and beyond, West of Lakshadweep Islands.

SR-006: Geological and geophysical investigations in Cauvery - Mannar offshore basin and Krishna - Godavari offshore basin, eastern, continental margin of India for the gas hydrate study.

SR-007: Morphotectonic and sediment characteristic studies of Laxmi Ridge.

SR-008: Preliminary assessment of lime mud in the continental margin off Gujarat.

#### **RV Samudra Kaustubh**

ST-237 : Mapping of seabed in the Territorial waters north off Rameswaram, Tamil Nadu coast.

ST-238 : Placer mineral resource evaluation in the Territorial waters of Santapalle, North of Bhimunipatnam, Andhra Pradesh.

ST-239 : Systematic magnetic survey within Territorial waters in the shelf area off Gopalpur, Odisha.

ST-240 : Seabed survey of continental shelf region, off Odisha and West Bengal coasts with an emphasis on deep core sediment and faunal study to distinguish the sea level fluctuation.

ST-241 : Placer mineral resource evaluation in the Territorial waters off Rushikulya river mouth, Odisha.

ST-242 : Parametric (Magnetic and Seismic) survey within Territorial waters off Vainateyam, Godavari river and Vasisitha Godavari river mouths, Andhra Pradesh coast.

#### **RV Samudra Shaudhikama**

SD-255 : Evaluation of sand resources beyond Territorial waters off Kodungallur, Kerala.

SD-256: Delineation of buried palaeochannels and sand bodies, off Hangarkatta, Karnataka coast.

SD-257: Mapping of seabed off Okha, Gujarat.

SD- 261 : Evaluation of heavy mineral sands off Muttamura, Tamil Nadu.

#### **Airborne Survey**

GSI pursued airborne geophysical survey for generating database by employing magnetic and gamma ray spectrometric techniques. The survey was followed by data processing, preparation of aerogeophysical maps and interpretations that help in ground evaluation and add information to geological maps and would aid prospecting and exploration for minerals. The data from the aerial surveys thus form an important backup for refining the geological understanding of an area, with focus on identification of favourable locales of mineralisation, crustal structure, etc.

During 2014-15, Airborne Survey System (TOASS) and Heliborne Geophysical Survey System (HGSS) could not be taken up owing to a number of technical and related issues. However, processing of multisensor heliborne geophysical data acquired while conducting test flights over the Aladahalli are taken up for ascertaining the response of the HGSS.

Since the acquisition and induction of TOASS, a total of 495,062 line km, over an area of 294,045 sq km, was covered by multi-sensor survey involving magnetic, spectrometric, radiometric and electromagnetic methods till the field season 2010-12 in the following areas: Mamandur (Tamil Nadu), Aladahalli, Gadag, Wajrakarur-Vedavathi basin (Karnataka and Andhra Pradesh), Agartala-Silchar (for ONGC in Tripura and Assam), Ratnagiri (Maharashtra), Siliguri-Guwahati (for ONGC in West Bengal and Assam), Tosham-Singhana (Haryana and Rajasthan), Sukinda-Baripada (Odisha), Bundi-Bharatpur (Rajasthan), Agucha-Malpura-Chaksu (Rajasthan), Moradabad -Bareilly (for OIL in Uttar Pradesh), Gorakhpur-Muzaffarpur (for OIL in Uttar Pradesh and Bihar), Satyamangalam (Tamil Nadu), Hindoli (Rajasthan), Bhilwara (Rajasthan), Gangapur-Nasirabad (Rajasthan), Chhattisgarh basin (Chhattisgarh and Odisha), Betul-Chhindwara (Madhya Pradesh), Narayanpet-Raichur (Andhra Pradesh and Karnataka), Hungund-Mudhol (Karnataka), Lalitpur (Uttar Pradesh), Mahoba-Panna (Uttar Pradesh and Madhya Pradesh), Nalgonda-Mahbubnagar (Andhra Pradesh), Bangalore-Penukonda

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(Karnataka and Andhra Pradesh), Mulbagal-Tambalpalle (Karnataka and Andhra Pradesh), Nagpur-Wardha valley area (Maharashtra), Baihar-Katru area (Madhya Pradesh and Chhattisgarh), Kanker area (Chhattisgarh), Mauranipur-Sarila area (Madhya Pradesh and Uttar Pradesh), Hosadurg-Vengurla area over Western offshore and Chandrapur-Brahmapuri (Maharashtra).

Ground evaluation of aerogeophysical data is carried out with the help of aerial photos and imageries, mostly by detailed mapping, sampling, pitting and trenching, and wherever necessary, by drilling.

### MECL

The highlights of exploration carried out by MECL during 2014-15 are given below:

- i) The company has registered 4,09,536 m of drilling for various minerals, out of which 3,42,468 m was through departmental resources and 67,068 m from outsourcing..
- ii) A total of 1,92,882 m of borehole geophysical logging was carried out.
- iii) A total of 215 sq km of detailed geological mapping was carried out for different minerals in various parts of the country.
- iv) In laboratories, a total of 60,011 samples were analysed and 2,66,306 radicals were determined along with petrological and ore microscopic studies of 605 samples.
- v) A total of 22 detailed geological reports for mineral exploration, geophysical survey, environmental & remote sensing studies were submitted which culminated in 4,105.45 million tonnes of reserves/resources.
- vi) A total of 4,105 million tonnes of mineral resources were established. Mineral-wise details of resource estimated by MECL during 2014-15 are:
  - Coal - A total of 3,547 million tonnes of coal resources were established in Mand-Raigarh Coalfield, Chhattisgarh; Godavari Valley Coalfield, Telangana and Singrauli Coalfield, Madhya Pradesh.
  - Lignite - 392 million tonnes of lignite resources were established in Tamil Nadu.

- Limestone - 42 million tonnes of cement grade limestone resources were established in Nimi-Pyakatsu block, Nagaland.

- Copper - 11 million tonnes of copper ore resources were established at Chandmari intervening block, Khetri Copper Belt, Jhunjhunu, Rajasthan.

- Lead - Zinc - 0.530 million tonnes of lead - zinc resources established in Gurla South block, Bhilwara, Rajasthan.

- Gold - 2.65 million tonnes of gold ore resources established at Parasi East Block, Ranchi, Jharkhand and Phardia Gold Prospect, Raigarh, Chhattisgarh.

- Iron Ore - 110 million tonnes of iron ore resources established at Sandur Schist Belt, Ballari distt., Karnataka.

### MINERAL-WISE EXPLORATION ACTIVITIES PETROLEUM AND NATURAL GAS

The Government of India has formulated a New Exploration Licencing Policy (NELP) to accelerate and expand exploration of oil and gas in the country. A total of 254 blocks have been awarded so far in IX rounds of NELP. The pace of exploration for oil and gas has increased after introduction of NELP regime. The awarded 254 blocks are located in onland (111), offshore shallow water (62) and deep water (81) areas. As a result of exploratory activities, several unexplored and poorly explored areas in particular offshore and deep water areas have been appraised through geophysical surveys and exploratory drilling.

### ONGC

Business Development and Joint Ventures Group of ONGC (BD & JV), in line with the ONGC's pursuit for Business Growth Plans have initiated several measures for achieving enhanced value chain integration in hydrocarbon business in the field of Petrochemicals, Power & Fertilizer.

ONGC continued its operations for exploration of oil and gas. Out of 26 identified sedimentary basins in onshore and offshore areas of the country, exploration was continued in Cambay Basin, Gujarat; Jaisalmer in Rajasthan; Upper Assam, Tripura, Mizoram in Assam-Arakan; Himalayan foothills, Himachal Pradesh; Vindhyan/Gondwana (Madhya Pradesh); Krishna-Godavari (Andhra Pradesh); Cauvery (Tamil Nadu); West

Bengal and in East Coast and West Coast offshore areas.

During 2014-15, ONGC has deployed a total of 105 rigs with 786 thousand m drilling in 371 wells. Out of which, 69 rigs with 532 thousand m drilling in 276 wells and 36 rigs with 253 thousand m drilling in 95 wells were in onshore and in offshore areas, respectively.

During 2014-15, ONGC reported 22 new hydrocarbons discoveries, namely, Tukbai-3A, (TK-3A) in AAFB-Cachar; Rupal-2, Vadatal-10(VDAH), Vadatal-11&Gandhar-699 in Cambay; Thirunagari/Thirunagari-1 & Madanam/Madanam-6 in Cauvery(On); South Pasarlupudi-1 in KG(On); YS-9-1(Shift), GS-29-10(AJ), G-1-NE-1 & G-1-NE-2 in KG(SW); GD-11/GD-11-1 in KG(DW); GKS092NAA-1 & GKS091NDA-1 in Kutch offshore; C-1-7, C-1-8 & WO-5/WO-5-11 in Mumbai offshore; Rudrasagar/Rudrasagar-184, Khoraghat-35 & Khoraghat-37 in A&AA(Assam) and Damoh/Damoh-4 in Vindhya. As a result of these exploratory efforts, ONGC accreted 61.05 MMToe of 2P reserves.

## OIL

OIL owns a vast array of advanced computing systems to process and interpret geo-scientific data through integrated exploration applications such as Remote Sensing, Structural & Stratigraphic Interpretation, Seismic Attribute Analysis, Source Rock Evaluation, Biostratigraphy, Sequence Stratigraphy, Petrophysics, Basin Analysis, Techno-Economic Evaluation etc.

During 2014-15, OIL carried out 140 thousand m drilling in 37 wells in onshore areas.

Significant discoveries of oil/gas struck by OIL in India during 2014-15 are as below:

OIL has made twelve (12) oil and gas discoveries during the year; eleven (11) from Upper Assam Basin and one (1) from its operated NELP-VI block KG-ONN-2004/1.

i) The Well Nadua-1 (Loc. CH) is located in Nadua structure under Chabua PML and has been drilled down to 3,693 m to probe the hydrocarbon prospects within Paleocene-Eocene formations. The well has encountered few prospective sand ranges within Paleocene-Eocene formations and presently producing oil from one of the tested sands. This discovery of oil has opened up new

avenues for exploration and exploitation of hydrocarbon in Paleocene-Eocene formations in Nadua and adjoining area.

ii) The Well Rangmala-1 (Loc. TAJ) is located in Balijan-II structure under Tinsukia PML and has been drilled down to 3,930 m to probe the hydrocarbon prospects within the Paleocene-Eocene formations. The well has encountered few prospective sand ranges within Paleocene-Eocene formations and presently producing gas from one of the tested sands. The discovery of gas in this well has opened up new avenue for exploration and exploitation of hydrocarbon within the Paleocene-Eocene formations in Balijan-II and adjoining structures.

iii) The Well Mechaki-3 (Loc. MKA) is located in the West Mechaki structure under Mechaki Extension PML and has been drilled down to 5,636 m to probe the hydrocarbon prospects within Paleocene-Eocene formations. The well encountered few prospective sand ranges within Paleocene-Eocene formations and produced oil from one of the tested sand within Narpuh Formation. The discovery of oil in this well has opened up new avenue for exploration and exploitation of hydrocarbon within the Paleocene-Eocene formations in West Mechaki and adjoining area.

iv) The Well NHK-616 (Loc. NLB) is located in Balagaon structure within Nahorkatiya Extension PML and has been drilled down to 3,005m to probe the hydrocarbon prospects within the Barail and Tipam formations. The well has encountered few prospective sand ranges within Barail Formation and one of the tested sands produced oil intermittently during testing. However, commercial oil production could not be sustained and well is presently kept shut-in.

v) The Well NHK-466 (Loc. HHW) is located in Langkasi area of Greater Jorajan Oilfield under Hugrijan PML and was drilled and completed during the year 1991. During 2014-15, oil has been discovered in new/unappraised Kopili sand through workover operations. The discovery of oil in this sand has opened up a new reservoir for exploration and exploitation of oil in Kopili Formation of Langkasi and adjoining areas.

vi) The Well Balimara-2 (Loc. BF) is located in Balimara structure under Borhat PEL and was drilled and completed during year 2012. During

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2014-15, oil has been discovered in new/unappraised Barail sand through work-over operations. The discovery of oil in the Barail Formation has opened up a new reservoir for exploration and exploitation of oil in Balimara and adjoining areas.

vii) The Well Barekuri-2(Loc. TR) is located in the central part of Barekuri structure under Tinsukia PML and was drilled and completed during the year 2005. During 2014-15, gas has been discovered in new/unappraised Narpuh sand through work-over operations. The discovery of gas in the Narpuh Formation has opened up a new reservoir for exploration and exploitation of oil in Barekuri and adjoining area.

viii) The Well Hapjan-24 (Loc. HKC) is located in the North Hapjan structure under Hugrijan PML and was drilled and completed during the year 1993. During 2014-15, oil has been discovered in new/unappraised Narpuh Barail sand through work-over operations. The discovery of oil in the Barail Extra Sand has opened up a new reservoir for exploration and exploitation of oil in Hapjan and adjoining areas.

ix) The Well Hapjan-28 (Loc. HNP) is located in Hapjan area under Hugrijan PML and was drilled and completed during the year 1997. During 2014-15, gas/condensate has been discovered in one sand within Lakadong+Therria Formation through work-over operations. The discovery of gas/condensate has opened up a new reservoir for exploration and exploitation of gas in Hapjan and adjoining area.

x) The Well Baghjan-7 (Loc. BGE) is located in Baghjan structure under Baghjan PML and was drilled and completed during the year 2008. During 2014-15, gas/condensate has been discovered from new/unappraised sand within Narpuh Formation through workover operations. The discovery of gas in Narpuh Formation has opened up a new reservoir for exploration and exploitation of gas in Baghjan and adjoining area.

xi) The Well Moran-78 (Loc. MBT) is located in Moran area under Moran PML and was drilled and completed during the year 1981. During 2014-15, oil has been discovered in new/unappraised Barail sand through work-over operations. The discovery of gas in Barail Sand has opened up a new reservoir for exploration and exploitation of gas in Moran area.

xii) The Well is the first exploratory well drilled in NELP Block KG-ONN-2004/1. The well has been drilled down to 3,719 m and the well encountered few prospective sand ranges within Kummugudem Formation of Permian-Triassic age. Four(4) sand packages have been tested in the well and all the four sands flowed gas. The discovery of gas in this well opened up new exploration potential in this NELP Block. Appraisal programme is being worked out to ascertain commercial viability of the gas discovery. OIL is operator in this NELP block and holds a 90% Participating Interest (PI).

The area wise development of deep drilling rigs, wells & meterage drilled by ONGC, OIL and private/ Joint Ventures during 2014-15 are given in Table - 1.

**Table - 1: Area wise Development of Deep Drilling Rigs , Wells & Meterage Drilled by ONGC, OIL & Private/ Joint Ventures 2014-15**

Agency	Onshore			Offshore			Total		
	Rigs (Numbers)	Wells	Meterage (in'000)	Rigs (Numbers)	Wells	Meterage (in'000)	Rigs (Numbers)	Wells	Meterage (in'000)
<b>(A) ONGC</b>	69	276	532	36	95	253	105	371	786
<b>(B) OIL</b>	17	37	140	-	-	-	17	37	140
<b>(C) Private/JVs</b>	36	201	346	20	28	81	56	229	427
<b>Total</b>	<b>122</b>	<b>514</b>	<b>1018</b>	<b>56</b>	<b>123</b>	<b>335</b>	<b>178</b>	<b>637</b>	<b>1352</b>

Source: Oil & Natural Gas Corpn. Ltd, Oil India Ltd & DGH

## Reliance Industries Ltd (RIL)

During the year 2014-15, RIL and Myanmar Oil & Gas Enterprise (MOGE), an enterprise of the Government of Myanmar signed a production sharing contract for two offshore blocks (M17 and M18) in the Tanintharyi basin of Myanmar. RIL will be the operator of the blocks with a 96% participating interest. The United National Resources Development Services Co. Ltd (UNRD), a Myanmar company will hold the remaining interest in the block. Gas production from the KG-D6 field declined by 12% to 157.6 Billion Cubic Feet (BCF) in 2014-15. Efforts by RIL and its JV partners to augment production from the field through interventions like side track wells and onshore terminal booster compressor helped partly offset the natural decline in the field.

During the year, RIL made significant progress towards development of two Coal Bed Methane (CBM) blocks-Sohagpur East and Sohagpur West. Detailed engineering and construction activities have been completed. RIL expected first gas production from these blocks during 2015-16.

## COAL

The agencies engaged in exploration for coal during 2014-15 were mainly GSI, CMPDI, MECL and State Directorates of Geology & Mining.

## GSI

GSI continued its operations for search and assessment of coal resources in the country through regional exploration in coalfields of Assam, Bihar, Chhattisgarh, Madhya Pradesh, Maharashtra, Odisha, Telangana and West Bengal.

In Assam, regional exploration for Gondwana coal was taken up in and around Phatapara area in the down dip extension of Sukchar- Singrimari area, Singrimari Coalfield, Dhubri distt., at the border of Assam and Meghalaya(G3). An area of 2 sq km was covered by Large Scale Mapping(LSM) on 1: 10000 scale in and around Khopati-Baratila area, which is totally covered by alluvium. During the period under review, a total of 715 m was drilled in two boreholes, viz. SP-01 and SP-02 in Phatapara area. Lower Barakar Formation is coal bearing. Borehole SP-01 has reached a depth of 340m and intersected Lower Barakar Formation. One coal seam of 0.74 m thickness has been intersected at a depth of 214.26 m. The second borehole SP-02 has been closed on 17.03.15 at a depth of 375 m. Three coal seams of 1 m, 5.45 m and 4.79 m thickness have been intersected at depths of 108.63m, 191.73 m and 290.51 m, respectively.

Cumulative coal thickness is 11.24 m, which is, so far, the maximum thickness of coal recorded from a single borehole in Singrimari Coalfield since commencement of regional exploration in 1985-86. Coal samples have been sent for chemical analysis and coal petrographic study. Regional exploration carried out for Gondwana coal in the area adjacent to Sukchar-Singrimari area, Singrimari Coalfield, Dhubri distt., at the border of Assam & Meghalaya (G3) (spill over item). A total meterage of 185.55 m was drilled in one borehole (SK-02 part) during 2014-15. Two thin coal bands ranging in thickness from 0.70 m (SK-02) to 0.90 m (SK-01) have been intersected within a depth range from 109.00 m (SK-01) to 254.60 m (SK-02). These coal seams are associated with carbonaceous shale-grey shale-mudstone intercalations. The recovery in coal-carbonaceous shale zones is very poor due to technical drilling difficulties. Proximate analysis show Moisture (1.55-7.91%), Ash (62.00%), Volatile Matter (15.46-23.57%) and Fixed Carbon (6.52-20.99%). Ultimate analysis reveals Carbon (17.33-26.44%), Nitrogen (1.12-1.40%), Hydrogen (2.07-2.62%), Sulphur (2.34-2.92%), and Oxygen (16.5-26.14%). Overall analysis of the samples indicate Ash + Moisture content varying from 63.55% to 69.91% revealing that the samples are carbonaceous shale in nature. Coal petrographic study also reveals that the samples are of carbonaceous shale in nature with 70-88.88% of total shale + Mineral matter. Liptinite (8.0%) and vitrinite (3.12-7%) are the main minerals present with inertinite (0-15%) present only in trace amounts. The sample has a Ro range from 0.59- 0.40% with Ro mean value of 0.46%. Therefore, from the borehole record, it may be inferred that the development of coal seams towards downdip direction of the earlier explored Sukchar-Singrimari area is significant. This finding has further strengthened the possibility of occurrence of potential coal seams in the northern deeper part of the basin .Therefore, from the borehole record, chemical and petrographic analysis of coal, it may be inferred that the development of coal seams towards northern side of the earlier explored Sukchar-Singrimari area is not significant.

In Bihar, the G4 stage exploration programme in Mirjagaon area, Bhagalpur distt, has been initiated in November, 2013 and is continued in 2014-15. In Mirjagaon area, a total of 3,330.10 m was drilled in 7 boreholes (RBMG-1 to RBMG-7) out of which 2,467.75 m drilling have been carried out during 2014-15. Cumulative coal seam thickness as intercepted

at each bore hole are 41.32 m in RBMG-1, 55.00 m in RBMG-2, 30.00 m in RBMG-3, 32.00 m in RBMG-4, 35.10 m in RBMG-5, 21.75 m in RBMG-6 and 11.15 m in RBMG-7. Based on band by band proximate analysis of coal intersected at each borehole, four coal seam zones have been identified. Coal seam zone-A thickness varies from 10.60m (432.80-443.40) in RBMG-1 to 103.15 m (495.85-599.00) in RBMG-4. Zone B thickness varies from 57.00 m (400.35- 457.35) in RBMG-2 to 122.75 m (261.25-384.00) in RBMG-1. Zone C thickness varies from 27.80 m (220.00-247.80 m) in RBMG-1 to 41.60 m (360.90-402.50) in RBMG-3. Zone D thickness varies from 58.95 m (109.75-168.70) in RBMG-1 to 102.36 m (241.89-344.25) in RBMG-3. The Intertrappean beds with *Ptilophyllum* sp in RBMG-4 above Barakar Formation indicates cretaceous age for the Intertrappean bed. Coal petrographic study reveals, that rank wise the coal can be categorised under Lignito-Bituminous to Sub-Bituminous type. From the data accrued so far, a tentative geological resource of coal of about one thousand million tonnes is expected from the Mirjagaon area.

In Chhattisgarh, regional exploration for coal under G2 stage of UNFC was initiated in two blocks namely, Samarsingha and Amlidhonda during 2010-12. Subsequently, another two blocks, namely Purunga and Gare (South), were also brought under the ambit of regional exploration for coal under G2 stage of UNFC in the state during 2014-15. All these blocks are in Mand-Raigarh Coalfield, Raigarh district. Regional exploration for coal in Samarsingha block commenced in the month of December 2011. During 2014-15, a total of 789.80 m was drilled in three boreholes, namely, MRSS-12 to 14. A major part of the block exposes rocks of Barakar Formation. A total of nine regional Barakar coal seams (I, II, IV to IX & XIII in ascending order) have been intersected between depths of 106.68 m (MRSS-14) and 668.55 m (MRSS-14). Thickness of coal seams varies from 1.94 m (Seam VIII; MRSS-14) to 8.38 m (Seam IV; MRSS-14). Seam I is an important seam with thickness varying from 5.65 m (cumulative, MRSS-13) to 7.81 m (cumulative, MRSS-14) and has been intersected in the depth range of 450.72 m (MRSS-13) to 668.55 m (MRSS-14). The continuity of the coal seam have been established along dip direction towards south-west for about 5 km. Coal seams are inter-banded in nature and quality-wise are of power grade. In Purunga block, a total of 4,472.40 m drilling was achieved during regional exploration for coal in nine boreholes. Among these,

six boreholes are completed (MRPR-1 to MRPR- 6) and three boreholes were in progress (MRPR-7, MRPR-8 and MRPR-9). Altogether, twelve regional Barakar coal seams (I to X, XII & XIII in ascending order) were intersected. Thickness of individual coal seam varies from 0.53 m (Seam no. X in borehole MRPR-1) to 10.74 m (Seam no. IV in borehole MRPR-2) The block area is covered by lithounits of Barren Measures and Barakar Formation. A total of 1,581.85 m geophysical logging and a total of 4 sq km large scale mapping (RF 1:10000) has been carried out. In Amlidhonda block, during regional exploration for coal, a meterage of 541.75 was drilled in two boreholes during this period viz. MRA- 15 (in part) & 17. The strike of beds is NW-SE with 2° to 4° south-westerly dip. During this period, the maximum intersected thickness of Barren Measures is 105.05 m have been recorded in borehole MRA-17 located at the western part. A total of five regional coal seams (Seam- IV, VI+VII combined, IX and X in ascending order) and a few local seams intersected between 170.65 m and 318.84 m depths. Thickness of individual coal section varies from 0.69 m to 2.56 m. The coal seams have been traced for nearly 4 km in strike and 4 km in dip direction within the block. Most of the seams, particularly the thicker seams, are interbanded in nature and are of power grade. The regional exploration for coal in Gare (South) block, Mand-Raigarh Coalfield was commenced in June, 2014 with initiation of LSM on RF: 1:10000. Sub-surface probing by drilling was commenced on 1<sup>st</sup> September 2014 with the deployment of two drill rigs. During this period, 5,171 m drilling has been achieved in twelve boreholes, viz., MRGS-1 to MRGS-12 (all completed). Seven regional Barakar coal seams / zones (seam nos. III, IV, V, VI+VII, IX & X in ascending order) have been intersected between the depths of 166.15 m (Seam X, MRGS-5) and 516.87 m (Seam III, MRGS-12). Thickness of individual coal seam / zone varies from 0.51 m (Seam V, MRGS-12) to 13.24 m (Seam VI + VII in four split sections, MRGS-9). A total of 3,307.62 m geophysical logging was carried out in this block. Regional exploration for coal under G2 stage was continued in Pipraul block in Tatapani-Ramkola Coalfield, Sarguja district. Coal exploration in Pipraul block was commenced in November 2013 under promotional programme. During the period, a total of 3,346.60 m drilling was achieved in six boreholes namely TRP-3 to 8. Large Scale Geological mapping of 4 sq km area was carried out on 1:10000 scale. One East-West trending fault, identified in the north central part of the block has been found passing

just south of borehole TRP-1 separating the exploration area in two lithologically distinct zones in north and south. Eleven regional Barakar coal seams (Seam-I to IX, XII, XIII in ascending order) and few local seams with thickness ranging from 0.50 m to 17.17 m (cumulative) have been intersected between the depths of 8.94 m and 757.15 m. During this period, Seam-III Top & Bottom occurs as the thickest seam in the studied area which is interbanded in nature and generally occurs in two split sections.

In Madhya Pradesh, regional exploration for coal in Pench Valley Coalfield was continued in Dhorakuhi Sector, Chhindwara district under G-3 stage. Exploration for coal in Bhurkumdhana Sector was continued under the phase of time extension (Spill over Items). Exploration for coal in Bhurkumdhana Sector, the Large Scale Mapping on (1:12500 scale) has revealed that the area is covered by flows of Deccan Trap. A total of 445.50 m (including re-drilling) has been drilled in two boreholes namely PBK- 4A & 5. Borehole PBK-4A was re-drilled at the adjacent location of PBK-4 which was abandoned at a depth of 299.50 m within Motur Formation. The contact between Motur & Barakar formations marked at 403.25 m depth. In this borehole, Barakar coal seams were intersected between the depths of 424.78 and 485.41 m. The cumulative thickness of coal is 12.85 m and individual seam thickness varies from 0.55 to 3.95 m. The borehole closed at the depth of 498.50 m within Barakar Formation on 07.09.2014. The borehole PBK- 5 commenced on 06.06.2013 and drilled up to a depth of 484.50 m and abandoned in Motur Formation on 20.05.2014. The coal exploration operation in this sector has been closed with the completion of the borehole PBK-4A. The programme of exploration for coal in Dhorakuhi Sector, total 6 sq km area was geologically mapped on 1:10000 scale. The LSM revealed that the area is covered with Deccan Trap of Khampa and Amarwada formations of Amarkantak Group. A total of 759.85 m was drilled in three boreholes, namely, PDK-1, 2A & 3. The first borehole PDK-1 progressed from 0.00 to 351.30 m depth. The contacts between Deccan Trap & Motur Formation, Motur & Barakar formations are demarcated at 163.45 m & 305.40 m depths, respectively. A total of 3.65 m coal (cumulative thickness) has been intersected within the depth range from 327.02 m to 348.03 m and borehole abandoned due to drilling difficulties at 351.30 m within coal zone. The second borehole PDK-2 commenced on 26.11.2014 and progressed up to

the depth of 363.50 m. This borehole was also abandoned at the depth of 363.50 m in Motur Formation on 09.03.2015. The borehole was redrilled at adjacent location as PDK-2A and progressed up to 157.10 m in Deccan Trap. Borehole no. PDK-3 commenced on 12.03.2015 and progressed up to depth of 54.95m in Deccan Trap. In Singrauli Coalfield, regional exploration for coal in Sarai (West) Sector, a total of 1,745.45 m of drilling has been achieved in five boreholes (completed: SSW-7, SSW-9, & SSW-10; in-progress: SSW-11 & 12). LSM (RF: 1:10000) over an area of 5 sq km in the studied block has been completed. Raniganj, Barren Measures and Barakar formations have been intersected in the boreholes. Three regional Raniganj coal seams/zones (Seam nos. R-I to R-III in ascending order) have been intersected in the depth range from 5.58 m to 134.02 m. The individual thickness of Raniganj coal seam varies from 0.68m (Seam R-II, SSW-12) to 4.22 m (Seam R-I, SSW-11). However, borehole wise cumulative thickness of all Raniganj coal seams including the local ones varies from 7.17 m (SSW-11) to 8.82 m (SSW-12). Down-dip extension of Raniganj seams for about 800 m has been established during the period. Seven regional Barakar coal seams/zones (Seam I to VII in ascending order) have been intersected in the depth range from 431.13 m (SSW-11) to 620.35 m (SSW-10). The thickness of individual coal seams varies from 0.88m (Seam IV, SSW-10) to 3.22 m (Seam II, SSW-10). The maximum cumulative thickness of regional Barakar coal seams has been recorded to be 8.15 m (SSW-10). In Sohagpur Coalfield, regional exploration for coal in Bihar block, district Shandol a total of 2,583.55 m was drilled in nine boreholes SBR-10 to SBR-18 and 5 sq km area was geologically mapped on 1:10000 scale. Both surface and subsurface data revealed that most part of the block area is covered with light violet to pinkish grey coloured calcareous sandstone of Lameta Formation. It occurs as massive units forming flat terrain with no distinct bedding plane. The thickness of the Lameta Formation intersected in boreholes ranges from 26.30 m to 54.60 m. The North eastern part of the area is covered with Barren Measures, which is mostly dominated by feldspathic sandstones and variegated mudstones/shales. General strike of bedding is NW-SE with low dip (1° to 2°) towards NE. The thickness of the Barren Measures intersected in boreholes ranges from 50.40 m to 87.75 m. Four regional Barakar coal seams (I to IV in ascending order) and four local seams (L1, L2, L3 & Local) were intersected between the

depths 122.90 m and 321.20 m. Seam III is considered as the marker seam. The thickness of the coal seams varies from 0.50 m to 5.18 m. Continuity of all the coal seams intersected in the present block has already been established through exploration in the adjacent Pachri and Devanitola blocks to the north. The coal seams have been traced over 6 km in strike and over 2 km in dip direction within the block. In Malka block, a major part of the block exposes rocks of Raniganj Formation while the southern portion of it exposes basic intrusive. The maximum thickness of Raniganj strata intersected in the boreholes is 121.85m. Surface and subsurface data acquired through investigation during the period reveal that strike of beds is NNW-SSE with 2°- 3° dip towards ENE. A total of 2,305.30 m (including re-drilling) has been drilled in five boreholes namely, SMLK-2 (part), 3 (part), 5, 6 & 7 and 1 sq km area was geologically mapped on 1:10000 scale. Raniganj and Barakar formations are the main coal bearing sequence in the Malka block. Though the Barakar Formation is the main storehouse of coal, Raniganj Formation also contains two to five coal zones. Four regional Barakar coal seams namely, I, III, IV and V (in ascending order) and three local seams (L1, L2 & L3) have been intersected within a depth range from 371.46 to 642.50 m with cumulative coal thickness ranging from 0.55 to 7.78 m. Seam III is the thickest seam. Quality wise Barakar seams are mostly of superior grade. Raniganj coal seams are interbanded in nature and qualitywise are of power grade. It has been intersected between the depth range of 14.90 m and 108.80 m. The continuity of the coal seam has been established along dip and strike directions for about 4 km and 1 km, respectively. The investigation was concluded in February, 2015. In Harri block, a major part of the block exposes rocks of Raniganj Formation while the southern portion of it exposes basic intrusive. The maximum thickness of Raniganj strata intersected in the boreholes is 145.45 m. Surface and subsurface data acquired through investigation during the period reveal that strike of beds is NNW-SSE with 2°-3° dip towards ENE. A total of 1,132.25 m has been drilled in three boreholes namely, SHR-1, 2 & 3 through the deployment of three drill rigs and 4 sq km area was geologically mapped on 1:10000 scale. Three regional Barakar coal seams namely, III, IV and V (in ascending order) and one local seam (L1), have been intersected within a depth range from 362.92 m to 438.00 m with cumulative coal thickness ranging from 1.53 m to 5.75 m. Raniganj coal seams have been intersected between the depth range of 17.45 m and 92.10 m.

The continuity of the coal seam has been established along dip and strike directions for about 5 km and 1 km, respectively.

In Maharashtra, Wardha Valley Coalfield exploration was carried out in Jhamkola area, Dabhadi Sector and Wadhona-Phukta area. In Jhamkola area, LSM revealed that the area is covered with two basaltic flows of Ajanta Formation of Sahyadri Group of Deccan Trap. A total of 975.50m has been drilled in two boreholes viz. WJ-3A, 4D. Drilling by outsourcing commenced on 22.03.2014 with the commencement of borehole WJ-3A. In borehole WJ-3A, Deccan Trap/ Motur and Motur/ Barakar formational contacts were demarcated at 110.62 m and 460.55 m depths, respectively. One composite Barakar coal seam has been intersected within the depth range from 521.95 m to 540.59 m. The cumulative thickness of coal is 5.35 m with individual seam thickness varies from 0.55 m to 3.20 m. The borehole was closed at the depth of 546.50 m in Barakar Formation. Boreholes WJ-4 to 4C abandoned in Motur Formation. After abandonment of these boreholes redrilling commenced as WJ-4D on 30.01.2015 and again abandoned at the depth of 321 m in Motur Formation on 28.02.2015. Investigation closed on 12.03.2015. In Dabhadi Sector the LSM of 2 sq km carried out in the area on 1: 12500 scale revealed that the area is covered with mainly three basaltic flows of Ajanta Formation of Sahyadri Group. During the period total eight boreholes were drilled. However, the effective drilling of 2,082.50 m has been considered by outsourcing from 17.04.2014 in five boreholes WDD-1A, 2, 3 (completed), 4A & 5A (abandoned). The intersected thickness of Deccan Trap varies from 128.27 m (WDD-1A) to 171.33 m (WDD-2). The Motur-Barakar formational contact in this sector varies from 322.70 m (WDD-3) to 363.89 m (WDD-1A). The entire Barakar Formation has been intersected in borehole WDD-3 and the thickness of Barakar Formation is 82 m in this area (from 322.70 m to 404.70 m). The borehole closed at 417.50m depth within Talcher Formation (12.80m+). Barakar coal seams were intersected within the depth range from 357.70 m (WDD-3) to 452.58 m (WDD-1A). The individual coal thickness varies from 0.80 m (WDD-1A) to 5.05 m (WDD-2) but borehole wise cumulative coal thickness varies from 2.30 m (WDD-3) to 6.98 m (WDD-1A). Borehole depth of 417 m and 324 m, respectively. Investigation closed on 12.03.2015. In Wadhona-Phukta area, the LSM revealed that the area is covered with black soil with scanty outcrops of Deccan Trap of Chikhli & Ajanta

formations of Sahyadri Group. During the period under review, a total of 291.45 m drilling has been carried out in two boreholes namely WWP- 1 & 2. The planning of borehole WWP-1 was made on the basis of geophysical investigation carried out during 2004-05 by Geophysics Division, CHQ, GSI. The drilling operation in the area commenced on 14.10.2014 with the commencement of borehole WWP-1. Interpretation of geophysical report showed considerably thick sediments below the Deccan Trap but the borehole WWP-1 reached to the basement sediments of Sullavai Formation after intersecting Deccan Trap & Lameta Formation without intersecting lower Gondwana sequence. The Deccan Trap/Lameta Formation contact demarcated at the depth of 61.05 and Lameta/Sullavai Formation at 65.90 m depth. The borehole closed on 29.11.2014 at a depth of 125.70 m. Borehole WWP-2 commenced on 14.12.2014 and also intersected basement at the depth of 139.12 m below Deccan Trap. The borehole closed at the depth of 165.75 m in Sullavai Formation on 05.02.2015.

In Odisha, in Mahanadi Valley Coalfield exploration was carried out in Grindola block, Bandbahal block and Bartap block. During this period a total of 321.10 m was drilled in Grindola Block in last two boreholes (IBGD-6 & IBGD-7 completed) in which two regional coal seam zones of Barakar Formation i.e., Rampur seam zone (intersected from 626.27 m to 789.69 m in two boreholes) and Ib seam zone (intersected from 761.01 m to 771.63 m in B.H. no. IBGD 7 only) were intersected. A total of 91.95 m coal sample was collected and sent to CIMFR for analysis. Rampur seam zone is the thickest seam zone having maximum cumulative coal thickness of 49.68 m with eight splits intersected at roof depth of 666.32 m in IBGD-6 and Ib seam zone has cumulative coal thickness of 2.83 m with four split sections. Coals are rich in vitrinite and inertinite percentage with moderately high percentage of liptinite in some of the seams. VRo% (random) varies from 0.35 to 0.48 and rank wise the coal can be categorised under 'Sub-Bituminous Coal' type. The grade of coal varies mostly from D to F. Total indicated resource of 839.64 million tonnes has been assessed for the block. In Bandbahal Block, a total of 2,687.45 m was drilled in five boreholes (three completed and two in progress) in Bandbahal Block along with collection of 504.47 m coal sample. Four regional coal seam zones of Barakar Formation (Belpahar, Parkhani, Lajkura and Rampur from top to bottom) were intersected from 235.86 m to 861.75 m depths. The Lajkura seam zone, having the

maximum cumulative thickness of 63.09 m (in BH no IBBA-5), is the most important for its regional persistence and its thickness increases towards the down dip direction. The Belpahar and Parkhani seam zones have maximum cumulative thickness of 15.77 m in IBBA-5 and 35.30 m in IBBA-6, respectively. Four regional coal seams of Raniganj Formation (R-IV to R-I) were intersected within 54.95 m to 230.48 m depths. The R-I seam zone having maximum thickness of 17.58 m is most important for the shallow depth occurrence. The maximum cumulative coal thickness of R-IV, R-III and R-II is 5.82 m, 14.71 m and 2.26 m, respectively. The exploration in Bandbahal block also indicates promising down dip occurrence of R-I seam in shallow depth and increase in cumulative coal thickness of Lajkura seam zone. The extensions of regional Barakar and Raniganj coal seam zones have been established for about 2 km along the strike and 1.5 km along the dip. In Bartap block, a total of 2,686.15 m was drilled in four boreholes in Bartap Block (3 completed and one in progress) along with collection of 629.88 m coal sample during this period. Three regional coal seam zones of Raniganj Formation (Raniganj: R-III to R-I in descending order) and five regional coal seam zones of Barakar Formation (Belpahar to Ib from top to bottom) were intersected between 13.96 m and 684.47 m depth. Amongst the Raniganj seam zones R-I (2 to 4 splits) was the most important seam intersected at 13.96 m depth in IBBR-1 and it has the maximum thickness of 10.10 m in IBBR- 2. The other seam zones R-III (maximum cumulative thickness of 1.72 m with two splits in IBBR-4) and R-II (maximum cumulative thickness 5.37 m with two splits in IBBR-2) have their regional persistency. Amongst the Barakar seam-zones, Lajkura (with 4 to 6 splits) was the most important seam intersected at 357.72 m depth in IBBR-1 and it had the maximum thickness of 61.58 m in IBBR-3. The other seam zones, Belpahar (maximum cumulative thickness of 19.10 m with ten splits in IBBR-4), Parkhani (maximum cumulative thickness 28.84 m with fourteen splits in IBBR-2), Rampur (maximum cumulative thickness 51.82 m with seven splits in IBBR-2) and Ib (maximum cumulative thickness 4.79 m with four splits in IBBR-1) have their regional persistency and were intersected in all boreholes. CBM desorption study of eighteen coal samples from IBBR-1 indicate the maximum desorbed gas content of 0.12 cc/g at NTP. Extension of Raniganj and Barakar regional coal seams has been established for about 2 km along strike and 2.5 km along dip direction. In

Kantaikoliya area, Talcher Coalfield, total 1,331.10 m was drilled in Kantaikoliya area, Talcher Coalfield in 3 boreholes (2 completed and one in progress) and an area of 4 sq km coalfield map was updated on 1:50000 scale. Four regional coal seams (seam nos: IX, IV, III and II) of Barakar Formation have been established for 2 km in strike direction. A total cumulative coal thickness of 15.22 m (during this period only) was intersected from the depth range from 155.50 m to 372.94 m representing parts of seam zones IX (0.54 m-2.04 m), VII (0.75 m), IV (1.04 m-2.44 m), III (0.75 m-2.23 m) and II (1.07 m) in borehole TKK-2. In the third borehole TKK-3, total cumulative coal thickness of 17.07m was intersected from 116.04 m to 363.92 m depth forming part of seam zone IX (0.85 m-2.11 m), IV (0.76 m-1.15 m), III (0.51 m-2.19 m) and II (1.03 m). A total of 955 m geophysical logging was done in two boreholes. The fourth borehole (TKK-4) was progressed up to 342.40 m depth intersecting Barren Measure Formation and Barakar Formation devoid of any coal seam. However, a thin band of coal (0.44 m) was intersected between the depth ranges from 180.74 m to 181.18 m probably representing the part of the degenerated seam zone of III.

In Telangana, exploration was carried out in Sirpur-Kagaznagar blocks, Rudrakshapalli-Ganugalapalli area, Pagaderu (East) section, Bayyaramcherla area and Mangrude village, Bela Mandal in Godavari Valley Coalfield. The Sirpur-Sitanagar area is located in the main basin of Godavari Valley Coalfield in Adilabad district. The Sirpur-Kagaznagar exploration block area is covered by the rocks of Upper and Lower Gondwana formations. The overall regional strike of the lithologies is trending NW direction & dip towards NE with varying dip amount but southern side of block gives the NW dip direction. On the basis of borehole drilled by MECL earlier, borehole in GSS-1 at elevation 200m was finalised towards dip section from MECL boreholes MK-13, 22. Megascopically Kamthi Formation exposed on surface to approximately 50-60 m depth. Borehole encountered Kamthi Formation as well as Barren Measure Formation with <30cm carbonaceous bands/coaly bands at depth of 102 m, 118 m, 170 m & 173 m. In Rudrakshapalli-Ganugalapalli area, the target of 300 sq km has been achieved. On the basis of current study, an area of 25 sq km was delineated for taking up LSM and to initiate mapping on (1: 10000) around 4 sq km. During the mapping (Reconnaissance Survey) and LSM, mainly four formational units were identified in the area, namely,

Gangapur Formation, Kota Formation, Kamthi Formation and Maler Formation. A total of 21 rock samples were collected and 6 samples submitted to petrology division and their results are awaited. Some of the samples from Gangapur Formation suspected to contain fossil impression were collected and submitted to Paleontology division, GSI,SR, Hyderabad for further study. During the course of mapping, fossil wood (>1mt) is also encountered in the mapping area within the Kota Formation. In Pagaderu (East) sector, the regional exploration is carried out covering an area of about 6 sq km located to the north of Manuguru Mining block. A total of 1,848 m drilling was achieved from three boreholes (GPDE- 1, 2 and 3), GPDE-1 borehole drilled from 294.50 to 631 m (drilled depth is 336.50 m) passed through Barakar Formation. In GPDE-1 borehole, a cumulative thickness of 9.15 m (pre-analysis by CIMFR) of coal intersected within the Lower Kamthi Formation ranging its thickness from 0.50 to 1.20 m in 12 split sections. It also intersected coal bands/seams of Barakar Formation with a cumulative thickness 38.02 m (pre-analysis by CIMFR) ranging its thickness from 0.50 to 11.64 m in 28 split sections. GPDE-1 borehole intersected hot water artesian aquifer at 340 m depth having an average temperature of 60°C at surface. GPDE-1 borehole closed at a depth of 631 m after intersecting Talcher Formation at 624.99 m depth. GPDE-2 borehole drilled in the down dip side of Pagaderu (East) sector. GPDE-2 borehole drilled from 0.00 to 770 m (drilled depth is 770 m), it initiated within Upper Kamthi Formation. GPDE-2 intersected Middle Kamthi Formation at 76.96 m depth, which is characterised by grey to greenish grey, variegated shale and siltstone with occasional bands of red clay and grey, fine grained, micaceous sandstone. It intersected Lower Kamthi Formation at 155.50 m depth which consist of greyish white, coarse grained, massive, micaceous, feldspathic (fully kaolinised) sandstone, grey to dark grey massive shale and siltstone with bands of coal and carbonaceous shale. Intersected Barren Measures at 283.50 m depth, it is of greenish grey to grey, massive shale and siltstone with bands of siderite devoid of coal and carbonaceous shale bands. GPDE-2 intersected Barakar Formation at 356 m and still continuing through the same formation. In GPDE-2 borehole a cumulative thickness of 5.78 m (pre-analysis by CIMFR) of coal intersected within the Lower Kamthi Formation ranging its thickness from 0.50 to 1 m in 9 split sections. It also intersected coal bands/seams of Barakar Formation with a cumulative thickness

22.36 m (pre-analysis by CIMFR) ranging its thickness from 0.50 to 4.34 m in 19 split sections. GPDE-3 borehole drilled in the same strike direction of GPDE-1 borehole in Pagaderu (East) sector. GPDE-3 borehole drilled from 0.00 to 447 m (drilled up to depth of 447 m), it initiated within Lower Kamthi Formation which consist of greyish white, coarse grained, massive, micaceous, feldspathic (fully kaolinised) sandstone, grey to dark grey massive shale and siltstone with bands of coal and carbonaceous shale. Intersected Barren Measures at 237.91 m depth and is of greenish grey to grey, massive shale and siltstone with bands of siderite devoid of coal and carbonaceous shale bands. GPDE-3 intersected Barakar Formation at 320m and still continuing through the same Formation. In GPDE-3 borehole a cumulative thickness of 10.64 m (pre-analysis by CIMFR) of coal intersected within the Lower Kamthi Formation ranging its thickness from 0.50 to 1.20 m in 14 split sections. It also intersected coal bands/seams of Barakar Formation with a cumulative thickness 2.32 m (pre-analysis by CIMFR) ranging its thickness from 0.55 to 1.22 m in 3 split sections. In this sector, a total of 896 m was geophysically logged in GPDE-1 and GPDE-2 boreholes. In Bayyaramcherla area, petrified wood is reported about 2.5 km NW of Janampeta in old building stone quarry (Max. size 0.90 m length and 0.65 m width). The study area is covered by the rocks of Upper Kamthi, Maleri and Kota formations. The 1<sup>st</sup> coal seam of 0.25 m was intersected within Lower Kamthi Formation at 295.92 m depth. Several coal seams were intersected in the Lower Kamthi Formation between 295 m and 356 m with a maximum thickness of 1 m for an individual coal seam. A cumulative thickness of 4.05 m coal was obtained in 06 splits ranging in thickness from 0.50 to 1 m, within Lower Kamthi Formation. In Mangruda village, the field area is located at Bela mandal of Adilabad district and an area of 100 sq km adjacent to Telangana-Maharashtra border is taken up for LSM in 1:125000. There is reported occurrence of coal in an agricultural borewell dug by locals at a very shallow depth of 15 mt. Moreover, in a place called Mukutban in Maharashtra around 4 km north-east from the present area there are 3 operative opencast mines. One coal seam of around 2 m thickness at a very shallow depth is being mined there. So, this sandstone area (appx 1.5 km) mapped can be taken for drilling of scout borehole around 100 m ± 50 m. The sandstone unit showing faulted contact with adjoining limestone (in the eastern direction and western direction) resulting in an isolated small basin like feature where the sandstone and shale of Talcher got deposited. Along with sandstone a thin patch of khaki green coloured siltstone has been observed north of the sandstone body. This

lithounit is fine grained shale with assorted clast of shale, siltstone of random orientation and random size has been observed. This can be placed under Talcher Formation of Lower Gondwana. An interesting observation is made at the contact between the sandstone of Barakar Formation and shale of Talcher Formation. An exposure of sandstone resembling pillow has been observed near the Mangruda village (19°44'51.3" and 78°49'51.24"). The structure is elliptical to subrounded in nature, red in colour with layering (may be due to exfoliation). This structure is called sand pseudomorph structure. This is for the first time sand pseudomorph structure reported from Godavari Valley Coalfield. Previously, this structure was also reported from IB-River Coalfield. The limestone of the Mangruda Formation has been mapped and samples (13 nos.) for chemical analysis are taken to assess the potentiality of the limestone for various industrial use. Apart from this, in certain exposures mainly near the Penganga river occurrence of manganese was also observed and samples for chemical analysis were taken. The red shale is mostly exposed along the nala section and a dominant lithology of the entire mapping block. The red shale in the area is mostly very low dipping (1-5°) towards NE. They are also, at places, showing two sets of joints (350,040). The red shale formation showing alternate thick red coloured and thin pale green coloured shale bands. An area of approximately 15 sq km previously mapped as red shale has been remapped as recent deposit from areas north of Kapsi village. The area is showing black coloured soil with few isolated exposure on nala section north of Kapsi (E-W trending nala joining Penganga river) to Maniyarpur village. The recent deposit was observed to rest over the red shale of Bela Formation.

In West Bengal, the exploration for coal under G-3 stage was continued in Gaurangapur-Bankati area, concealed under younger Tertiary sediments lies in the easternmost extremity of the known limits of Raniganj Coalfield. This block is outside the domain of CBM Block and in the east of previously explored Bistupur-Dandeswar area. A total of 2,560.70 m was drilled in five boreholes (two complete and three running) viz. RGB-1 to 5 and 2,126 m was geophysically logged. Raniganj coal seam zones namely R-IX, R-VIII and R-VII (in ascending order) were recorded in borehole RGB-3 within the depth range of 276.80 m and 435.50 m. The coal seam Three zone R-IX is a solitary seam with a thickness of 1.02 m. Coal seam zone R-VIII is the most promising seamzone, having cumulative coal thickness of 8.25 m with seven split sections and their thicknesses varying from 0.50 m to 3.20 m. Seam zone R-VII in this borehole is also having two split sections with thicknesses 0.67 m and 3.95 m, respectively. Two thin

seams of around 0.50 m thickness were intersected in borehole RGB-4 within the depth range of 281 m to 302 m. Another two coal seams of thicknesses 0.90 m and 0.63 m, respectively were recorded in borehole RGB-5 within the depth range of 199.78 m to 227.85 m. A 1.85 m thick lignite band was also recorded in borehole RGB-5 at a depth of 147 m. Gastropod and bivalve shells were recorded in Tertiary sediments and plant and vertebraria fossil impressions were recorded in Raniganj Formation in all the borehole cores. Coal petrographic study reveals that rank wise the coal can be categorised under High Volatile Bituminous C type. A total of 2,424.25 m has been drilled in four boreholes in Djara area, Rajmahal Birbhum Coalfield, Birbhum district, WB (three boreholes completed and one borehole in progress) with intersection of 2.48 m lignite (in two split sections) within the depth range of 95.39 m to 162.01 m. Barakar coal seam zones II (thickness-1.49 m), III (Cumulative coal thickness from 3.22 m-6.91 m) and IV (thickness-2.14 m) in ascending order were intersected between the depth range of 663.38 m to 787.86 m. During this period, 11 samples of CBM desorption study was carried out with maximum 0.99 cc/gm desorbed gas. The area is covered with Tertiary sediments. The maximum thickness of Tertiary sedimentaries is 323.40 m, Rajmahal Formation is 317.40 m, Barakar Formation is 233.41 m and Talcher Formation is 61.37 m, respectively. Geophysical logging of 797m has been done in one borehole in ascending order and having a cumulative coal thickness range between 0.63 m to 1.30 and 1.96-1.97 m, respectively, has been intersected between the depth ranges of 520.21 m to 710.88 m. Desorption study carried out in borehole no. BGZW-4 for two of samples and the desorbed gas (cc/gm) ranged between 0.011 cc/gm to 0.012 cc/gm. The borehole data reveals that the entire area is covered by Tertiary sedimentaries is 275.60 m; Rajmahal Formation is 383.30 m and Barakar Formation is 183.19 m, respectively. Geophysical logging of 657 m was undertaken in one borehole. Exploration in this area was completed on 17.03.2015.

Geological Survey of India has estimated coal resources at 3,06,595.56 million tonnes as on 01.04.2015.

### **CMPDI**

CMPDI continued its coal exploration activities in 2014-15, mainly in CIL and Non-CIL/Captive Mining Blocks. Exploration in CIL blocks was taken up to cater to the project planning/production support needs of subsidiaries of CIL, whereas exploration in Non-CIL/Captive Mining Blocks was undertaken to facilitate allotment of coal blocks to prospective entrepreneurs for captive mining. A total of 140 to 160 drills were deployed in 2014-15, out of which 57-61

were departmental drills.

CMPDI deployed its departmental resources for exploration of CIL/Non-CIL/Promotional blocks, whereas State Governments of Madhya Pradesh and Odisha deployed resources in CIL blocks only. Besides, eight other contractual agencies have also deployed resources for detailed drilling/exploration in CIL/Non-CIL blocks.

In 2014-15, CMPDI and its contractual agencies took up exploratory drilling in 93 blocks/mines spread over 22 coalfields in six states. Out of 93 blocks/mines, 30 were Non-CIL/Captive blocks and 63 CIL blocks/mines. Departmental drills of CMPDI took up exploratory drilling in 57 blocks/mines, whereas contractual agencies drilled in 36 blocks/mines.

A total of 8.28 lakh m of exploratory drilling was carried out by CMPDI in 2014-15 through departmental resources (3.56 lakh m) and outsourcing (4.71 lakh m) to State Governments/MECL/Tendering (CIL/Non-CIL blocks). Details of exploratory drilling carried out by CMPDI in 2014-15 are given in Table - 2.

### **Singareni Collieries Company Ltd (SCCL)**

During 2014-15, the total production of coal from SCCL mines was at 52.54 million tonnes. With addition of 89.86 million tonnes proved reserves during the year, the total reserves of coal in Godavari Valley Coalfield are placed at 10,163.4 million tonnes as on 31.03.2015.

### **State Directorates**

The details of exploration for coal carried out by the State Directorates of Geology & Mining during 2014-15 are given in Table-3.

### **LIGNITE**

GSI, MECL, State Directorates of Gujarat & Rajasthan, GMDC and NLC conducted investigation for lignite during 2014-15.

### **GSI**

GSI continued exploration for lignite in the East Coast Lignite fields, Tamil Nadu and West Coast Lignite field, Rajasthan to identify and assess lignite potentiality.

The search for lignite resources has been accorded priority in the states of Tamil Nadu and Rajasthan which are devoid of any coal deposit.

**Table - 2 : Exploratory Drilling by CMPDI (Departmental and Outsourcing) in 2014-15**

Sl. No.	Agency	Target (lakh m)	Exploratory drilling achieved (lakh m)	Achieved (%)
1.	Departmental	3.50	3.56	102
2.	Outsourcing			
	i) State Govts.	0.10	0.07	70
	ii) MECL (MoU)	2.15	2.20	102
	iii) Tendering (CIL Blocks)	3.74	1.59	43
	iv) Tendering (Non-CIL Blocks)	2.51	0.85	34
	<b>Total</b>	<b>12.00</b>	<b>8.27</b>	<b>69</b>

In Tamil Nadu, for regional exploration in the Uttarakosamangai Sector, Ramnad Sub-basin, a total of 1,936.15 m have been drilled in six boreholes (RUL-22 to RUL-27) during 2014-15 which includes 286 m of Quaternary Formation, 955.75 m of Cuddalore/Tittacheri Formation and 694.40 m of Neyveli Formation. The thickness of these Quaternary sediments including alluvium intersected during the period ranges between 94 m (RUL-27) and 96 m. Tittacheri Formation intersected during the period ranges from 177 m (RUL-25) to 204m (RUL-22). The thickness of Neyveli Formation intersected in boreholes during the period varies from 87 m (RUL-25) to 134.50 m (RUL-23). All the six boreholes intersected lignite seams and the cumulative thickness of lignite seams intersected in boreholes drilled during the field season varies from a minimum of 6 m (RUL-26 & RUL-27) to a maximum of 16.50 m (RUL-24) within a depth range of 311 m to 395 m. A total of 27 boreholes have been drilled for a total meterage of 11,141.35 m in the Uttarakosamangai Sector in an area of 56 sq km. Geophysical logging was carried out in twenty three out of the twenty-seven boreholes for total of 9,174 m. In Kalari West Sector in the Ramanathapuram district where a total of 2,454.50 m was drilled in seven boreholes in the Kalari West Sector during 2014-15, which includes 753m of Quaternary sediments, 1,197.60 m of Cuddalore/Tittacheri Formation and 503.90 m of Neyveli Formation. The thickness of Quaternary sediments intersected during the period including alluvium ranges between 95 m (TRKW-3) and 117 m (TRKW-1) in the Kalari West Sector. The thickness of Cuddalore/Tittacheri Formation intersected during the period varies between 177 m (TRKW 1) and 231 m (TRKW-3). The thickness of Neyveli Formation intersected during the period ranges between 105 m (TRKW-4) to 130.60 m (TRKW-3). Lignite was intersected in all the completed (4 nos) boreholes (TRKW-I to TRKW-4) between depths of 374 m and 442m. The cumulative thickness of lignite seams varies between 12 m and 22 m. The occurrence of lignite has been proved in the entire

explored area of about 30 sq km. Lignite samples have been sent to Chemical Laboratory at NLC, Neyveli for Proximate and ultimate analysis.

In Rajasthan, exploration under G-4 stage continued in Panna area, Palana basin, Jaisalmer and Bikaner districts under Promotional scheme to locate lignite bearing blocks, establish the stratigraphic set up of the area and preliminary assessment of lignite resource. A total of 119.50 m drilling has been done in two boreholes RPP-7 and 9 without intersecting any lignite seams. Scout drilling to locate lignite bearing blocks, establish the stratigraphic set up of the area and preliminary assessment of lignite resource in the Charanwala area (27°51'08" to 27°55'00"N and 72°00'00" to 72°15'00"E) in the unexplored virgin areas of Palana basin, Bikaner district. A meterage of 3,950.50 m of drilling have been completed in sixteen boreholes in the block. Geophysical borehole logging of 3,063.19 m was carried out in the block. Lignite seams have been intersected in western and northern parts of the area. Thickness of individual lignite seam varies from 0.50 m to 3.50 m in the depth range from 109 m to 195 m. The lignite seam is hosted within the Lower Tertiary Palana Formation. Carbonised leaf impression was observed. Considering the variation in lithopackages intersected, basin tectonics and sedimentary history a conceptualised model of deposition of lignite bearing formation was developed in the area and applied to delineate new areas with progressive success.

As on 01.04.2015, the total resources of lignite as estimated by GSI were placed at 44,114.24 million tonnes.

#### **STATE DIRECTORATES/GMDC/NLC**

Particulars of exploration for lignite as carried out by these agencies are given in Table-4.

#### **NON-FERROUS METALS BASE METALS**

GSI, MECL and HZL conducted investigations for copper, lead and zinc ores in different parts of the country during 2014-15.

EXPLORATION & DEVELOPMENT

**GSI**

The details of exploration activities carried out by GSI during 2014-15 are given in Table-5.

**MECL**

During 2014-15, MECL carried out exploration for copper in Chandmari Intervening Block, Jhunjhunu district, Rajasthan (HCL Contractual) by involving: mapping-1.10 sq km area on 1:1000 scale; drilling-10,584.35 m in 35 boreholes; sampling & chemical analysis-1,965 of primary+ check (drill) and 34 composite samples; petrological studies-85 nos; mineragraphic studies-24 nos; specific gravity determination-01 no and estimation of 11.062 million tonnes (221) resources of copper ore with 0.996% Cu at 0.50% Cu cut off. Similarly, for lead-zinc, conducted exploration in Gurla (South) block, Bhilwara district, Rajasthan by mapping-0.50 sq km on 1:1000 area; drilling-1,352.50 m in 08 boreholes; sampling & chemical analysis-537 nos of primary + check (drill); fire assay-50 nos; petrological studies-25 nos; mineragraphic studies-25 nos; specific gravity determination- 30 nos and estimation of 0.53

million tonnes (333) of ore with average grade of 0.64% Pb and 2.31% Zn.

**HZL**

A total of 1,94,400 m (107,100 m from surface and 87,300 m underground) of core drilling was completed in financial year 2015 at various brownfield exploration sites. Resource additions were primarily reported from Sindesar Khurd Mine, which has now touched reserves and resources of 106 million tonnes as well as from Rajpura Dariba Mine. The reserves and resources of Kayad mine increased from 7.7 million tonnes to 8.1 million tonnes. During the year, gross addition of 19.4 million tonnes were made to reserve and resources, prior to depletion of 9.4 million tonnes, adding further to reserves and resources. Total reserves and resources as on March 31, 2015 were 375.1 million tonnes containing 26.9 million tonnes of zinc metal, 8.4 million tonnes of lead metal and 970 Moz of silver metal and grading 7.2% Zn, 2.2% Pb and 80.4 g/t Ag. Overall mine life continues to be 25+ years.

**Table – 3 : Exploration for Coal by State Directorates of Geology & Mining, 2014-15**

State/ District	Location	Geological mapping		Drilling		Remarks
		Area (sq km)	Scale	Boreholes	Meterage	
<b>Chhattisgarh</b>						
Surguja	Ghataun-Birjupali area	20 1.10	1:50000 1:4000	-	-	Survey work carried out.
-do-	Tara area	25 0.50	1:50000 1:4000	01 -	214.50 -	Total 19.08 m core and 05 rock sampling along with 5 lakh tonnes coal resources estimation were done.
<b>Jharkhand</b>						
Latehar	Banhordi block	10.57	1:4000	66	35,298	Block is allotted to JUUNL. Special tests are being carried out by CIMFR.
<b>Maharashtra</b>						
Nagpur	Dawa Phukeshwar area	-	-	04	1,158.30	During the year 0.12 million tonnes of coal deposit was proved and total coal reserves was proved at 10.70 million tonnes till end of 2014-15.
-do-	Nand-Panjrepar area	-	-	16	7,757.90	During the year 3.89 million tonnes of coal deposit was proved and the total coal reserves was proved at 35.86 million tonnes till end of 2014-15.
Yavatmal	Adkoli-Khadak-doh-Chichghat area	03	1:25000	08	1,722	During the year 4.11 million tonnes of coal reserves was proved and the total reserves was proved at 9.60 million tonnes by the end of the 2014-15.
-do	Ashtona Kothurna & Mangli area	-	-	05	915.50	During the season 0.63 million tonnes coal reserves was proved and the total coal reserves was placed at 2.5 million tonnes by the end of 2014-15.
<b>Meghalaya</b>						
West Garo Hills	Damal Asim	03	1:4000	03	82	Total 14 nos of pitting/trenching and 21 nos geo-chemical analysis were done.

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**Table-4: Exploration for Lignite by DGMs & Central/State Undertakings, 2014-15**

Agency/State/ District/Location	Mapping		Drilling		Sampling (No.)	Result
	Area (sq km)	Scale	No. of boreholes	Meterage		
<b>DMG, Rajasthan</b>						
<b>Bikaner</b>						
N/v Kenya-ki-Basti and Diyatra	-	-	24	4,113.80	122	Geological reserves of 9.79 million tonnes of lignite have been computed. Progressive total is 25.19 million tonnes.
N/v Bikampur, Tavariwala etc.	500	1:50000	-	-	-	No lignite/carbonaceous zones are found.
<b>Jaisalmer</b>						
N/v Deunga & Ainta	200	1:50000	01	195	146	Cumulative thickness of lignite found to be 0.55 m.
<b>Nagaur</b>						
N/v Phalki, Lunias etc.	400	1 cm =500 m	-	-	10	Carbonaceous zones were identified in tube wells.
<b>GMDC, Gujarat</b>						
<b>Bhavnagar</b>						
Surka (North)	-	-	43	4,494.68	222	Total geological reserves were estimated at 114.72 million tonnes (111).
<b>Kachchh</b>						
N/v Panandhro	-	-	-	-	-	Balance reserves of lignite at the end of March, 2015 was at 2.55 million tonnes.
N/v Mata No Madh	-	-	188	13,825.30	1348	-
<b>Surat</b>						
N/v Tadmeshwar	-	-	29	2,268	60	Recoverable (111) reserves is about 29 million tonnes.
<b>NLC</b>						
<b>Tamil Nadu</b>						
<b>Cuddalore</b>						
East of Sethiathope	-	-	41	12,888	149	It is inferred that this block has got substantial lignite resources.
Vayalamur	-	-	19	8786	29	Work was under progress.
<b>Rajasthan</b>						
<b>Barmer</b>						
Baytu block	-	-	01	72.30	-	-
Bhurtiya block	-	-	57	20077.70	300	Work was in progress.
Matasar Tala block	-	-	01	384.00	01	-
<b>Nagaur</b>						
Gangradi & Ucharda blocks	-	-	54	13,486.10	134	Work was in progress.
Deswal	-	-	15	3,393.10	15	-
East of Gangradi	-	-	05	12,44.10	-	Work was completed.

EXPLORATION & DEVELOPMENT

**Table - 5 : Exploration for Base Metals by GSI, 2014-15**

State/District	Name of block	Details of exploration	Results
<b>Andhra Pradesh</b>			
<b>BASE METAL</b>			
Cuddapah	Mangampeta area	Mapping and drilling	A deep lithostratigraphic-cum-structural drilling and large scale mapping of 52 sq km was carried out in Mangampeta area. The Mangampeta mine area which forms a part of Cuddapah basin and it comprises of rocks of Rajampeta minor basin of Nallamalai Group. Drilling of 1,600 m was carried out in two boreholes M-01 of depth 873 m with RL 84 m and M-02 of depth 727m with RL 260 m. The first borehole was drilled in the hinge of the synform of F1 fold in Mangampeta Barytes Mine near the old GSI borehole MGP 29 where the maximum thickness of barytes was recorded to check the occurrence of base metal below the bedded barytes horizon which is likely to occur in this type of deposit (Missisipian Valley Type deposits) and also to check for any other barytes bed other than the existing barytes bed. The second borehole was drilled 470 m east of first borehole along the dip direction to check the continuity of barytes bed which pinches out around 250 m due east of first borehole.
Guntur	Karempudi block	Pitting, trenching and XRD analysis	In the western and central parts of the Karempudi block, the dolomite band is sandwiched between phyllite with gradational contact both in up and down dip direction which are tightly folded with northern limb being overturned. An E-W trending dolomite band having about 24 m strike length and width up to 5 m having specks of chalcopryrite and galena is mapped at about 30 m SSW of proposed borehole KD-1. The Karempudi drilling block lies in the eastern part of the ENE-WSW trending Karempudi-Papayapalem mineralised dolomite band having 6.5 km strike length which is located in the extreme northern part of the 50 km long Agnigundla mineralised belt of Cuddapah basin. The ENE-WSW trending northern limb of anticline of the dolomite band extends about 700 m long having 12 m thickness shows gradational contact with phyllite hosts basemetal mineralisation (mainly galena) within a 4.5 m zone in central part. The central part of the dolomite is massive and has galena mineralisation in them. AAS analysis of dolomite from central part of the Trench-1 samples show up to a maximum of 1.9% Pb and 5,804 ppm Zn. Pitting and trenching across an E-W trending dolomite band of about 24 m strike length and width up to 5 m shows incidence of disseminated chalcopryrite, galena and bornite which is about 30 m. XRD analyses of dolomite samples (Nos KD-1/5X & K9/x) from trench-1 in general given 67%-90% dolomite, 7-17% quartz, 1-6% muscovite etc. with ~1% Owyheeite ( $Pb_7Ag_2(Sb,Bi)_8S_2O$ ), 2% cerrusite ( $PbCO_3$ ) & 1% galena.

(Contd.)

EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
Guntur	Karempudi, Khandrika area	Mapping and sampling	In the preliminary investigation for base metal and other associated mineralisation west of Karempudi to east of Khandrika area of Agnigundala mineral belt, a few gossanised bands in association with grey to black dolomite and chert are reported in the area at 4 km NW of Remedicherla. The gossan is highly silicified and contains sulphide disseminations such as sphalerite, pyrite, chalcopyrite etc. A potential block of about 1 sq km (1.75 km × 0.6 km) is identified and mapped on 1:2000 scale with the help of GPS and tape. A few silicified, brecciated and gossanised lensoidal chert bands are also reported in the area. The silicified and brecciated lensoidal chert bands occurs along the eastern margin of the purple dolomite which is in contact with shaly dolomite and are noticed at 2 km east of Domalugundam. These bands extend over a cumulative strike length of about 1 km having a maximum width up to 15 m. They are gossanised at a few places containing disseminated sulphides such as sphalerite, pyrite etc. Two potential zones for mineralisation are worked out in the area. First is a gossanised zone (1.75 km × 0.6 km) 4 km NW of Remedicherla. A detailed map of this has also been prepared in 1:2000 scale. The chert lenses occur within the purple dolomite 2 km east of Domalugundam. These chert lenses having a maximum thickness of about 15 m are highly silicified and gossanised. Mineralisation is mostly observed in the chert bands associated with the dolomites. The chert bands are full of pyrite disseminations but a few specs of galena or chalcopyrite are also common. Apart from this the cherty dolomite is also seen to contain mineralisation at few places as disseminations of galena.
<b>Arunachal Pradesh</b> COPPER	Pakke-Kessang area	Mapping and sampling	Large scale mapping was done around Pakke-Kessang area, covering an area of 51 sq km, detailed mapping around Ningcho covering an area of 0.5 sq km was investigated. The mapped area consists of Palaeoproterozoic rocks of Bomdila Group having metasedimentary enclaves of Khetabari Formation within the Ziro Gneiss. The Khetabari Formation comprises of schists and quartzites and is intruded by Rilo Granite, pegmatite, quartz veins and basic intrusives. About 2-3 m wide sulphide rich zones with intermittent barren zones have been identified over an extent of 150 m wide zone within the garnetiferous-quartz-biotite schist interbanded with thin bands of ferruginous quartzite, southeast of Pakke-Kessang. The thickness of the quartzite bands ranges from 7 cm-3 m. The main mineralised zone having 2 m wide oxidised band is 15 m wide and has been traced up to 60 m in strike continuity, whereas the entire zone having schistose quartzite and garnetiferous- quartz-mica schist is 30 m wide. The zone is marked by ferruginisation, limonitisation, sericitisation and malachite stains with few specks of chalcopyrite. Available analytical data of trench samples indicate 1,502 ppm to 2,498 ppm Cu, with an average of 0.196% Cu over a width of 6 metre.

(Contd.)

EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Haryana</b>			
<b>COPPER</b>			
Mahendragarh	South of Beghopur	EPMA Studies	G4 stage investigation of copper mineralisation was taken up to the south of Beghopur. The objective of the project was to assess the potential of copper mineralisation in depth as well as strike extension in alluvial covered area. Sulphide mineralisation i.e. chalcopyrite, pyrite and pyrrhotite is present as disseminations and specks along the foliation and fracture planes of quartz-biotite schist. EPMA studies of core samples confirm the presence of Ullmannite (NiSbS), Benavidesite (Pb <sub>4</sub> (Mn, Fe) Sb <sub>6</sub> S <sub>14</sub> ) and Gudmundite (FeSbS). Association of Ullmannite and Gudmundite with the ore minerals indicate hydrothermal origin of sulphide mineralisation. A total of 600.35 m drilling with three first level boreholes was carried out on the basis of geophysical anomalies interpreted from geophysical survey carried out in 2014-15. Analytical results of 128 core samples of SBBH-1 & 2 received so far indicate the value of different elements as Cu <5-529 ppm, Pb <10-107 ppm, Zn <5-2,360 ppm, Ni <10-398 ppm, Co <5-262 ppm. Total REE values in all 128 samples ranges from 51 to 477 ppm.
-do-	NE of Islampur	Drilling and EPMA Studies	G4 stage investigation of copper mineralisation was taken up in northeast of Islampur with an objective to assess the potential of copper mineralisation in depth as well as strike extension in alluvial covered area. EPMA studies of core samples show chalcopyrite veins in pyrrhotite, botryoidal pyrite, grains of sphalerite and small worm like galena hosted in chalcopyrite and pyrrhotite. Total 600.70 m drilling was completed on the basis of geophysical anomaly in three first level boreholes for a cumulative strike of 440 m to intersect the anomalies at 60 m vertically below the surface. A total 158 nos of core samples from the boreholes IPBH-1 to IPBH-3 were analysed for base metals and REE. Analytical results of 127 nos of core samples of IPBH-1 and IPBH-2 indicate Cu values 4 ppm-1619 ppm, Pb values <10 ppm-98 ppm, Zn values 10 ppm-3251 ppm, Ag values <1ppm, Co values <5 ppm-354 ppm and Ni values <10 ppm-271 ppm.

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EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Madhya Pradesh</b>			
<b>BASE METAL</b>			
Chhindwara	Belkheri block	Mapping and sampling	G4 stage exploration for base metals was taken up to assess the mineral potential of the host rock in Belkheri Block. Study in this area during 2006-07, has established two E-W trending 1,000 ppm zinc anomaly zones extending over a length of 400 m and 200 m respectively with a width of 50 m. Besides, one E-W trending 500 ppm Pb anomalous zone with a dimension of 250 m × 40 m was also established. Based on this, the area was taken up for G3 stage investigation during 2014-15. Detailed geological mapping was carried out in Belkheri area to delineate the host rock for base metal mineralisation. However, drilling could not be taken up for want of forest clearance. The sulphide mineralisation is represented by disseminations of sphalerite, pyrite, galena and minor chalcopyrite on freshly broken surface at many places. The analytical results of soil and bed rock samples were awaited and detailed assessment of the host rock will be done after receipt of the complete analysis.
<b>Maharashtra</b>			
<b>BASE METAL</b>			
Bhandara	Silejhari area, Sakoli Fold Belt	Mapping, sampling and analysis	G4 stage investigation to identify zones of anomalous base metal content viz; zinc and associated metals was taken up in this area. Presence of red, yellow and green ochres, limonitisation, ferruginisation and oxidation are frequently recorded in the chert bands, cherty quartzite and phyllites of the study area. Disseminations of sulphide minerals, which include mainly pyrite, chalcopyrite, sphalerite and covellite are observed in the chert bands, cherty quartzite and metabasalt from west of Silejhari and west of Bodra areas. The width of the chert bands varies from 0.5 m to 15 m having a maximum strike extension of ~300 m and trends mostly NS. Sulphide mineralisation occurs both as stratiform and stratabound nature in cherts and phyllites as well as hydrothermal nature associated with quartz veins. One BRS of oxidised chert band from west of Bodra indicated 0.13% Zn and 0.27% Pb and one sample of oxidised phyllite from the same area recorded 0.12% Zn. Seven samples of chert bands and phyllites from west of Silejhari shows presence of Tungsten ranging from 317 ppm to 587 ppm. 140 soil samples are collected on 100 x 20 metre grid along 7 traverse lines oriented E-W. Results received for 50 soil samples indicated values of Zn ranging from 125 ppm to 0.22% and Pb from 100 ppm to 0.18 percent.

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EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
Chandrapur	Bamni area block	Mapping, sampling and analysis	G-4 stage investigation was carried out to establish the base metal and associated gold mineralisation. LSM of 50 sq km area has been completed and it revealed that the quartzofelspathic biotite gneiss with amphibolites, known as Amgaon gneiss is the basement of the investigation area. A prominent quartz reef which intruded into the basement gneiss is exposed near Bamni and this is being mapped and sampled to establish the base metal and gold mineralisation. The quartz reef which is exposed in Bamni area trends N55°WS55° E for about 400 m in strike length with varying width from 02 m to 15 m. The quartz reef is mineralised at places intermittently in smoky grey portions. The primary sulphide phases identified include chalcopyrite, pyrite, sphalerite and galena. Pure sulphide phases are separated from the quartz reef sample and submitted for sulphide isotope study. Samples from Bamni quartz reef were submitted for fluid inclusion study to understand the fluid composition, temperature and pressure at which the hydrothermal deposit was formed. Bed rock samples are collected across the strike of the mineralised zone by channel and chip sampling from the quartz reef for chemical analysis. Chemical results of bed rock samples show the Cu values ranging from 30 ppm to 0.37 % while Pb varies from 73 ppm to 0.65% (one sample shows 1.12%) and Zn from 15 ppm to 0.63% (one sample shows 4.8%). Chemical analytical results of soil sample (65 nos) show he Cu values ranging from 10 ppm to 150 ppm while Pb varies from 25 ppm to 600 ppm and Zn from 20 ppm to 125 ppm. Ore petrography and SEM-EDS study is carried out and different sulphide phases are identified.
-do-	Nai Dilli and Lal Heti areas	Drilling sampling and analysis	G3 stage investigation of copper and associated mineralisation was taken up in this area. In Lal Heti block, leucocratic Mul granite is exposed in which the thin quartz vein is emplaced along the Thanewasna shear zone. In these two blocks, surficial evidence such as malachite staining and covellite as well as the occurrence of chalcopyrite and pyrite as observed in quartz vein indicate the hydrothermal activity in the area. In core samples of quartz chlorite veins, chalcopyrite and pyrite occur in the form of dissemination, veinlets and chunks. Eight boreholes were drilled which include four in Nai Dilli and four in Lal Heti blocks. In Nai Dilli block, the NDBH-1, one mineralised zone having an average grade of 0.23% Cu value is demarcated. In borehole no. NDBH- 2, total seven mineralised zones were demarcated with grade of Cu varying from 0.20% to 0.42%. The maximum gold value of 950 ppb is also recorded in one sample of NDBH-2. In Lal Heti Block, one mineralised zone having an average grade of 0.20% Cu is demarcated within LHBH- 1. In LHBH-2, two mineralised zones were identified with Cu grade varying from 0.21 to 0.42 percent.

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EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Rajasthan</b>			
<b>COPPER</b>			
Alwar	Mejorh - Bamanwas-Bisoni-block	Sampling and analysis	G4 stage investigation for copper and associated precious metals was carried out in this block, south west of Mundi yawas - Khera area. Based on surface indications of mineralisation in the form of malachite stains, fresh sulphides and old workings, three potential areas have been demarcated i.e. Angari block, Bisoni block and Mejorh block. The analytical results of the bedrock samples of the Angari block ranges from 10 ppm to 0.18 percent.
-do-	Mundi yawas block	Geo-chemical analysis	G3 stage investigation of copper and associated precious metals was carried out in Mundi yawas block, Mundi yawas-Khera area. Investigation was carried out to test the sub surface continuity of the Cu and associated precious metals. The rock types exposed are mica schist, quartzite, carbon phyllite, felsic meta-volcanics, dolomite and amphibole bearing dolomite and are traversed by quartz and calcite veins. Five boreholes drilled during 2014-15 intersected significant sulphide mineralisation in the form of specks, disseminations, stringers, fracture filling and occasional massive sulphides in the form of chalcopyrite, arsenopyrite, pyrrhotite and minor pyrite. Part analytical results of borehole MUBH-1 shows mineralisation between 198.0 – 203.0 m = 5.0 m × 3.66% Cu at 0.2% Cu cut off with 19.11 g/t Ag, 200.0 – 202.40 m shows 2.40 m × 7.29% Cu (at 1.0% Cu cut off) with 33.64 g/t Ag.
-do-	Khera SE block	Geo-chemical analysis	G3 stage exploration in Khera SE block, Mundi yawas- Khera area, was carried out for copper, which is located in the SE of the Khera main block. Four boreholes drilled during 2014-15 intersected significant sulphide mineralisation. In the form of occasional foliation parallel, specks, stringers, fracture and vein filled chalcopyrite and pyrrhotite. Part analytical results received show significant Cu mineralisation intersected in the borehole KEBH-6 as given below: Cu lodes at 0.2% Cu cut off: 127.0-147.75= 20.75 m × 0.41%, 151.25-164.75= 13.50 m × 0.34%, 169.30-171.30= 2.0 m × 0.30%, 175.30-178.30= 3.0 m × 0.21%, Cu lodes at 0.5% Cu cut off: 127.55 - 129.70 = 2.15 m × 0.50%, 139.25 - 147.25 = 8.00 m × 0.66%, 157.15 - 160.25 = 3.10 m × 0.70 percent. (Contd.)

EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
Alwar	Khera block	Drilling	Exploration (G-3) by deep drilling was carried out to evaluate the depth continuity & grade of the ore at deeper levels. Two boreholes drilled intersected light grey to dark grey coloured felsic meta volcanic with thin bands of felsic tuff, scapolite rich bands and thin cherty quartzite bands and tremolite bearing marble. A number of thin smoky quartz occurs at different depths along the borehole. Bluish quartz and clasts of felspar present at places. Besides, zone of brecciation/fault zone observed with angular fragments set in finer matrix. The boreholes intersected sulphide mineralisation in the form of specks, disseminations, foliation parallel, vein filling, fracture filling and occasional massive chalcopyrite, arsenopyrite and pyrrhotite.
BASE METAL Bhilwara	Kundiyan-Parmeshwarapura and Dhamana -Devariya blocks	Sampling	G4 stage investigation for base metal was continued from 2013-14 in these blocks and geochemical sampling on 100 m × 25 m grid pattern has been carried out in Dhamana–Devariya block. Mapping revealed two distinct lithounits exposed in the area, they are calc silicate and amphibole bearing calc silicate rock in the form of alternate bands, belonging to the Rewara Formation of Pur-Banera Group of rocks. The surface indications of sulphide mineralisation in the block found in the form of profuse malachite stains & disseminations of chalcopyrite, bornite and covellite in the exposed calc silicate and amphibole bearing calc silicate rock. Samples for petrochemical (12 nos) and petrological studies were collected from the area. Out of the 440 nos geochemical samples, 52 nos of samples are bed rock samples and 388 nos are soil samples. Besides the bed rock/soil sampling, a total of 12 nos of channel samples were also collected.
-do-	Salampura and Dariba blocks	Drilling and analysis	G4 stage investigation for basemetal was taken up these two blocks in northern extension part of Salampura block, Pur-Banera Belt. Mineralisation in this block is associated with garnet-biotite-sericite schist, magnetite bearing calcareous schist, Banded Magnetite Quartzite (BMQ) and calc-silicate sequence. The presence of old workings, oxidised and gossanised material and presence of BMQ are the important surface manifestations of mineralisation. A total of 484.85 m drilling was carried out in three boreholes numbered SBH-17, SBH-18 and SBH-19. These boreholes were planned to test the soil geochemical anomaly of Cu, Pb and Zn at 60 m to 80 m vertical depth i.e. first level intersection. SBH-17 intersected two Cu and one Pb+Zn mineralisation, Cu mineralised zone-I from

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Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
			36.65 m to 40.65 m (4 m × 0.12% Cu); zone-II from 126.00 m to 130.30 m (4.30 m × 0.95% Cu); Pb+Zn mineralised zone-I from 64.15 m to 66.90 m (2.75 m × 1.0% Pb+Zn). This borehole was closed at depth of 164.65 m. The borehole no. SBH-18 and 19 intersected soil geochemical anomaly at first level mineralisation and were closed at depth of 153.70 m and 166.50 m, respectively. Chemical analytical results of these two boreholes are not received.
do-	Rampuriya-Gadariyakhera North block	Channel sampling, drilling and geophysical logging	Investigation for base metal and associated precious metals was taken up in Rampuriya-Gadariyakhera North block. There are two BMQ bands; the western BMQ band trending NNE-SSW, reddish in colour, feebly magnetic with thickness varying from few centimetres to few metres is favourable host rock for mineralisation. Results of three channels cut south to north from western BMQ band gave encouraging results viz. 1) RCH-4 - 1.7 m × 2.5% Pb+Zn (Southern most), 2) RCH-8 - 9.5 m × 1.86% Pb+Zn, RCH-9 - 8.6 m × 1.19% Pb+Zn (Northern most). Three nos of boreholes namely BRG-1, BRG-2 and BRG-3 (150 m each) were planned to check the subsurface continuity of mineralisation below the above mentioned channels. A total drilling of 450 m was carried out and a total of 192 nos of processed core samples were submitted to Regional Geochemical Laboratory, WR. Geophysical logging of all the three boreholes was also carried out. The dominant lithology intersected in all the boreholes is garnet quartz mica schist. Borehole BRG-1 (Southern most) intersected the mineralised zone of 1.90 m × 4-5% Pb + Zn (VE) from 105.70 m to 107.60m depth along the borehole and 0.47 m × 3-4% Pb + Zn (VE) from 117.90 to 118.37 m. BRG-2 intersected a mineralised zone of 2.68 m × 1-1.5% Pb + Zn (VE) from 87.60 to 90.28 m, 1.92 m × 1% Pb + Zn (VE) from 90.88 to 92.80 m, 0.53 m × 1-1.5% Pb + Zn (VE) from 100.75 m to 101.28 m and 0.47 m × 1-1.5% Pb + Zn (VE) from 110.33 to 110.80 m. BRG-3 intersected mineralised zone of 1.58 m × 1-1.5% Pb + Zn (VE) from 71.49 to 73.07m, 0.68m × 1-1.5% Pb + Zn (VE) from 76.33 to 77.01m, 0.59 × 0.5-1% Pb + Zn (VE), from 81.16 to 81.75 m, 0.50 m × 1% Pb + Zn (VE) from to 92.65 to 93.15 m, 0.30 m × 1.5 - 2 % Pb + Zn (VE) from 96.96 to 97.26 m, 0.47 m × 0.8-1% Pb + Zn (VE) from 103.38 to 103.85 metre.

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EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
Bhilwara & Ajmer	Sandmata complex	Mapping, sampling and analysis	<p>Investigation for base metal and gold was taken up in Sandmata Complex terrain. An area of 51 sq km was mapped by LSM (on 1:10000 scale) in and around Hanutiya, Garvar, Sapola, Devpura and Dhanikhera village of Masuda tehsil of Ajmer district. Larger part of the mapped area falls in the Sandmata Complex and Mangalwar Complex of Bhilwara Supergroup. Surface indication of mineralisation is found in the form of several detached old working pits, slag heaps, malachite encrustation and fresh sulphides (pyrite, chalcopyrite, azurite) occur in gritty conglomerate. There is a series of 4-5 old-workings on the northwestern part of the Hanutiya metasedimentary sequence. This gossanised/oxidised zone consists of cherry-red encrustation of sulphide and yellowish stains of limonite occurring in the mapped area. Gritty conglomerate with schistose matrix with detrital tourmaline is the main host rock for sulphide mineralisation. The sulphide mineralisation in the Hanutiya area is mainly controlled by lithology i.e. gritty conglomerate. Sulphides occur as specks and dissemination. The strike of the zone of mineralisation is NE-SW which is parallel to the regional strike of rocks indicating structural control on mineralisation (axial traces of both F1 &amp; F2 fold). Mineralisation is also associated with the silicification (low temperature hydrothermal alteration). The northeastern extension of already explored Hanutiya block has been demarcated for possible zone of mineralisation based on the presence of profuse malachite stain, oxidation and gossanisation within the gritty conglomerate. The zone extends 350-400 m in strike, with a width of 100m to 150m, importantly, it is in continuation of old working zone in the southwest. The litho-geochemical prospecting was carried out in the area to establish the anomalous zone of basemetal and gold mineralisation. Oxidised/gossanised rocks with indication of mineralisation were sampled (grab and chip sampling). Total 304 nos of bedrock samples (grab &amp; chip) were processed following standard procedure and submitted for the chemical analyses. Total analyses of 149 nos of bedrock samples have been received, out of them one sample of slag from Hanutiya area analysed 2.6% Cu, two samples from sheared quartz vein from nearby Sapola analysed 0.37% Pb, 0.14% Cu and 0.24% Pb, respectively. One samples from gritty conglomerate from the extension zone of already explored Hanutiya block yielded 2.6% Cu.</p>

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EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
Jaipur & Alwar	Tehla-Khoh-Bighota area	Channel sampling and analysis	G4 stage investigation for basemetal and associated precious metals was taken up in this area. Based on surface indications of mineralisation in the form of malachite stains and fresh sulphides, channel sampling was carried out to the west of Palpur, west of Baldevgarh area, north of Baldevgarh area and west of Kho area. The analytical results of BRS samples show 0.21% Cu at west of Palpur, 0.34% Cu at NW of Tilwari-Dabkan area, 0.22% Cu from Doli-khan stone quarries SW of Palpur.
COPPER Jhunjhunu	Bokri & Malwali prospects	Sampling and mapping	In Bokri and Malwali prospects of eastern Khetri metallotect, investigation was taken up for copper and associated minerals in gap area. An area of 1.19 sq km has been mapped on 1:2000 scale along with pitting and trenching of 50 cu m. A total of 460 nos of bed rock samples were collected on 100 m × 25 m grid and 60 nos of pitting and trenching samples were also collected. The surface manifestations of mineralisation are development of gossans as observed at places in the fault zone, malachite staining within the thin discrete shear zone, malachite and azurite staining over magnetite quartzite and at places in calc-silicate body. The calc-silicate body shows mineralisation of chalcopyrite, pyrrhotite, pyrite and bornite associated with blotches of recrystallised calcite. Chemical analyses of 116 of bed rocks samples from calc-silicate rocks and quartzite shows copper values from 20 ppm to 6,616 ppm (0.66 %). A total of 3 nos of bed rock samples have been assayed with over 0.10 % Cu.
BASE METAL Sikar	Nanagawas area	Mapping, drilling and analysis	G3 stage investigation for base metal was taken up in west of Nanagwas area. Two mineralised zones MZ-I & MZ-II were delineated on surface. MZ-I in the northern part of mapped area, extending for about 450 m in strike length while MZ-II extends for about 800 m in strike length. Both these zones were drilled by 10 number of borehole and a resource 8.05 MT × 0.34% Cu (at 0.2% cut-off) has been estimated by cross section method. During 2014-15, a total of 1,065.95 m drilling has been completed in 4 second level boreholes (WNBH-11 TO WNBH-14) in the northern part of the area. All the boreholes show thickening of zones with depth. Sulphide mineralisation occur in the form of disseminated, vein/ vug filled, fracture filled and stringers of bornite (2Cu <sub>2</sub> S•CuS•FeS), chalcopyrite (CuFeS <sub>2</sub> ), covellite (CuS), chalcocite (Cu <sub>2</sub> S) and pyrite (FeS <sub>2</sub> ). First borehole WNBH-11 was planned behind borehole WNBH-1 to intersect the lodes intersected in borehole WNBH-1 at depth. Depth of this borehole is 308.95 m. Analytical results of borehole WNBH-11 shows the following Cu lodes at 0.2% Cu cut-off 226.25 m to 232.50 m (6.25 m × 0.40% Cu), 237.80 m to 244.10 m (6.30 m × 0.28% Cu), 274.70 m to 279.75 m (5.05 m ×

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EXPLORATION & DEVELOPMENT

Table - 5 (Contd.)

State/District	Name of block	Details of exploration	Results
			0.24% Cu), 288.86 m to 291.75 m (2.89 m × 0.20% Cu) and 293.90 m to 296.00 m (2.10 m × 0.31% Cu). WNBH-12 is the second level borehole planned for deeper level intersection of the lodes intersected by WNBH-2. The borehole WNBH-12 was drilled up to 256.20 m depth. Analytical results of borehole WNBH-12 shows the following Cu lodes at 0.2% Cu cut-off, 158.70 m to 171.85 m (13.15 m × 0.31% Cu), 180.20 m to 205.95 m (25.75 m × 0.22% Cu), 209.15 m to 225.65 m (16.50 m × 0.12% Cu) and 230.05 m to 232.00 m (1.95 m × 0.14% Cu). The third borehole WNBH-13 has been planned as second level borehole in between the boreholes WNBH-4 and WNBH-9 to test the subsurface continuity of copper mineralisation between WNBH-4 and WNBH-9.
Sikar	Palaswala-ki-Dhani block	Mapping, sampling and drilling	G3 stage investigation for basemetal was taken up in southeast area of this block. The bed rock sampling has been done at a 100 × 25 m grid and collected 107 nos of samples from the area. Three surface mineralised zones have been delineated on the studied area. Two zones (MZ-I & MZ-IA) are in the eastern part of the area and zone (MZ-II) is in western part of the study area. The zone(MZ-I) is the extension of the previously delineated mineralised zone on western limb, which is very thin and shows pinch and swell nature having 2 to 4 m width with 400 m strike length. The Zone (MZIA) is the eastern most zone having 250 m strike length and width varies from 2 m to 10 m. The 3rd surface mineralised zone (MZ-II) has been delineated on the western part of the study area having about 200 m strike length with thickness varying between 10 to 15 m. The surface indications of mineralisation is in the form of malachite staining, intense ferruginisation, presence of occasional fresh pyrite, chalcopyrite, bornite and specularite associated chalcocite hosted within biotite rich marble, amphibole marble and dolomitic marble. A total of 961.50 m drilling has been done by targeting the surface mineralised zone. All the boreholes intersected the sulphide mineralisation at the projected depth; however it is noticed that the concentration of copper mineralisation is weak in all the boreholes. The boreholes intersected two sulphide zones nearly at a depth of 60 m and 90 m, except borehole PDBH-5.
-do-	Mahawa North block	Bedrock/ channel sampling and analysis	G4 stage investigation for basemetal was taken up in Mahawa North block. The evidences of sulphide mineralisation are present in lithounits belonging to Kushalgarh formation of the Ajabgarh Group of the Delhi Supergroup. The surface evidence of sulphide mineralisation is present in the form of Malachite stains. In total 112 nos of bedrock samples and 164 nos of channel samples were collected. About 20 nos of samples were collected for petrological and ore petrographic study. 54 cu m of trench was dug to check continuity of lithounits under soil cover. The partial analytical results available so far indicate encouraging values for copper. For channel sample, the value of copper ranges from 0.2% to 1.0%, whereas in bedrock samples Cu values ranges from 0.2% to 0.88 percent.

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EXPLORATION & DEVELOPMENT

Table - 5 (Concl.d.)

State/District	Name of block	Details of exploration	Results
Sikar	SE of Kharagbinjpur	Mapping, bedrock/ channel sampling and analysis	G4 stage investigation for basemetal was taken up in southeast of Kharagbinjpur. The potential area for mineralisation has been identified on the basis of surface evidences within the mapped area and detailed mapping has been carried out. A total of 0.60 sq km area has been mapped in 1:2000 scale along with channel sampling and bed rock sampling. In the northern part of the block, a surface mineralised zone defined by occurrence of disseminations of pyrite and chalcopyrite, in thin bands of ferruginised dolomitic marble without malachite staining. The zone is confined to the western limb of a mesoscopic fold and is exposed discontinuously for a distance of about 1300 m, varying in thickness from 5 m to 15 m. Three grab samples collected from the northern part of these bands of 0.30 m to 0.50 m in width showing Cu content 0.38%, 0.34% and 0.19 percent.
-do-	Toda Ramliyas block	Drilling and analysis	G3 stage investigation for basemetal was taken up in Toda Ramliyas block, Nim Ka Thana belt. During 2013-14, two mineralised zones were delineated on the surface, the one prominent zone was traced for about 1.5 km strike length with Cu values varying from 200 ppm to 10,000 ppm. The subsurface investigation by drilling was taken up in Toda-Ramliyas block in 2014-15 to test the subsurface copper mineralisation of the 1.5 km strike length (MZ-I) on the basis of analytical results of bed rock and channel samples. A total of 1,037.80 m of drilling was done in six boreholes. The borehole TRBH-1 was drilled to a depth of 133.30 m and intersected sulphide mineralisation from 90 m to 97.70 m and 101.10 m to 127 m with V.E. 0.1-0.2% Cu in the form of disseminations, stringers and veins of chalcopyrite, bornite, covellite, pyrite and specularite. The borehole TRBH-2 was drilled to a depth of 156.70 m and analytical results indicated copper lodes 60.45 - 68.35 = 7.9 m × 0.2% Cu and 94.30 - 103.22 = 8.92 × 0.31% Cu. The borehole TRBH-3 was drilled to a depth of 151.60 and analytical results shows a copper lode 119.20 - 128.20 = 7 m × 0.62% Cu. Borehole TRBH-4 was drilled to a depth of 210.20 m and intersected sulphide mineralisation from 167.35 m to 200.05 m (V.E.0.1-0.2%), the borehole TRBH-5 was drilled to a depth of 210.00 m, which intersected sulphide mineralisation as expected at 180.25 m to 190.65 m (VE0.1-0.2% Cu). The borehole TRBH-6 was drilled to a depth of 176.20 m and didn't intersect any significant sulphide mineralisation.

## Bauxite

### GSI

During 2014-15, in Chhattisgarh a G4 stage investigation for bauxite was carried out in Chilpi area. A base map was prepared for 2.5 sq km and a total of 4 nos of BRS, 2 nos of PCS, 6 nos of samples for chemical analysis were collected. A G4 stage investigation was carried out for bauxite ore in Jawaharnagar-Khajri-Barpat-Chandadarhi area, Balrampur district. A total of 50 sq km area was covered by LSM (1:12500 scale), 2 sq km by DM on 1:5000 scale and PT of 159.462 cu m. Collection of a 25 BRS, 10 each for PCS & SEM studies, 50 each from PTS and channel samples was carried out. 135 samples were submitted for analyses. The area mainly comprises Precambrian metasediments and metabasics, Deccan trap rocks and laterite of Recent age. The laterite is characteristically red, yellow and brown in colour. It is pisolitic to massive type, porous and sparsely oolitic. Aluminous laterite occurs as irregular pockets and lenses throughout the mapped area. In the west of Karundha village, pockets of massive bauxite extends upto 200-300 m. In the east of Damchuan village in a scarp section massive bauxite of 200 m length and 2 to 3.5 m thickness is observed. Pisolitic/oolitic bauxite is also observed in the Damchuan plateau. The size of the pisolites varies from 2 mm to 1 cm. In the south of Chandadarhi village, pocket types of ore body extend up to 1.5 km underlain by laterite. Thickness varies from 0.5 to 1 metre. 15 numbers of pit excavated which show the pocket nature of bauxites in Chandadarhi plateau. Laterite was also observed to the east of Premnagar, Bijatoli and Mahuatoli village which contains few lenses of bauxite at places. The laterite is characteristically red, yellow and brown in colour. It is pisolitic to massive type, porous and sparsely oolitic. Aluminous laterite was observed in the south of Damchuan village. 97.61 cu m volume of pit was excavated which shows the pocketed nature of bauxite. Detailed mapping was carried out in Damchuan block. Aluminous laterite was observed in and around Damchuan village. Massive and pisolitic bauxite occurs between 1,020 m to 1,040 m above msl in Damchuan, between 980 m and 1,100 m above msl in Chandadarhi and 1,100 m above on the surface as pockets in north of Khajri

village. In the west of Karundha village, pockets of bauxite extend laterally for 200 metres. Chemical analytical data for 22 BRS, 34 channel, 20 pit and 03 PCS samples was received from Chemical Division, GSI Nagpur.  $Al_2O_3$  values range 47.81-54.17% in BRS, 30.31-58.42% in channel sample, 30.75-58.27% in pit sample for bauxite and 24.46-37.98% for laterite in BRS.  $SiO_2$  ranges from 1.21 to 4.95% for bauxite and 6.59 -10.85% for laterite in BRS.

In Meghalaya, 1.50 sq km DM and 26 cu m pitting and trenching have been completed in the investigation for lateritic bauxite around Rambrai area West Khasi Hills district (G4). The lateritic bauxite observed in the area is buff and brick red in colour. Pisolitic structure was also observed at many places. Four main bodies of lateritic bodies were identified in the area having the following dimensions, viz, 1<sup>st</sup> body: 900 m length  $\times$  400 m width; 2<sup>nd</sup> body: 260 m length  $\times$  150 m width; 3<sup>rd</sup> body: 280 m length  $\times$  100m width and 4<sup>th</sup> body: 620 m length  $\times$  350 m width. Besides these four main bodies, four small patches were also identified in the northwestern and northeastern part of the area. A total of 26 m trenches have been dug in these bodies in order to collect samples as well as to expose the lithology in soil covered areas. 50 m of sections were exposed in bauxite bodies to study the complete weathering profile. The thickness of the complete profile of lateritic bauxite is about 8-10 m. A total of 13 nos petrological samples, 8 nos samples for ore microscopy and 6 nos of XRD samples were collected to study thin/polished sections to understand the ore mineral phases. A total of 78 nos. of BRS samples were collected from lateritic bauxite for chemical analysis. Analytical results received so far show encouraging values of  $Al_2O_3$  ranging from 15.33% to 60.88% with an average value of 38.5%. Cr and V are also showing encouraging values up to a maximum of 1,230 ppm and 875 ppm, respectively.

### State Directorates

During 2014-15, Directorate of Geology & Mining, Chhattisgarh conducted exploration for bauxite in Darai area, Kabirdham district (Mapping on 1:50000 and 1:4000 scales in 153 sq km and 1.79 sq km areas, respectively; 116.8 cu m pitting; 1,594

m drilling in 174 boreholes; 969 sample collections and estimation of about 5 lakh tonnes of bauxite); in Kindha area, Raigarh district (Pitting: 24 cu m in 3 pits) and in Dandkeshra block, Mainpat plateau, Surguja district (Mapping on 1:50000 and 1:4000 scales in 128 sq m and 2.11 sq km areas, respectively; 150 cu m pitting; 1,483.6 m drilling in 137 boreholes; 1,098 nos of sample collection and estimation of about 6 lakh tonnes of metal grade bauxite).

During 2014-15, Directorate of Geology and Mining, Maharashtra carried out 40 sq km mapping and 33 nos sampling for bauxite/aluminous laterite in Guhaghar area, Ratnagiri district.

## FERROUS MINERALS

### CHROMITE

#### GSI

In Nagaland, a G4 stage investigation for chromium and associated base metals was taken up during 2014-15 in the 'ophiolite belt' in and around Waziho, Ziphu, Moki, Satuza, Phor, Sutsu, Laluri, Washelo villages and Shilloi Lake (Lacham) in Phek district. The lithounits of the ophiolite suites are peridotite, gabbro, basalt, chert and limestone. The general trend of lithounits is in N-S direction. Surface indications for sulphide mineralisation are recorded in Moki village. Malachite staining disseminations of chalcopyrite and pyrite are recorded for about 7 m with 3-4 m in width, along a fracture plane within peridotite. A sample collected from northwestern extension area of this zone analysed 3.662% Cu. Analytical results of 36 nos groove samples collected from a groove gave Cu values 353 ppm to 21,711 ppm.

In Odisha, a G4 stage investigation for chromite was taken up during 2014-15 in North Bhuasuniparbat block, Dhenkanal distt, with an objective to evaluate possible occurrence of chromite bodies by test drilling. The study area is located in the contact between Eastern Ghat Mobile Belt (EGMB) and Supracrustals of Singhbhum Craton (SC). A number of discontinuously occurring ultramafic bands occur from Chandar to Tangeria-Bhuasuniparbat-Tulasipasi. It is represented by silicified serpentinite, altered peridotite, pyroxenite, gabbroic anorthosite, magnetite and gabbro etc. Chromites are found to be associated with serpentinite and silicified serpentinite in the form of dissemination, stringers, veins and thin bands.

Seven boreholes were drilled to study the presence of chromite at depth. On the basis of present work, ultramafic bands extending for 250 m strike length in the eastern part and 200 m strike length in the central part of the block with disseminations of chromite have been identified. A 1.40 m thick chromite band (23.03% Cr<sub>2</sub>O<sub>3</sub>) was also intersected in borehole no BBH-3 at the depth from 52.95 to 54.35 metre.

During 2014-15, in Chimalpahad Ultramafics Complex in Khammam distt, Telengana, LSM has been carried out with a two fold objective - to carry out investigation for chromite and PGE along with other mineralisation. The chromite occurs as podiform lenses within the ultramafic unit viz. dunite, pyroxenite, websterite, talc-tremolite schist and form thickened sheaths within the layered sequence. These Ultramafic units may be emplaced along the shear zones trending in N-S, NE-SW direction. Leucogabbro is the predominant rock type with 70-80% of plagioclase and 20-30% of mafic minerals. On the basis of percent of mafic minerals this leucogabbro classified megascopically into gabbroic anorthosite and anorthositic gabbro with mafic and felsic layering. The thickness of layering ranges from few mm to 2-3 cm. The layered portion has been sampled for Chromite & PGE analysis. Few discontinuous lenses of pyroxenite having dimension 4-5 m in length and 1-2 m in width have also been noticed around Vinobanagar, Himannagar and Rangapuram villages. The pyroxenite is blackish green in colour with fine to medium grained texture. Float chromite mineralisation is noticed in Shriramgiri, Jannaram, Linganpeta and Yenkur areas. The chromite mineralisation occurs within talc tremolite schist which is the alteration product of pyroxenite. Talc-tremolite schist with disseminations of chromite is associated with innumerable calcareous material/caliche along the shear zone as observed near Konnayapalem, Yenkur and Linganpeta villages. Potential zones for chromite mineralisation was identified within ultramafic units around known mineralised area/old chromite quarries on the basis of abandoned mines, float ores and scattered ultramafic assemblages. During pitting and trenching, the weathered anorthosite along with leucogabbro in trench T3 and T4 and weathered talc-tremolite schist in T5 & T6 were encountered. This weathered talc-tremolite schist may contain chromite mineralisation. Trenching was carried out in intervening areas between known mineralised zones near Nacharam,

Vinobanagar and Himamnagar areas on the basis of exposed in situ pyroxenite bodies. These bodies seemed to be lensoidal and of very small dimension. Seven to eight zones of Ti-V magnetite has been traced near Rampuram Tanda, Ramanapalem, Vinobanagar, Rangapuram, Bajumallayagudem and Burdaraghavpuram villages which may be favourable locale for PGE mineralisation. These bodies are associated with pyroxenite and leucogabbro of Chimalpahad ultramafic complex which indicates that magnetite may have been formed as cumulates during fractional crystallization of basic magma forming layered complex. These zones are having extension over a strike length of approximately 200-300 m and are lumpy, bouldery in nature and have sporadic occurrences. The V-Ti magnetite layers at the surface are partially oxidised and broken into rectangular to triangular fragments due to weathering and spread as float-ore covering a large area in the cultivated land. The EPMA analysis of chromite shows  $\text{Cr}_2\text{O}_3$  content ranges from 50.319 to 51.841%, FeO ranges from 29.663% to 30.993%,  $\text{Al}_2\text{O}_3$  ranges from 14.235% to 15.05%, MgO ranges from 2.523 to 10.21%. As per the data so far received from chemical laboratory the layered anorthosite and massive anorthosite from Chimalpahad ultramafic complex shows Cr % values ranging from 100-3,807 ppm with 10-389 ppm copper and 10-1,540 ppm nickel, while float chromite ore from the quarry shows 41.09 % of Cr. Whole rock analysis of ultramafics in the area shows low PGE – concentration: Ir = 21 ppb, Ru = 96 ppb, Rh=5 ppb, Pt = 12 ppb and Pd =23 ppb. The chemical analysis of V-Ti magnetite shows FeO upto 46.94%,  $\text{TiO}_2$  up to 49.06% and  $\text{Cr}_2\text{O}_3$  upto 0.81% and Vanadium up to 6,990 ppm.

#### **Mysore Minerals Ltd. (MML)**

During 2014-15, MML carried out exploration for chromite in Thagadur chromite mines by geophysical mapping on 1:1000 scale, analysed two samples and estimated of 5.02 lakh tonnes resources.

#### **Odisha Mining Corporation Ltd (OMC)**

During 2014-15, OMC carried out exploration for chromite in various mining leases and exploration activities include - In Jajpur district : (i) South-Kaliapani: mapping on 1:1000/1:2,000 scale in 17.5 ha and 103 ha, respectively, chemical analysis of 150 nos

of samples and 27.80 m drilling in two boreholes and (ii) Sukrangi: 205 nos sampling and 202.20 m drilling in three completed and one running boreholes. Similarly, exploration in Bangur chromite mine, Kedujhar distt includes - mapping 1:2000 scale in 120 ha, chemical analysis of 10 nos samples and 259 m drilling in two boreholes.

## **IRON ORE GSI**

In Andhra Pradesh, a G4 stage investigation was carried out during 2014-15 in Yerrabali Area, Karimnagar distt, to search for iron ore. LSM helped in delineation of a NW-SE trending banded magnetite/hematite quartzite band for a strike length of 4.5 km with width varying from 50 m to 70 m. Another band trending NNW to SSE for a strike length of 2 km length with a width of 30 m is recorded to the east of the above band.  $\text{Fe}_2\text{O}_3$  values within the banded magnetite/hematite quartzite range from 30.94 to 80.22%. A G4 stage investigation for iron and manganese ore was carried out in Vedullacheruvu – Krishnapuram, Chandragiri and Srikalahasti Taluk, Chittoor distt with an objective to delineate the iron ore bands along with manganese ore. The study area exposes quartzite and phyllite of Bairenkonda Formation and phyllite of Cumbum Formation & Cuddapah Supergroup. The intercalated sequence of quartzite and phyllite is found to host iron and manganese bands. The band very close to the contact with massive quartzite is the thickest with width ranging from 8-12 m for a strike length of around 1.5 km. Another significant band is in the east central part of the intercalated sequence of quartzite and phyllite with average thickness of 8 metre.

In Arunachal Pradesh, a G4 stage investigation was carried out in Jaiyor-Yomgum-Gamkak area, West Siang district. Bands of magnetite quartzite were mapped by detailed mapping. Three inclined scout boreholes with depths ranging from 100-150 m (total 400 m) were drilled for establishing the depth persistence of the magnetite quartzite and associated ironstone bands. In the first borehole YJ-1, manifestation of iron mineralisation and disseminated sulphides were observed from 38.50 m to 150 m depth. A zone of magnetite with relatively higher concentration is observed from 62.90 m to 94.50 m along borehole depth and at a vertical depth

of 35 m. A rich zone of sulphide mineralisation (pyrite, chalcopyrite, pyrrhotite, bornite) was intersected from 38.85-39.30 m along the borehole depth. The second borehole YJ-2 has intersected the iron mineralised zone at the depths of 52-58 m, 82.35-88 m and 93.50-97m along the borehole. Sulphide mineralisation occurs in the form of disseminations, specks, veinlets/stringers and smears of pyrite and chalcopyrite from 38.10-82 m along the borehole and rich zones are intersected at 38.10-46 m, 49-61m, 73-82 m, 88.10-88.15 m and 122-124 m. In the third borehole YJ-3, highly ferruginised quartz-mica schist ( $\pm$  garnet) is observed from 24.55-50 m. Magnetite bearing quartzite is intersected at borehole depth of 84-86m and 97.20-100 m, magnetite occurs as disseminations and also as stretched grains along the foliation. Sulphide-mineralised zone is intersected at 50-58.50 m along the borehole.

In Karnataka, a G4 stage investigation for iron ore was carried out in Amingad-Kamatgi-Sirur (Hungund-Kushtagi Schist belt) Bagalkot district. The schist belt comprises metabasalt, meta-acid volcanics, Banded Iron Formation (BIF), meta-argillite and minor intercalated meta-sedimentary units like quartz-chlorite schist and greywacke. Four banded hematite quartzite bands trending NNW-SSE are delineated with width ranging from 10 m-35 m. One BHQ band is traced for 2.4 km strike length east of Huvinahalli. The bands are highly deformed. Analytical values obtained indicate  $Fe_2O_3$  up to 45%. A G4 stage investigation for iron ore was taken up in Basavapatna-Kerebilichi block, Channagiri taluk, Davanagere distt, with an objective to assess iron ore and gold in BIF. The BIF in the area is mainly banded hematite quartzite, at places it is banded magnetite quartzite/ banded hematite chert. Three parallel bands of BIF extend from Hosahalli to Basavapatna with width varying from 1m to 10 m for a strike length of 4 km. The BIF in the Yalodahalli area also consists of three bands with a maximum width of 17 metre.

In Odisha, a G3 investigation has been taken up in Kalamang West block (northern part) in Sundargarh distt, with an objective to assess iron ore potential in the eastern continuous area of Ghorhaburhani and Sagasahi east blocks for augmentation of resource. Eleven boreholes viz.

BH SKN-1 to SKN-11 achieving a total drilled meterage of 1,040.85 m were drilled at 200 m  $\times$  200 m grid interval. Borehole SKN-1 to SKN-7 intersected the medium to high grade iron ore body (occasionally powdery ore and laminated ore) with a considerable cumulative thickness of 78 m, 50.80 m, 43 m, 30.30 m, 44.60 m, 93.10 m and 54.0 m with average grade 59.61% Fe, 57.82% Fe, 61.61% Fe, 62.07% Fe, 61.17% Fe, 60.77% Fe and 60.11% Fe, respectively. Boreholes SKN-8 to SKN-11 intersected the medium grade iron ore body with 50-60% Fe as per visual estimation (as analytical results are yet to be received) with a considerable cumulative thickness of 76.30 m, 72 m, 104 m and 69.25 m, respectively. The contiguous area towards north is found to be encouraging. Second exploration item was taken up in Ghorhaburhani South Block, Sundargarh distt with an objective to assess the iron ore potential in the southern continuous area of Ghorhaburhani and Sagasahi south blocks for augmentation of resource. Seven boreholes were drilled and all have intersected the mineralised zone with thickness varying from 14m to 76 m. The borehole data indicate that the ore body is closely associated with shale and its thickness varies along strike as well as in the dip direction. The study area comprises ferruginous shale, iron ore and laterite.

During 2014-15, in Uttar Pradesh, a G4 stage investigation was carried out in Bharhari area, Sonbhadra distt, for resource evaluation of iron ore in Mahakoshal Group. The area is characterised by Son-Narmada North Fault (SNNF), trending ENE-WSW and other sympathetic faults in phyllitic country rock. In the mapped area, five BIF bands parallel to each other are observed trending N70E- S70 W over a strike length of 20 km with width ranging from 170 m to 450 m. The BIF bands are interbanded with phyllite. Apart from this major BIF zone, several other banded hematite jasper (BHJ), banded hematite chert (BHC) occur. Analytical results of grab samples from BIF yielded  $Fe_2O_3$  value ranging 40.63% to 62.51 percent.

In Uttarakhand, a G4 stage investigation for iron ore and sulphide mineralisation was taken up during 2014-15 in the undifferentiated Ramgarh Group, Nainital district. Thin veins of iron oxides

are observed within siliceous limestone of Betalghat Formation of Jaunsar Group in Paswara area. The mineralisation is localised and uneconomical.

#### State Directorates

During 2014-15, DMG, Jharkhand carried out exploration for iron ore in the areas near Karampada and Kiriburu (Bhangaon), West Singhbhum district. and area near Lowadih and Tiridih, Saraikela-Kharswan district. Exploration activities include - (i) Karampada and Kiriburu (Bhangaon): geological mapping on 1:25000/1:4000 scale in 25 sq km and 1.57 sqkm areas, respectively, analysis of 35 nos samples have shown Fe content from 50.26% to 65.34 percent and estimation of 40 million tonnes (334) iron ore and (ii) Lowadih and Tirildih area: geological mapping on 1:25000/14000 scale in 40.50 sq km 0.50 sq km areas, respectively, collection of 28 nos samples and analysis of samples have shown Fe content between 47-55 percent. Occurrences of manganese ore are also located in this area.

#### MECL

During 2014-15, MECL carried out exploration for iron ore in six nos blocks/leases in Sandur Tq, Ballari distt, Karnataka for DMG, Karnataka on contractual basis. Lease wise exploration works conducted are (i) M/s B.R. Yogendranath Singh mining lease area (ML no. 2,186): mapping -0.1589 sq km area on 1:1000 scale; drilling - 487.50 m in 14 boreholes; chemical analysis - 500 nos samples and estimation of 2.84 million tonnes of iron ore at 35% Fe cut - off with 39.01% Fe (G-3) (ii) M/s Deccan Mining Syndicate mining lease area (ML no. 2,525): mapping - 0.1743 sq km on 1:1000 scale; drilling - 644 m in 12 boreholes; chemical analysis - 657 nos samples and estimation of 35.86 million tonnes of iron ore at 45%. Fe cut-off with 62.51% Fe (G-1) (iii) M/s Lakshminaryana Mining Company lease area (ML no. 2,487): mapping 0.8612 sq km on 1:1000 scale; drilling - 1,671 50 nos in 56 boreholes: chemical analysis - 1,605 nos samples and estimation of 14.71 million tonnes of iron ore at 45% Fe cut-off with 52.91% Fe (G-1). (iv) M/s Hotur Traders mining lease area (ML no. 2,313): mapping - 0.2,161 sq km area on 1:1000

scale; drilling - 644 m in 14 boreholes; chemical analysis - 620 nos samples and estimation of 10.03 million tonnes of iron ore at 45% Fe cut-off with 54.41% Fe (G-12). (v) M/s Kartikeyas Manganese and Iron Ore mining lease area (ML no 2,559): mapping - 0.2671 sq km area on 1:1,000 scale; drilling -1,000.5 m in 17 boreholes; chemical analysis - 985 nos samples and estimation of 28.4 million tonnes of iron ore at 45% Fe cut-off with 55.33% Fe (G-1) and (vi) M/s V.S. Lad and Sons mining lease area (ML no. 2,290): mapping - 0.2161 sq km area on 1:1000 scale; drilling - 2,240.5 m in 48 boreholes; chemical analysis - 2,182 nos samples and estimation of 28.618 million tonnes iron ore reserves at 45% fe cut-off with 56.69% Fe (G-1).

#### NMDC

During 2014-15, NMDC carried out exploration for iron ore in Bailadila Iron ore Deposit, South Bastar, Dantewada distt, Chhattisgarh. Deposit nos 14 & 11 C: 1943.5 m drilling in 23 boreholes with 100 m grid and Deposit no. 10/11 A: 192 m drilling in 02 boreholes. Similarly, in Donimalai Iron Ore Mines, Ballari distt, Karnataka, 974.20 m drilling in 24 boreholes and collection of 360 samples have been carried out. Total 2.61 million tonnes of iron ore reserves enhanced in (111) category in Donimalai mine.

#### Mysore Minerals Ltd (MML)

During 2014-15, MML carried out exploration for iron ore in Subbarayanahalli and Thimmappanagudi mines both in Ballari distt, Karnataka by drilling. In Subharayanahalli mines 2,055 m drilling in 32 boreholes and in Thimmappanagudi mines 92 m drilling in 02 boreholes were conducted. Total 67.43 million tonnes and 14.38 million tonnes of geological reserves of iron ore were computed in both the mines, respectively.

#### Odisha Mining Corporation Ltd (OMC)

During 2014-15, OMC carried out exploration for iron ore in its various mining leases and exploration activities include - In Kendujhar district :(i) Unchaballi (Mahaparbat) mining lease: chemical analysis of 463 nos samples, 516.60 m drilling in 22 boreholes and the explored area is reported as barren and not promising and

(ii) Seremda - Bhadrasi mining lease: mapping on 1:500 /1000 scale in 46 ha area, chemical analysis of 593 nos samples, 505.90 m drilling in 13 boreholes and estimation of 7.77 lakh tonnes of iron ore resources with + 45 to + 58% Fe. In Sundargarh distt: (i) Koira - Kasira iron ore mines: mapping in 38 ha area on 1:2000 scale, collection/analysis of 19 nos grab samples and as on 01.04.2015, the total iron ore resources are estimated at 7.768 million tonnes and (iii) Koira-Bhanjapalli iron ore mines: mapping in 10 ha area on 1:2000 scale and as on 1.4.2015 estimated resources of iron ore are placed at 6.948 million tonnes.

## **MANGANESE ORE**

### **GSI**

During 2014-15, in Odisha, a G4 stage investigation taken up in Bhagawanpur-Santipur block and Tentalapani block in the eastern part of Eastern Ghat Granulite Belt covering part of Angul district. The objective was to locate potential zones of manganese ore bands. Manganese occurs as E-W trending; 2 m to 3 m wide discontinuous bands within calc silicate and quartzite for 60 m with low to moderate dip towards north. Most of the ores are hard, compact and fragmented in nature. Pyrolusite and psilomelane are the major ore minerals. It displays botryoidal texture. Five discontinuous manganese ore bands have been exposed in trenches. Its width varies from 2 m to 3 m and its strike continuity has been established for 15 m to 60 m, approximately. Analytical results of trench samples show manganese and phosphorous from 5.02 to 21.03% and 0.28 to 2.48%, respectively.

### **MOIL**

During 2014-15, MOIL carried out 8,475 m exploratory drilling involving 45 boreholes in nine mines: two mines Tirodi & Bharweli situated in Balaghat distt, Madhya Pradesh; and seven mines Dongri Buzurg & Chikla in Bhandara distt and Gumgaon, Kandri, Mansar, Old Satuk and New Satuk in Nagpur distt, all in Maharashtra. The reported reserves /resources of manganese ore as on 01.04.2015 were in Bharweli (23.72 million tonnes), Tirodi (0.99 million tonnes), Ukwa (10.09 million tonnes), Sitapatore/Sukli (0.36 million

tonnes), Gumgaon (4.25 million tonnes), Kandri (8.17 million tonnes), Mansar (5.76 million tonnes), Chikla (4.71 million tonnes), Dongri-Buzurg (11.37 million tonnes), Beldongri (0.28 million tonnes), Old Satuk (0.53 million tonnes) and New Satuk (0.026 million tonnes).

### **State Directorates**

During 2014-15 DMG, Jharkhand carried out exploration for manganese ore in West Singhbhum district in two areas- (i) Babriya and Pukhariya area: geological mapping on 1:4000 scale in 1.77 sq km area and collection of 18 nos samples and (ii) Hesapi-Halmatburu area: geological mapping on 1:25000/1:4000 scale in 10 sq km & 1.79 sq km areas, respectively; collection of 25 nos samples and chemical analysis of samples have shown 22-30% Mn content.

During 2014-15, DMM, West Bengal carried out exploration of manganese ore along with laterite around Belpahari area, Paschim Medinipur district by mapping on 1:10000 scale in 100 sq km area; 50 nos pitting and sampling/ analysis of 50 nos samples.

## **STRATEGIC METALS**

### **TUNGSTEN**

#### **GSI**

In Assam, a G4 stage investigation was taken up in 2014-15 for search of W, Sn & REE in Chakrashila, Nadangiri and Bhumeswar areas in Bongaigaon, Dhubri and Kokrajhar districts. The rocks at places are intruded by basic intrusive of doleritic composition. The PCS and BRS samples collected from the lepidolite bearing pegmatite has been analysed by XRF and show a higher value of 15,337 ppm of Rb and 943 ppm of Y (Yttrium). ICPMS study of these samples show a high value of 287 ppm of Tantalum and 338 ppm of tin. A G4 stage investigation was taken up for search of W, Sn & REE in Satali, Surya Pahar, Pancharatna, Bamundanga, Nalanga and Pandaba in the Goalpara district. Porphyritic granite is major lithounit observed in Satali/ Surya Pahar which shows signatures of ductile deformation in terms of rotation of phenocryst, assymetrical shape, mica swerving around the porphyroclast, grain size reduction and quartz ribbons at few places. The

dominant lithounits of Pancharatna Hill is granite and granite gneiss. Other lithounits are amphibolite, pegmatite, quartz-mica schist and granulite occurring as boulders and quartzite. Bamandanga Pahar is a linear ridge standing as an inselberg surrounded by Quaternary sediments. The lithological assemblage is amphibolite, banded magnetite quartzite (BMQ), granite-gneiss, sillimanite-schist, pegmatite veins and quartz reef. Some sulphide specks (pyrrhotite) are visible. The banded magnetite quartzite (BMQ) comprises bands of quartzite and magnetite and/or hematite. Garnetiferous pegmatite along with quartzo-felspathic veins is intrusives within granite gneiss. Granite, granite gneiss, amphibolite, migmatite, pegmatite and quartz reef have been observed in Nalanga Pahar. The granite shows evidence of shearing. Boudins are very common in granite gneiss. At places, sulphide mineralisation in disseminated form represented by pyrrhotite, azurite and bornite. Pandaba Pahar consists of granite gneiss, muscovite gneiss, amphibolite, pegmatite, aplite, migmatite and banded magnetite quartzite and quartz reef/vein. The rock has undergone ductile deformation. Sulphide mineralisation, bornite, azurite and pyrrhotite is noticed in all the lithounits but are more prominent in veins of aplitic composition. Analytical results of the samples so far received are not encouraging.

A G4 stage investigation was taken up for tungsten and associated mineralisation in Lawari-Amboli area, Chandrapur distt, Maharashtra with an objective to identify the zones of tungsten and associated mineralisation in Lawari- Amboli area. Scheelite is observed (under UV lamp) in quartz tourmaline vein situated SW of Amboli village. The tungsten mineralisation is confined mainly in quartz-tourmaline veins and greisen zones. The exposed rock shows smoky quartz and peacock colour staining indicating copper and possible gold mineralisation. In the Lawari reserve forest, bed rock samples of quartz tourmaline vein, analysed W values of 301 ppm and Pb values of 0.34%. The highest W value so far recorded is 530 ppm from bed rock sample of quartz vein near Amboli village. Pitting and trenching samples of quartz tourmaline vein of the Amboli village given the maximum W value of 284 ppm and sulphide

mineralisation. Scheelite was noticed only in the samples of Lawari reserve forest. Bed rock sample of pegmatite vein from Chichola village gives the W values of 151 ppm. Similarly, 80 ppb gold values is also reported from BRS and PT samples of quartz tourmaline vein.

## **TITANIUM AND VANADIUM GSI**

During 2014-15, a G4 stage investigation was taken up to study potentiality of Ti & V in the bauxite of Serangdag Plateau in Garna Hanrup-Kaprapat- Risapattoli-Kubertola area of Gumla distt, Jharkhand. A total of 417.45 m drilling was completed in ten boreholes viz SRBH- 10 (part) to SRBH-19 in the assigned block. Surface and sub-surface data generated reveals that the top part contains thick and extensive in situ laterite capping (3-5 m) underlain by segregated boulders/pebbles and discontinuous lenses of bauxite with thick aluminous clay bands along with ferruginous/limonitic clay bands (24 m-39 m) followed by lithomargic clay. Analytical results of borehole samples received so far show  $TiO_2$  (0.01-21.36%),  $V_2O_5$  (0.01-0.49%) and Ga (7-113 ppm). Mineral phases identified for titanium occur as anatase and rutile. Other important phases present are kaolinite, gibbsite, goethite, sphene, quartz, biotite etc. Results of seven nos of bed rock samples show slight enrichment in Ce (61.6-63.6 ppm in three samples) and Nd (46.3 ppm in one sample). La ranges from 23.5-40.2 ppm and total REE value ranges from 107-178 ppm.

## **NICKEL GSI**

During 2014-15, in Karnataka, a G4 stage investigation for nickel was carried out in Hassan and Tumkur districts. LSM of 100 sq km and detailed mapping of 0.5 sq km has been completed. The Archaean greenstone belt (Sargur Type) J.C.Pura-Antaraghatta ultramafic belt is significant with respect to the outcrop pattern, monolithic framework and proximity to the terrain boundaries (Sasivala) with younger greenstone terrain (Bababudan-Type; sensu stricto Dharwar). The belt comprises meta-dunite/peridotite (chlorite

serpentine schist), meta-pyroxenite (tremolite-chlorite schist/chlorite schist), amphibolite (hornblende schist/hornblendite) defining the mafic-ultramafic suite. Other significant mappable units comprise migmatite gneiss (PGC), quartz-sericite muscovite schist ( $\pm$ fuchsite), epidote-hornblende gneiss (sheared variants) and granite (Arsikere Granite) traversed by younger gabbro/dolerite (N30°E-S30W and N20°W-S20° E) and pegmatite veins/units. The palaeosome of these gneisses are amphibolitic. Both massive (adcumulus) and schistose ultramafic variants are recorded. Hornblendite rocks compositionally (monomineralic) grades to amphibolite/ gabbroic composition (minus quartz) at the rims/contacts. The serpentinite and meta-pyroxenite variants are generally non-chromiferous, rare disseminations noted at places. Yellow/ green-spots (high Ni) in serpentinite and meta- pyroxenite (magnetite alteration) are common. Carbonated (cumulus) meta-peridotite near Tumbapura represents relatively fresh form and is to be probed further. Elsewhere, serpentinitisation followed by carbonitisation has altered original assemblages. Near Kamasamudra, garnet occurs at places in the metaperidotite along a narrow zone. The southward extension of ultramafic rocks near Kamasamudra with cumulus texture possibly represents bottom part of a volcanic pile. Sulphide mineralisation is absent; few pyrrhotite-pyrite disseminations is recorded in gabbro dyke (Rattanahalli). Presence of vermiculite, magnesite, muscovite, chlorite veins and scattered patches suggests late alterations. The fabrics in amphibolite, altered pyroxenite are conformable with the metadunite/ peridotite rocks; their disposition implies the intrusive nature taking part in deformation episodes. The rocks exposed along the ridges between Mallenahalli and Rudrapura preserves sinisterly folds in meta-dunite/peridotite. Evidences of shear zones with dominant sinister sense are noted in the form of S-C fabrics, shear fractures and sheath folds in migmatites/ tremolite chlorite schist. The structural fabrics in rocks are defined by foliation, cleavage and schistosity planes. Near Rattanahalli, a pegmatite vein is noted shifting its trend from early to late planes implying a synchronous development of these fabrics during

single deformation progressive episode. Asbestiferous veins (1-5 cm) are noted along fractures in meta-dunite/peridotite units near Mallenahalli, Borinakere, east of Rampura and South of Sasivala.

The reconnaissance stage (G4) investigation for search of Ni, Cr and PGE mineralisation in mafic-ultramafic suite of rocks was initiated during 2013-14 around Bagalia- Sonajuri area in Purulia distt, West Bengal which was concluded during 2014-15 around Lalpur-Hura-Bishpuria area. The major lithounits are metabasic rock (amphibolite), mafic granulite, granite gneiss and hornblende gneiss of Chhotanagpur Gneissic Complex (CGC). The pyroxenite gabbro-anorthositic-gabbro suite of rocks occurs as intrusives into the CGC country in the mapped area. Sulphide dissemination in gabbroic rocks is noticed at places. The sulphide minerals were identified to be pyrite, chalcopyrite, pyrrhotite and pentlandite by petrography and SEM study. Inclusion of subhedral Co bearing pentlandite in pyrrhotite is noticed in the gabbro east of Hura. No PGE bearing mineral has been identified. The analytical results of powdered samples from pyroxenite-gabbro-anorthositic gabbro suite of rocks received so far, revealed the concentration of Ni ranges from 36 to 475 ppm, Cr 34 to 275 ppm, Pt <10 to 35 ppb and Pd from <5 to 17 ppb.

## **BISMUTH GSI**

Investigation for bismuth and possible gold mineralisation in areas between Badnor and Patan, Ajmer distt, Rajasthan was taken up in 2014-15. LSM was carried out on 1:10000 scale covering a total area of 50 sq km. A total of 97 nos of BRS/SS samples were processed and submitted for analysis. One ferruginised brecciated horizon (Gossan) was observed, with imprints of sulphide mineralisation beneath (in the form of staining and occurrence of clay), extending for about 1.8 km. About 400 m west of Bar, a mineralised granitoid body (undeformed, quartz rich granitoid) of dimension 13 m $\times$ 5 m is identified. Silver coloured sulphide minerals have been identified to be occurring along with a black coloured mineral (streak-black and soils finger). Bi value of 1.8 ppm has been recorded from a BRS of this lithounit. Stream sediment samples from streams draining western and west-central parts

of the study area have analysed anomalous bismuth (0.9 to 3.5 ppm).

## **RARE METALS & RARE EARTHS (RM/REE) ELEMENTS GSI**

In Andhra Pradesh, seven major pegmatite bodies are mapped out of which one is emplaced in agglomerate, another in the leucogranite and the rest in actinolite-chlorite schist. All the quartz and pegmatite bodies are emplaced along major fault planes. The pegmatites are intruded by multiple quartz and hematite veins. Trenching in the west of Chetlamallapuram helped in identification of a zoned pegmatite body. A major tourmaline bearing leucogranite unit is mapped which was earlier mapped as grey biotite granite. Around Basitipadu zoned pegmatite intrudes the leucogranite as horizontal sheets, both containing tourmaline. Outliers of Gulcheru quartzite are mapped which were recorded as Narji limestone in earlier maps. A Nb-Ta mineral (Euxenite) grain is identified through EPMA enclosed within a feldspar grain from the main pegmatite of Chetlamallapuram. All the pink feldspar bearing pegmatites emplaced along WNW-ESE trending fault planes bear multiple injections of specular hematite. Malachite stains are also recorded in this zone. An old working is located in this zone. Euxenite (Nb-TaU) mineral is identified with the help of BSE studies of pink pegmatite from Chetlamallapuram.

In Bihar, a G4 stage investigation of REE was taken up in Bihar Mica Belt around Chandan area, parts of Jamui and Banka districts. During the course of mapping several bands and lenses of aplitic granite and pegmatite have been mapped. The most significant aplitic granite band has been located near Salonia village having length of about one kilometre and width varying between 1 m and 10 m. This unit has analysed 86.86 to 500.10 ppm tREE, while the pegmatites have analysed 17.28 to 516.11 ppm of tREE. On the basis of chemical analysis of 59 samples in respect of REE, source rocks of REE minerals have been identified to be pegmatite, aplitic granite and quartzofeldspathic veins intruding amphibolites and granite gneisses. In situ soil and laterite have also shown higher tREE concentration. tREE

concentration in different units have been recorded as following: pegmatite - 17.28 to 516.11 ppm, aplitic granite - 86.86 to 500.10 ppm, quartzofeldspathic veins intruding the amphibolites and granite gneisses - 135.28 to 413.72 ppm, Laterite - 372.85 ppm, Soil samples - 210.44 to 376.90 ppm, Stream Sediment Sample - 143.31 to 510.28 ppm, Weathered Aplitic granite - 323.71 ppm and Weathered amphibolite - 412.54 ppm. Out of 59 nos of samples analysed, 40 nos of samples have indicated tREE value above the Upper Continental Crust value of 146.37 ppm. Chemical analysis in respect of Unit Cell Stream sediment samples (60 nos) have also been received which have analysed significant REE values ranging from 146.37 to 9,884.36 ppm.

In Chhattisgarh, G4 stage investigation for REE was taken up in Gobra-Pendra area of Gariabandh district. The granitoids of Dongargarh Granite Formation is the major lithounit of the area. The area exposes coarse grained granite, coarse grained-porphyritic granite, medium grained pink/grey granitoids, biotite granite and patches of Older Bengal Group of rocks. REE values of 4 BRS samples have been received and plotted in La/Gd vs Eu/Eu\* plot. BRS-1 is falling in Placer Monazite field. Plotting study reveals that LREE is enriched along with 'negative europium' anomaly which is comparable with the granitoids of the area. High CeN/ YbN and LaN/YbN ratios of BRS-1 and BRS-3 represent more evolved/fractionated magma compared to the others. Thorium shows high values of 414 ppm & 389 ppm in SS samples and 166 ppm in BRS-1 sample.

In Jharkhand, G4 stage investigation was carried out in Maheshpur-Kamta-Nawatoli-Jaratoli-Guridih area, Ranchi district to assess the REE and RM potentiality. The pegmatites are very coarse grained, at places sheared and show presence of spodumene, zinnwaldite, epidote, muscovite, tourmaline, garnet etc. The pegmatite bodies recorded in the study area are usually 3-5 m wide and 10-15 m long and are mostly aligned E-W though few discordant (NS to NNE-SSW) bodies are also recorded in the area. South of Nawagarh, thick laterite capping is developed which is good site for REE rich ion-adsorption clays. The analytical results received so far show good value of Ga (22-41 ppm), Nb (<5-185 ppm),

Rb (7-535 ppm), Sc (<5-33 ppm), Y (12-732 ppm) and Zr (9-581 ppm).

For REE investigation in Karnataka, a total area of 100 sq km was mapped along with detailed mapping of 0.5 sq km in the area exposed with different variety of younger granites (Closepet Granite) which were intruded into the PGC. The granites are pink biotite granite, pink granite, leucogranite and patches of grey granite bodies within the pink granite. The Peninsular Gneissic Complex comprises biotite gneisses and migmatite. The younger dolerite dykes were intruded into the biotite gneisses (PGC) and encountered at Wanadurg. NW and Southern part of study area are comprised of biotite gneiss. The white coloured medium to coarse grained leucogranite  $\pm$  epidote was observed in south-eastern part of Wanadurg and rest of the eastern part is entirely occupied by pink biotite granite bodies. Patches of grey granite were seen all along the pink granite body. Lenticular bodies of mafic enclaves (ME), particularly of porphyritic ME with mafic and felsic phenocrysts were seen at NW part of the study area. Orientation of elongated euhedral feldspars within pink granite, pink biotite granite and leucogranite shows primary magmatic foliations with a general trend of NW-SE. Schlierens, biotite-rich segregations, within the host rock are also defining primary foliation fabric. Well developed of S-C mylonitic foliations were seen at places. Shear plane of mylonitic fabric also trends parallel to the primary magmatic foliation of the granitic pluton i.e., NWSE. Three sets of vertical joints are noticed all through the granitic body trending N20°E-S20°W, N65°E-S65°W and N-S. LSM of 100 sq km and DM of 0.5 sq km were completed in Tamankal and Raidurg, for REE investigation. During LSM, a 6-8 m wide and 27-30 m length pegmatite vein trending N80°E was observed in the area with suspected REE characteristic unit. The pegmatite vein exhibits various alterations like iron leaching, limonitisation, manganese layering, silicification in the form of veinlets and some metallic pits. The suspected mineralised portion appears dark grey in colour with fine grain nature. Some veinlets of metallic concentration were also observed. LSM in and

around Gogalgatti revealed a 20-25 m wide and 1.7 km length quartz reef trending N10°E with suspected REE characteristic unit. The pegmatite vein exhibits various alterations like iron leaching, limonitisation, manganese layering, silicification in the form of veinlets and some metallic pits. The suspected mineralised portion appears dark grey in colour with fine grain nature. Some veinlets of metallic concentration was also observed. During LSM at and around Bandihalli metallic mineralisation was observed in pegmatite bodies (N45°W). In Bandori brecciated and silicified grey quartz veins trending in north-south direction were observed in Lingadahalli quartz veins with epidotisation trending N-S direction were observed. Two sets of joints trending N80°W and N23°E were observed. Metallic minerals were also present in the quartz veins. The area is characterised by amphibolite, granodiorite gneiss, dolerite dykes and pink biotite granite. Minor intrusives of quartz vein have also been observed. During the LSM in and around Benchagaddi, a quartz hillock of 10-15 m radius was mapped. White quartz with Fe leaching observed. Pegmatite veins trending N45°W were observed in Tintini with sporadic metallic mineralisation. At Bandiholi, quartz vein trending N-S direction occur with exposed length of around 30 m long and 4 m wide with Fe leaching. Similar quartz veins were also observed at Yeragoti. Metallic mineralisation is also recorded. Trenches T1 and T2 were made to excavate the quartz carbonate vein near Aidbhavi.

In Maharashtra, a G4 stage investigation was taken up for locating the REE and RM bearing pegmatites of Deolapar within the rocks of Sausar Mobile Fold Belt and Tirodi Biotite Gneiss (TBG) Nagpur district. The field relationship between pegmatite and the host rock reflects the structural control of the pegmatite intrusion. Pegmatites occur as tabular to lenticular or pipe like bodies and generally range from a few cm to about 1 km in length and from 1 cm to about 50 m in width. Simple pegmatites are chiefly composed of quartz, feldspar, mica and garnet, whereas complex pegmatites, are composed of quartz, K-

felspar, plagioclase, mica, tourmaline, apatite, beryl, zircon and monazite. In some complex pegmatite K-felspar, beryl, tourmaline and mica commonly occur in larger crystals than the associated minerals. Zircon, monazite and fluorapatite have been identified in petrographic studies. Beryl bearing pegmatites have been recorded due east of Bandra, northwest of Nawegaon and south of Dulara village. The zoned pegmatite located 2 km east of Bandra contains beryl crystal as big as 28 cm in length and 14 cm in diameter. The beryl in these pegmatites is associated with the quartz core and quartz-muscovite zone. Out of the 100 BRS, geochemical results of 05 BRS have been received and the highest concentration of REE is 600.41 ppm. Be and Cs content of beryl sample from zoned pegmatite located east of Bandra is analysed up to 4.12 % and 612 ppm, respectively. The concentration of Ta, Nb and Rb as revealed by geochemical analysis of bed rock sample is up to 805 ppm, 122 ppm and 3,293 ppm, respectively. The concentration of tungsten in thirty bed rock samples is more than 300 ppm with the highest value of 1,267 ppm.

In Rajasthan, a G4 stage investigation of REE was continued from 2013-14 in Gothara Granite of Khetri Fold Belt, Jhunjhunu district. A total of 421 nos of grid samples collected on 50x20 m interval. Till date chemical analyses of 220 nos of samples are available, out of which 7 nos of samples yielded  $\Sigma$  REE > 2500 ppm (3.18%), 25 nos of samples yielded REE > 1000 ppm (11.36%) and 106 nos of samples yielded REE > 500 ppm (48.18%). The maximum value recorded is 0.025 mR/hr against a background value of 0.015 mR/hr. An instance of REE bearing phase-Bastanasite is observed in granite sample. In the mapped area of field season 2014-15, the maximum value recorded is 0.04 mR/hr against a background value of 0.015 mR/hr. A G4 stage investigation for REE and Rare Metals was carried out in Siwana area, Barmer district. The area covered by LSM (1:12500) comprises different acidic (rhyolite) and basic lava flows, intrusive

Siwana granite, late phase dykes i.e. rhyolite, felsites and micro granite dykes. REE mineralisation in the area is supposed to be hosted in late phase felsites, micro granite and rhyolite dykes, Siwana granite and rhyolite and pyroclastic unit rock. Felsite dykes, Siwana granite and rhyolite bears promising locale for REE mineralisation. Analytical result of REE in bed rock sample of felsite dykes, Siwana granite and rhyolite rock indicated significant REE mineralisation in the mapped area. Chemical result of one felsite dykes sample shows REE more than 1%. All 16 bed rock samples of granite show REE more than 0.1%; out of 16 samples of granite 6 sample show REE more than 0.3% with a highest value of 3,978 ppm. All 15 bed rock samples of rhyolite show REE more than 0.1%. Three bed rock samples of microgranite show REE more than 0.1%. 2 samples out of these 3 sample show REE more than 0.4%. Tuff unit also shows anomalous REE value which is ranging from 0.1% to 0.3%. Pb-Zn value in rhyolite dyke is 1.14%. Anomalous Pb-Zn value also observed in felsite dykes. Three samples of  $\Sigma$  rhyolite dyke, 7 samples of felsite and one sample of rhyolite flow shows Pb-Zn value greater than 0.1%. Zr value in felsite dykes varies from 0.58% to 0.99% and in rhyolite it varies from 0.1% to 0.59%. A G4 stage investigation for REE and Rare Metals was taken up in Perva Bisalpur area, Pali district. REE mineralisation in the area is supposed to be hosted in Dhani granite and in highly carbonatised-ferruginised-silicified brecciated rock. Dhani granite and brecciated rock bears promising locale for REE mineralisation. Analytical results of REE in bed rock sample of Dhani granite and carbonatised ferruginised- silicified brecciated rock depict significant REE mineralisation. Seven samples out of 55 samples show REE of more than 500 ppm. Three samples out of seven show greater than 0.1% REE. One sample of silicified brecciated rock shows 1.49% Ba value and two carbonatite dyke samples show

anomalous Ni value of 746 ppm and 300 ppm, respectively and Cr values of these two samples are 1,649 ppm and 2,263 ppm, respectively. A G4 stage investigation of REE in alkaline and carbonatitic plugs and associated dyke rocks was carried out in Sirohi district. During 2014-15, LSM on 1:10000 scale is carried out covering an area of about 104 sq km with collections of 314 nos bed rock samples and 100 cu m pitting/trenching. After Erinpura granite, the maximum part of the complex is occupied by the gabbro. A total of 16 nos of carbonatite dykes have been recorded. All the carbonatite dykes have varied colour, grain size and composition ranging from calcio carbonatite (sovite, alvikite) to ferro-carbonatite in nature. The strike length of the carbonatite dykes ranges from 15 m to 430 m and width from 15 cm to 1 m. Signatures of fenitisation have been observed along the contact of carbonatite and granite in the form of removal of silica with the excess addition of Na, K bearing felspar and presence of aegirine needles (Na- Pyroxenes) in the contact granite. More than 100 nos of basic dykes have been mapped in the area out of which one basic dyke with strike length of about 700 m and width of about 10 to 20 m intruding the Erinpura granite and basalt is the major dyke mapped in the area. A lamprophyre dyke intruding the granite with a strike length of about 450 m and width about 1 m is also recorded. The mineral assemblages present in the dyke are biotite (phenocryst), felspar and pyroxenes embedded within the fine grained groundmass. Besides this, 3 felsic and 2 mafic to ultramafic, porphyritic dykes have been mapped. Thin polished section study of essexite, gabbro, carbonatite, syenite and basic dykes was carried out and the dominant mineral phases identified in the rock types are plagioclase felspar, nepheline, zircon, pyroxene, calcite, K-felspar, respectively with a fine dissemination of chalcopyrite and magnetite. Petrographic study of lamprophyres reveals, presence of biotite, phlogopite, pyroxene,

plagioclase felspar with some apatite grains and opaque minerals. Analytical results of total 58 nos of bedrock samples collected were received out of which 09 samples have analysed noteworthy anomalous REE concentration. One sample of carbonatite dyke have analysed 7% total REE with other samples analysing 300 ppm, 800 ppm, 1% and 2% total REE. A G4 stage investigation for REE and Rare metal elements in Bhilwara Pegmatite Belt-Sandmata Complex was carried out in Bhilwara district, Rajasthan in two selected blocks, namely Bhagwanpura southwest and southeast block. The work carried out includes geological mapping on 1:10000 scale with collection of 302 nos of geochemical samples covering an area of 50 sq km. The geochemical samples both as grab samples and grab chip samples were mostly from pegmatite bodies with few samples from adjoining gneissic rocks. Pegmatite bodies profusely intruded within gneisses and mica schist within the two blocks do not show pronounced zoning except presence of quartz core. Separate quartz veins have also been noticed which is milky white with occasionally smoky in nature. Clusters of pegmatite are exposed at ground level in west of village Kishanpura and south of village Kabradiya in Bhagwanpura southwest block. Remaining area of the southwest block also has pegmatite bodies with noticeable sizes. Bhagwanpura southeast block is largely covered by soil and comparatively less numbers of pegmatite bodies. However, few pegmatites in north of village Thabola have presence of tourmaline, beryl and garnet within the zoned pegmatite. The pegmatites have strike length varying from few metres to 300 m and width from few metres to 50 m. These pegmatites have a complex mineralogy with varying proportion of quartz, potash felspar, plagioclase felspar, muscovite, and biotite. Biotite and muscovite are present both in the form of large books and small size. Tourmaline, beryl and garnet are present

only within zoned pegmatite. Significant amount of beryl and tourmaline is observed in the pegmatite bodies which are rich in plagioclase feldspar. It is also observed that occurrence of beryl and tourmaline is found where migmatitic gneisses are holding the pegmatite intrusion. The close relationship between the presence of tourmaline and beryl within the pegmatite and migmatite indicates that the formation of beryl and tourmaline is related to the process of migmatization. Chemical analyses of the 86 nos of bed rock samples collected from pegmatite bodies and gneissic rock are not showing encouraging result of REE and RM. However, one sample collected from gneissic rock has assayed over 1,000 ppm of total REE.

In Tamil Nadu, REE investigation was taken up covering mostly A2 and B2 quadrants of 58 1/4 toposheets. In the study area, REE mineralisation occurs as disseminated or isolated spots in granitic gneiss, pink migmatite, pink grey gneiss and probably at the contact of these rocks with country rock hornblende gneiss. Disseminated grains of hematite is also present in certain leucogranites near Poyyeri where it has been assumed that the original magnetite grains might have oxidised to hematite. In a well dump east of Nochipatti, specks of pyrite, chalcopyrite, bornite and molybdenite are observed in a quartz vein associated with hornblende-biotite gneiss the quartz vein hosting the sulphides is traced to a distance of 15 m up to an adjacent well; thereafter no outcrop is noticed and rather the body appears to be terminating. Even the depth penetration as observed in the well section appears to be negligible. In summary, areas covering Sukkampatti ( LREE ranges from 299.97 ppm to a maximum of 1,203.57 ppm & HREE ranging with a minimum of 10.58 ppm to a maximum of 83.40 ppm), Chinnatambipalaiyam ( LREE=205.36 to 1,359.59 ppm with HREE=25.19 to 85.44 ppm), Pallathur ( LREE=359 to 1,459.70 ppm with

HREE=01.67 to 107.34 ppm), Sembakavundanpudur-Surampatti contact zone ( LREE=505.36 ppm to 778.51 ppm with HREE=36.62 to 76.77 ppm), Seviturangampatti ( LREE=240.10 to 1168.40 ppm & HREE=35.19 to 117.90 ppm) and Tannipandal ( LREE=262.14 to 3,282.23 ppm & HREE=34.59 to 131.70 ppm) and have yielded relatively high values for REE in chemical analysis. Hence, an area of 0.55 sq km is taken for DM in three different blocks, namely Sukkampatti, Chinnatambipalaiyam and Ayyampalaiyam area. Detailed mapping is carried out on 1:1000 scale for an area of approximately 0.55 sq km. The main rocks type exposed in DM area are leached pink migmatite, pink migmatite, pink granite, hornblende granite gneiss, granite gneiss, pink pegmatite and hornblende-biotite gneiss. The alteration zones are closer or at the contact of pegmatitic or quartz rich portions and at the contact with country rock hornblende biotite gneiss which could have contributed to the source of REE. In some places, the alteration zones are along the foliation and gneissic bands in the pink migmatite. The detailed mapping is completed in all three blocks. Radiometric surveying is also carried in the DM. Scintillation count of 25 micron R/h and above in granite and its variants in the area is taken as background value above which all values are treated as anomaly prone area having plausible potential area. Rock chip samples were collected for thin polished section from the groove sample located in the last year FSP area which have recorded higher values. The opaque mineral grains were collected as individual grains besides separating from crushed chip samples by hand picking and simple magnetic separation and a total of 13 nos of samples were submitted to PPOD laboratory, Bengaluru for XRD studies to identify mineral phases.

## BEACH SAND/PLACER MINERALS GSI

(i) An area of 51 sq km was taken up to evaluate placer mineral resources, within the territorial waters off north of Bhimunipatnam (Off Santapalle), Andhra Pradesh. Sixty-nine vibro-core seabed sediment samples, varying in length from 0.13 m to 2.77 m with an average core length of 1.30 m were collected in 1 × 1 km grid pattern within 21 to 37 m Sea water depth. The current observations and water samples from three stations, at surface and sub-surface levels were also collected. Total 70 l km of bathymetric data along 13 coast perpendicular transects was carried out. The vibro core sediments were sub-sampled at half a meter interval for the heavy mineral resources evaluation. The concentration of heavy minerals is in the range of 3-4% on the surface followed by 2-3% at the sub-surface level with grey to brown medium sand. The important heavy minerals in the area include ilmenite (39.15%), sillimanite (28.84%), and garnet (23.02%) as major mineral constituents in the decreasing order of abundance. Whereas, zircon (1.22%), monazite (0.54%), rutile (0.59%) and others (6.64%) occur as minor minerals. The pyroxene, amphibole, epidote, staurolite, tourmaline, kyanite etc, occur as minor mineral constituents. A total of 2.95 million tonnes of heavy mineral resources are estimated within the area: ilmenite 1.18 mt, sillimanite 0.83 mt, garnet 0.68 mt, zircon 0.035 mt, monazite 0.016 mt, rutile 0.016 mt and others 0.19 mt. The EPMA analysis reveals the following composition of heavy minerals : 51% of  $TiO_2$  & 46% of FeO for ilmenite; 61%  $Al_2O_3$  & 37%  $SiO_2$  in sillimanite; 30% FeO, 21%  $Al_2O_3$  & 38%  $SiO_2$  in garnet; 67%  $ZrO_2$  & 32%  $SiO_2$  in zircon; 28% of  $P_2O_5$ , 11%  $La_2O_3$ , 26%  $Ce_2O_3$ , 11%  $Nd_2O_3$  & 8.104% of  $ThO_2$  as major constituents and 1.6% of  $Y_2O_3$ , 2.9%  $Pr_2O_3$ , 0.37% PbO & 0.26% of  $UO_2$  as minor constituents in monazite and 98% of  $TiO_2$  in rutile. Heavy mineral suite with ilmenite, garnet and sillimanite as major constituents followed by zircon, pyroxenes, epidote and monazite suggest their source from crystalline host migmatites, khondalite, charnockites, granite gneiss, pyroxene granulite etc of Eastern Ghat Mobile Belt (EGMB). The Vamsadhara, Nagavalli, Gosthani, Sarada, Varaha and Mahendratana rivers that drain through the rocks of EGMB have contributed these minerals to the offshore.

(ii) The present cruise for evaluation of relict sand resources beyond TW off Kodungallur, Kerala was taken up with an objective to locate the possible occurrences of construction grade sand, to assess the economic heavy minerals in the sandy sediments and to delineate palaeo-strandline. The study area is carpeted with variants of sand (about 98.5% of the area) except in the north western part where it is silty sand. Very fine sand fractions are observed in the north western part while fine sand is distributed in the eastern, western and central part of the study area. Medium sand is distributed in the south as well as small patch in the western part. Coarse and very coarse sand is distributed in the south-western part as well as in the central part of the study area. Sand size grades up from north to south in the study area. Sand in this area is mainly lithogenic (60 to 90%). Quartz is the major mineral followed by rock fragments and heavy minerals. Biogenic constituents are shells and shell fragments of gastropods, ostracods and foraminifera. The reserve estimated for 0-50 cm is 99.74 million tonnes; 50-100 cm is 22.44 million tonnes; 100-150 cm is 16.58 million tonnes; 150-200 cm is 11.02 million tonnes; 200-250 cm is 5.72 million tonnes; 250-300 cm is 1.85 million tonnes and 300-350 cm is 0.45 million tonnes. Total sand reserve estimated in the study area is about 157.68 million tonnes.

(iii) The survey carried out so far has delineated an elongated heavy mineral (HM) bearing block from Sonapurapeta in the south to Chilka in the north covering an area of about 600 sq km. The concentration of the HM varies from 0.5 to 17 wt % in the top one meter sediments often extends up to 2m depth. This promising sector was subsequently undertaken for closer grid vibro coring for evaluation of placer mineral resources. Assessment of the Heavy mineral concentration shows encouraging results in the contiguous areas. Cruise ST-241 was taken as an alternative item for 2014-15 from 14-12-2014 to 05-01-2015 to survey the remaining gap area in closed grid vibrocoring for evaluating placer mineral resources, in an area of 48 sq km area bounded by the coordinates: Lat  $19^{\circ}20.064'N$ , Long  $85^{\circ}5.589'E$ ;  $19^{\circ}23.870'$ ,  $85^{\circ}11.024'$ ;  $19^{\circ}22.009'$ ,  $85^{\circ}12.333'$  and  $19^{\circ}18.216'$ ,  $85^{\circ}6.924'$  in 1 km × 1 km optimum grid pattern to have a composite picture of the near shore placer mineral resources of southern Odisha coast. During the Cruise, a total of 58 nos of Vibrocore

sediment samples were collected from the water depths of 16 m to 47.6 m, against 59 nos of Stations occupied by covering an area of 44 sq km. The length of the core varied from 0.38 to 4.12 m, with an average length of 2.10 m. In addition to that, 5 gravity core with bathymetric survey was carried out along 43 line km along with collection of water samples and current meter data. The top sediment in the near shore zone are dominantly very fine sand while the sediment collected from the deeper part are mainly medium to coarse sand and consists of lots of shells and shell fragments. The bottom sediments reflect all types of sand depending upon the recovery below sea floor. The 26 m bathymetry contour is marked by the presence of sub aerially exposed variegated compact sticky silty sand / sandy silt at more than 50 cm b.s.f. The surface sediment collected from deepest part of the survey area ~ 45m or above water depth is dominated by clay.

(iv) An area of 225 sq km off Muttamtura, Tamil Nadu was covered by systematic sampling and bathymetry surveys to evaluate the heavy mineral sand resource in the inner shelf region. Vibrocore samples from 10 locations and grab samples from 78 locations were collected to understand the nature of sediments and their heavy mineral potential. The rock exposures and hard coralline bottom limited the systematic coring operations in the area. The maximum core length recovered is 0.46 m. Bathymetry data along 1 km spaced coast perpendicular lines was collected to understand the seabed morphology of the area. The bathymetry contour map prepared from tide corrected bathymetry data showed an uneven topography with gentle gradients. The visual estimation of the sediment samples revealed that major part of the survey area is dominated by coralline hard bottom (Octocoral both live & dead) and broken shell fragments with local occurrences of clayey silt, medium to fine sand with sub-angular to sub-rounded fine to coarse quartz grains, laterite pieces, spicules, forams and rock fragments. Sand is confined to the shallow part (<15 m water depth) and deeper part (>35 m) of the area. The heavy mineral concentration is mostly associated with medium to fine sand & clayey silt at places.

### **Indian Rare Earths Ltd (IREL)**

During 2014-15, IREL carried out exploration at OSCOM beach placer deposit, Ganjam distt, Odisha

by 3,385 m drilling in 409 boreholes and mineralogical analysis of 2,442 nos samples. Reserves of beach sand was estimated at 18.59 million tonnes under proved (111) and 16.34 million tonnes under probable (121 & 122) categories.

### **Atomic Mineral Directorate for Exploration & Research (AMDER)**

During 2014-15, AMDER carried out reconnaissance survey (342.28 sq km) and detailed survey (8.685 sq km) in coastal tracts and inland areas in parts of Andhra Pradesh, Gujarat, Kerala, Odisha and Tamil Nadu for delineating the potential heavy mineral (HM) concentrations:

(i) Red sediment horizon along Metturu-Sompeta-Ichapuram tract, Andhra Pradesh records THM ranging from 1.48 % to 32.04% with an average of 6.57% over an area of 85 sq km.

(ii) Naripaiyur-Valinokam tract, Ramanathapuram distt, Tamil Nadu records THM ranging from 0.5% to 49.8% with an average of 5.1% over an area of 77.28 sq km.

(iii) Inland sand bodies along Hazira and Devla coast, Surat and Bharuch districts, Gujarat record THM from 7% to 56% with an average of 22 percent.

In addition to reconnaissance surveys, detailed survey was carried out in (a) Arjapalli-Agastinuagon tract (IREL Project-Chhatrapur, Odisha) for collection of more data for the estimation of reserves and planning of dredge operations. (b) Bendi creek-Mela Ganguvada tract, Srikakulam distt, Andhra Pradesh for evaluating the sand body in closer grid and deeper depths for reserves estimation. (c) Indian Rare Earths Ltd, Chavara leasehold area on closer UNFC compatible grids and (d) Pallam-Alapuzha, Tamil Nadu and Kerala for the study of beach washings.

### **PLATINUM GROUP OF METALS GSI**

In Kerala, a G4 stage investigation was taken up in Kavundikal, Kunnanchala, Narasimukk, Bhutivali, east of Dodagatti and Kalpatti area, Palakkad district for delineating chromitite zones within the ultramafics and to evaluate its PGE potential. Since the chromites in the area are known to be PGE - bearing, importance was given to trace the chromite - bearing zones in the ultramafics. Bed rock sampling was done from chromite ± sulphide-bearing ultramafics. BRS/ groove samples were collected for PGE and trace

element analysis. Five trenches were given towards the SW and NE direction of the magnesite-quarry section at Kalkandi to expose the chromite bearing ultramafics. The strike extension of the chromitite exposed in a quarry section length of 350 m by trenching. The analytical results of the trench and groove samples by ICPMS method shows that some metapyroxenites show encouraging PGE values having total PGE values more than 200 ppb. The Platinum values in all rock types show a range from <5 ppb-317 ppb, palladium shows a range from <5-106 ppb, iridium values are all <3-56 ppb, ruthenium values range from <3-18 ppb and rhodium values range from <3-47 ppb. Two groove samples of metapyroxenite show encouraging total PGE values of more than 200 ppb. One trench sample of metapyroxenite show encouraging total PGE value of 542 ppb (Pt = 317 ppb, Pd = 106 ppb, Ir = 56 ppb, Ru = 17 ppb and Rh = 47 ppb). PGE grains are identified in four samples out of 11 nos of samples studied under EPMA. Out of the 110 samples analysed for PGE, 11 samples have yielded PGE values above 100 ppb and values of gold are not encouraging.

In Odisha, G4 stage investigation was taken up in Patakhali-Balijori and Ghuturigaon-Mundasahi areas of Kendujhar and Dhenkanal districts LSM (1: 12500 scale) was carried out in Patakhali-Balijori Block with the objective of delineating prospective areas for PGE. No significant surface indication of mineralisation (chromites/sulphides) for PGE has been observed. Fine disseminations of chromites and/or sulphides were observed in peridotite unit. A total of 105 BRS and 51 PTS have been collected. Analytical results of BRS show no encouraging PGE values. SEM-EDX study revealed several gold grains as discrete phase in pyroxenite and peridotite samples.

In Tamil Nadu, a G3 stage investigation was taken up in Namakkal distt, to prove the depth persistence of the PGE mineralisation in the central part of Tasampalayam block (T3 sector). The PGE mineralised zones delineated in T3 sector shows considerable variation in grade and width both along the strike and dip directions and the chromitite bands which host the PGE mineralisation occur as discontinuous bodies which show pinch and swell structure. In T3 sector, the Northern Zone is delineated for a cumulative strike length 700 m and close spaced

trenching and systematic drilling is being carried out to check the strike continuity and depth persistence of the PGE mineralised zones and also to see the western extension of this zone. First level drilling to test the PGE mineralised zones at 30 m vertical depth is taken up during the period. Seven boreholes T3BH-1 to T3BH-7 were drilled in segments A, B, C & D, (two boreholes in each segment) for the first level intersection of Northern Zone and drilling quantum of 517.15 m has been achieved. Planning of boreholes systematically at 100m interval is not possible due to the discontinuous nature of the chromitite bands and the spacing between the boreholes varies from 70 m to 284 m. Close spaced trenching was also carried out along the borehole profiles for borehole planning, surface to subsurface correlation of PGE mineralised zones and also to see the strike extension of the chromitite bands. A total of 115 core samples from seven boreholes and 47 trench samples were processed and submitted for PGE analysis. In T3 sector, Segment-A delineated in the eastern most part over a strike length of 300m, exposes the Northern Zone. The Northern Zone in this segment exposes several parallel bands/layers of chromitite/chromiferous meta-pyroxenite, meta-pyroxenite and mix zones of meta-pyroxenite and anorthosite. The individual bands are not traceable from one trench to another trench indicating pinch and swell nature. Scout borehole TBH-9 drilled earlier in the central part of the segment has intersected significant PGE mineralised zone and two first level boreholes were drilled to check the eastern and western extension of this zone. Segment-B, delineated for a strike length of 270 m exposes both Northern and Southern Zones. Scout boreholes TBH- 11 drilled earlier to check the Southern Zone and TBH-10 drilled earlier to test the Northern Zone. Two first level boreholes, T3BH-3 & 4 were drilled in this segment to see the extension of Northern Zone. Segment-C, delineated for a strike length of 385 m exposes the Northern Zone and two scout boreholes, TBH-12 & 13 drilled earlier to test the Northern Zone have intersected significant PGE mineralised zones. To trace the extension of these zones, two first level boreholes (T3BH-5&6) were drilled. Segment-D, delineated for a strike length of 330m exposes the Northern Zone and scout borehole TBH-14 drilled earlier to test this zone has intersected lean PGE mineralisation. Two first level boreholes

(T3BH-7&8) were drilled to see the western extension of the Northern Zone. Segment-E, delineated for a strike length of 300 m exposes only the Southern Zone and this zone is delineated for 70 m strike length. Close spaced trenching carried out to trace the strike extension of this zone clearly indicates pinching nature of the bands. Scout borehole TBH-15 drilled earlier to test the Southern Zone has proved the depth extension of this zone but the strike extension of this zone is limited and no first level borehole is proposed in this segment. Segment-F delineated for a strike length of 700m exposes the Northern Zone and scout borehole TBH-16 drilled in the western most part of the segment has not intersected any PGE mineralisation indicating pinching nature of the chromitite bands in the western part, but close spaced trenching carried out in the eastern and central part of this segment has resulted in delineation of significant PGE mineralised zones at surface. Detailed geophysical surveys consisting of Magnetic (Total Field), Gravity, IP and Resistivity surveys including multielectrode dipole-dipole surveys were carried out, covering a strike length of 650 m in both A and F Sectors, to delineate the Chromiferous meta-pyroxenite bands within the anorthosite, the host rock for PGE mineralisation and also to prove the depth persistence of the PGE mineralisation in the central part of Tasampalayam block (T3 sector), Sittampundi Anorthosite Complex, Namakkal district. Segment A falls in the eastern part and Segment F falls in the western part of T3 sector, are characterised by a group of rocks ranging in composition from chromitite, meta-pyroxenite, pyroxenite, garnetiferous pyroxene granulite and anorthosite. The chromitite and meta-pyroxenite bands hosting the PGE mineralisation occur within anorthosite. In Segment A, the magnetic contour map with 10nT contour interval shows a total variation of 450 nT. High dominant magnetic anomaly with a maximum value of +100nT recorded over anorthosite trending E-W direction in the northern part. Magnetic anomaly map has well brought out the structural step and lithological boundaries in the form of steep gradients and change in gradients. The contact between pyroxene granulite and anorthosite is well reflected with steep

magnetic gradients trending ENE-WSW direction in the southern part. The chromiferous meta-pyroxenite bands exposed in the trenches are well reflected in the form subtle magnetic variations of the order of 10 to 20nT, trending E-W direction. Bouguer gravity map with a contour interval of 0.1 mGal brings out a total variation of around 1.60 mGal recording a minimum value of -89.2 mGal in the northwestern part of the area over anorthosite and a maximum value of -87.6 mGal noticed over coarse grained garnetiferous pyroxene granulite in the southern part. Moderate anomalies of the order of -88.2 to 88.6 noticed between traverses E100 to E300 and stations: 0 to N50 over chromiferous meta-pyroxenite bands within the anorthosite trending east-west direction. The resistivity contour map with contour interval of 100 Ohm.m brings out a total variation of around 2,300 Ohm.m, recording maximum values up to 2,600 Ohm.m in the central part over massive anorthosite trending east-west direction, between stations 0 and S80. Low resistivity values of the order of 300-600 Ohm.m noticed over kaolinised zones within anorthosite consists of chromiferous metapyroxenite bands, corroborating well with high chargeability anomaly zones in the northern part between stations 0 and N70. Multi-electrode dipole-dipole surveys carried out along Tr: E250 between stations S100 to N140, indicated the presence of thin, narrow chromiferous metapyroxenite bands extended up to 60 m depth. In Segment B, the magnetic contour map with 20nT contour interval shows a total variation of 1,600 nT. High dominant magnetic anomaly with a maximum value of +200nT recorded over anorthosite trending ENE-WSW direction exposed in the central part. The contact between pyroxene granulite and anorthosite is well reflected with steep magnetic gradients trending ENE-WSW direction in both south and northern part (covered by soil). The chromiferous meta-pyroxenite bands exposed in the trenches/old workings are reflected in the form subtle magnetic variations of the order of 10 to 20nT, trending ENE-WSW direction. Bouguer gravity anomaly map with a contour interval of 0.1 mGal brings out a total variation of around 3.20 mGal recording a minimum value of -88.8 mGal in the northwestern part over soil cover and a maximum value of -88.8 mGal noticed over coarse grained garnetiferous pyroxene granulite in the

southeastern part. Moderate anomalies of the order of -86.4 to -87.2 noticed between stations S100 to N50 over the anorthosite band trending ENE-WSW direction. The resistivity contour map with contour interval of 100 Ohm.m brings out a total variation of around 4,400 Ohm.m, recording maximum values up to 4,800 Ohm.m in the southern part over pyroxene granulite. Low resistivity values of the order of 400-600 Ohm.m noticed over kaolinised zones within anorthosite consists of thin and narrow chromiferous metapyroxenite bands, corroborating well with high chargeability anomaly zones of the order of 12-14.5 m. sec/V in the central part between stations 0 and S50. The investigation will be continued. A G4 stage investigation was taken up in Tattayangarpettai-Turaiyur area, Namakkal and Tiruchirappalli districts to delineate potential zones of PGE mineralisation and to bring out the nature and control of mineralisation. The area forms another potential zone of meta-ultramafites that is present in the eastern segment of the PCSZ, in the proximity of its southern boundary i.e., the Cauvery Shear Zone. An area of 40 sq km was mapped on 1:12500 scale in parts of Tiruchirappalli district, around Tattayangarpettai, Devanur, Payattamparai, Valaiyeddupu, Serigudi, Arachhi and Krishnapuram to delineate the ultramafic rocks, to bring about their disposition and explore the possibility of PGE mineralisation in this area. The major rock types exposed in the area are hornblende gneiss and charnockite ( $\pm$ garnet). The other rock types exposed include garnet pyroxene granulite/gneiss, pyroxenite. Altered dunite with ramified magnesite veins occurs as a linear body with a near ENE-WSW trend 750 m west of Tattayangarpettai. This dunite band is traced for a strike length of 500 m with width varying from ~30 to 60 m. These outcrops are often covered by kankar. Thin and sporadic development of magnesite is seen at places within the dunite. Serpentinisation and development of vermiculite are found at the contact zone between gneiss and dunite. A number of pyroxenite and altered ultramafics (talc-tremolite) bands occur as discontinuous bands/ lenses, which vary in width from 10 m to 70 m and in length from 100 m to 800 m and are exposed in a 10 km wide zone to the south of Tattayangarpettai and Kasturippatti. A total of 24 nos of pyroxenite bands and 07 nos of altered ultramafics (talc-tremolite rock) were delineated. The

pyroxenites are medium to coarse grained, granular and black to dark green in colour. In hand specimen, it is medium to coarse grained with bottle green pyroxene, honey yellow pyroxene and occasional feldspar. Talc and chlorite alterations are also observed. Petrographic studies indicate the presence of orthopyroxenes (up to 40%) and clinopyroxenes (up to 25%), amphibole (up to 3%), epidote (up to 10%) and opaques (5%). Development of actinolite, tremolite and talc is commonly observed in the alteration zones. Under thin section, the pyroxenite is essentially composed of Opx (hypersthene) and Cpx (augite). The Opx exhibits strong pink pleochroism and the Cpx shows the lamellae of Opx (inverted pigeonite). The pigeonite (high temperature low calcium Cpx) carries lot of Opx and hence the lamellae of Opx is seen in the Cpx. Epidote occurs as discrete grains and is in equilibrium with Opx and Cpx. Few amphiboles are seen within the epidote. The opaque minerals are magnetite and chrome spinel.

## DIAMOND

GSI, continued with its engagement in exploration for diamond during 2014-15.

## GSI

In Chhattisgarh, a G4 stage investigation to locate kimberlite/ lamproite bodies was taken up in the Mainpur Kimberlite Field in Gariaband district. Photogeology and Remote Sensing and Aeromagnetic studies of 700 sq km area on 1:50000 were completed and base map was prepared. Reconnaissance mapping was carried out in toposheet No.64 L/2 covering 700 sq km area and DM of 5 sq km area on 1:5000 was completed. 162 stream sediment samples, 24 PCS, 32 PS and 162 samples for HMS were collected. The area constitutes granites of Bundeli granitoids, sandstone of Chhattisgarh Supergroup and intrusive mafic dykes. Three dykes are observed in the area, which are hard, compact, fine to medium grained and are trending N35°W-S35°E. A volcanic rock having 40 m  $\times$  30 m dimension is present in the vicinity of newly found ultramafic and mafic dyke. The investigation is completed. A G4 stage was taken up in the Mainpur Kimberlite Field to search for kimberlite clan rocks in Gariaband district. A

base map was prepared with inputs from PGRS studies. An area of 700 sq m was covered by reconnaissance mapping on 1:50000 scale and 180 SSS, 20 of PCS, 30 PS, and 180 HMS were collected. The study area predominantly exposes granitoids intruded by mafic dykes of meso-proterozoic age. Quartz veins and pegmatite are the youngest intrusives in the area. Sandstones of Devdhara Formation of Pairi Group occupies the southeastern part of the area. Field work was also carried out around Kodomali, Dhawalpur, Behradih and Parkom lamprophyre field Gariaband area to study known kimberlites/lamprophyres/lamproites.

In Jharkhand, a G4 stage investigation to locate kimberlite/ lamproite bodies was taken up in parts of Simdega district. Reconnaissance mapping of an area of 700 sq km has been completed and 150 stream sediment samples were collected from suitable trap sites. Regional samples were collected from 4<sup>th</sup> and 5<sup>th</sup> order streams and detailed samples from 2<sup>nd</sup> and 3<sup>rd</sup> order streams. The samples were processed to get heavy mineral concentrate in two fractions, coarser between - 1.25 to 0.5 mm and finer between- 0.5 to 0.17 mm. Ten nos of the heavy mineral concentrates were scanned and minerals which are suspected to be derived from the mantle were separated for further analysis. A total of 25 nos of PS and 20 nos of PCS are collected for studies.

In Karnataka, G4 stage investigation was taken up in Ballari and Chitradurga districts. Digital image processing of downloaded ETM+data of two scenes P144 R50 and P145 R50 was done using ERDAS Imaging software to prepare lineament map on a regional scale so as to cover the known Wajrakarur Kimberlite Field and the area under investigation. The structural elements observed in the Wajrakarur Kimberlite Field also prevail in the area under investigation. The digital signatures of the extensions of NE-SW trending fault in WKF inferred in the area under investigation. Close spaced geological traverses taken in the area where lineaments inferred are intersecting. A shear zone about 0.5 km width trending in N35°W-S35°W direction is found to the south east of Vaderahalli which is characterised by stretching of quartz grains. A N70°E-S70°W trending fault is intersecting the above mentioned shear. The fault is identified by silicification, brecciation, mylonitisation and the dislocation of quartz veins

on outcrop scale. PGRS study and study of Vasundhara lineament map reveals this to be extension of Wajrakarur Fault. The investigation will be continued in 2015-16. A G4 stage investigation was taken up to the northwest of Chirtagunta in Ballari and Chitradurga districts. The area is occupied by rocks belonging to unclassified eastern Dharwars consisting schistose rocks, granites and gneisses of PGC-II and Clospet granite equivalents and younger intrusives of acidic and basic dykes. Three km NW of Chirtagunta, calcrete capping is identified over the granite. Sample processing and screening of the samples was done at camp. The fraction with 1 mm to 0.5 mm and 0.5 mm to 0.3 mm size were taken up for further concentration with the help of Garytz type jig (gravitational separation apparatus) and subjected to iso-dynamic separation at PPOD laboratory. Magnetic minerals were removed by bar magnet rolled over the jig concentrate first. Samples separated with the help of iso-dynamic separator, further studied at camp under the binocular microscope to recover the kimberlite indicator minerals like ilmenite, garnet, spinel, chrome diopside, zircon, microdiamond, olivine etc.

In Telangana (erstwhile part of Andhra Pradesh), G4 stage investigation was taken up in Rangareddy, Mahbubnagar and Hyderabad districts. Eight blocks have been identified in structurally interpreted lineament map. A total of 515 sq km area has been covered by taking traverses. Dolerite dykes are emplaced along some of the lineaments. A total of 30 numbers of regional stream sediment samples (covering 25 to 30 sq km) and 90 numbers of detailed stream sediment samples (5 sq km) from appropriate trap sites have been collected and processed to recover heavies. One hundred samples were scanned under binocular microscope to identify kimberlite indicator minerals (KIMs). A lamprophyre dyke (16°56'6.8"N:78°6'36.7"E), located 1.5 km north of Raghavapuram, trending N-S direction and approximately 50 m length and 30 cm width. A hornblendite, located 3 km SE of Bodijanampeta (16°54'38.6"N:78°14'8.1"E) trending N40°W with 150 m × 80 m dimension, is noticed. It consists of phenocrysts of 2 cm to 3 cm size euhedral crystals of amphiboles and feldspars form the groundmass. A lamproite dyke, located 1.5 km southwest of Chintalapalli, trending E-W direction and approximately 1 km long (as inferred from stray

boulders lying in agricultural field). Megascopically, these lamproites are grey coloured, fine grained and highly altered. In thin section these lamproites are highly altered mostly into carbonate and chlorites. At places, pseudomorph of leucite is also observed. A hornblendite, located 700m NW of Emulnaram village is trending N-S and extends for 200m with a width of 120 m. It consists of phenocrysts of 2 cm to 3 cm size euhedral crystals of amphiboles and feldspars in ground mass as well. The investigation is completed. A G4 stage investigation was taken up in Somasila area, Mahbubnagar and Kurnool districts. In addition to field traverses, stream sediment sampling was carried out and 95 numbers of samples have been collected. A total of 78 numbers of heavy mineral concentrates are examined under binocular microscope to identify KIMs. Few suspected KIMs (spinel) are confirmed as Cr-spinel by EPMA studies showing their kimberlite affinity. Two new lamproite clusters were located for first time near Somasila village, Kollapur Mandal, Mahabubnagar district, at the NW margin of the Cuddapah basin. The ultrapotassic rocks are emplaced into the lower Cuddapah sedimentary sequences along WNW-ESE trend. So far seven numbers of lamproite bodies are discovered in Somasila area. The lamproite bodies are intersected in the hills of Cuddapah sedimentary sequences and found up to the height of 320 m in the Vempalle dolomite. The lamproite bodies are covered by Banganapalli conglomerate and quartzite of Kurnool Group in many places. Besides Somasila lamproites one more lamproite cluster is identified to the south of Kollapur village where lamproite dykes emplaced in the margin of Cuddapah basin and PGC basement following a WNW-ESE trend. Megascopically the lamproites are altered, brownish grey to greenish grey, hard, compact, vesicular (due to the removal of primary minerals) contain pseudomorphs of megacrystic to macrocrystic olivine, serpentine and secondary calcites. In addition, disseminated sulphides are also seen occurring as rim or necklace. Limited petrological studies revealed that the rock is made up of microphenocrysts of altered olivine, pyroxene, phlogopite, and translucent to opaque minerals set in a groundmass rich in carbonate, phlogopite, serpentine, and chlorite. At the first outlook this exotic rock seems very fresh among their rock clan in

South India. A G4 stage investigation was taken up in five sub-blocks namely Gurakonda, Koilsagar, Chinnamungalchedu, Manikonda and Komreddipalli of Mahbubnagar and Kurnool districts. Detailed ground traverses were conducted in all five sub-blocks to explore kimberlites. Numerous calcrete zones were observed and examined for their kimberlite affinity. A total of 150 nos of stream sediment samples were collected from five sub-blocks namely Gurakonda, Koilsagar, Chinnamungalchedu, Manikonda and Komreddipalli. The samples were processed and examined to locate kimberlites. Suspected kimberlite zones identified in Gurakonda sub-block after the recovery of fresh and coarser kimberlite indicator minerals. The calcrete chemistry of Gurakonda sub-block matches with Wajrakarur calcretes (Chigicherla cluster). Those calcrete zones which have kimberlitic affinity were identified for pitting/auger drilling.

#### **PRECIOUS MINERALS State Directorate**

During 2014-15, DMG, Jharkhand conducted exploration for precious minerals (beryl/emerald) in Hariyan, Barunmuti and Chadriburu areas, East Singhbhum distt by geological mapping on 1:25000 scale in 4 sq km area and collection of six nos samples. Occurrences of emerald are associated with pegmatite and biotite schist.

#### **GOLD**

The GSI, MECL and HGML were engaged in the exploration for gold during 2014-15. An account of exploration work done by GSI is given in Table-6. The details of exploration carried out by HGML are given in Table- 7.

#### **INDUSTRIAL MINERALS**

The details of exploration work carried out for industrial minerals by GSI, State Governments and Central/State Undertakings during 2014-15 are given in Table - 8.

#### **DECORATIVE DIMENSION STONES**

The details of exploration work carried out for granite, sandstone and decorative dimension stones by GSI and State DGMs during 2014-15 are furnished in Table - 9.

## EXPLORATION &amp; DEVELOPMENT

**Table - 6: Exploration for Gold by GSI, 2014-15**

State/District	Location	Details of work done	Results obtained/Remarks
<b>Andhra Pradesh</b> Kurnool	Gani-Kalava area	Trenching, sampling and analysis	G4 stage investigation was carried out in the Gani-Kalava area in the western part of the Proterozoic Cuddapah Basin. In Kalava South Block, the quartz veins are trending in NE-SW and ENE-WSW directions. They are intruded in gabbroic sills with cumulative strike extension of about 700 m with width varying from few cms to 2.5 m. This quartz veins show sulphide mineralisation in the form of chalcopyrite disseminations and malachite staining. In the Kalava block, two Cu old workings were noticed which are surrounded by the dump material consisting of quartz, basic sill and ferruginous shale fragments. Quartz vein rubble shows incidence of sulphides mainly pyrite and chalcopyrite with malachite staining. Sulphidic quartz vein (chalcopyrite, pyrite and chalcocite) has been noticed after a gap of 500 m from the old workings along the same trend of the mineralised quartz vein. The old workings in the Gani block extend for a strike length of about 2.4 km in an enechelon pattern in NW-SE direction and are situated generally at the shale/sill contacts. The Gani block is devoid of any gossan and wall rock alteration characteristics. However, chloritisation, silicification and introduction of carbonate is noticed. In the Kalava south block, 1 km SW of Gudembai Tanda, two quartz veins trending NE-SW and ENE-WSW direction are noticed within the gabbroic sills. They show indications of Cu mineralisation in the form of malachite staining and occasional chalcopyrite, pyrite disseminations. A total of 25 cu m trenching was carried out in the Kalava east block. Trench KT-1 was excavated in the old working which exposed quartz-carbonate vein with sulphides in the form of disseminations and malachite staining. Trench KT-3 excavated in the further east of the Kalava east block exposed quartz vein with chalcopyrite specks and malachite staining. Eight (08) bed rock samples analysed 60 ppb to 9 ppm Au. Out of the 04 samples collected from the NE-SW trending quartz vein in Kalava south block, 2 samples analysed 9 ppm and 1.5 ppm Au. Out of 25 trench samples from the Kalava east block submitted so far, results of 10 samples have been received. The Au values ranges from <25 ppb to 85 ppb. The quartz-carbonate vein exposed in the trench KT-1 analysed 85 ppb Au. IP/Res/SP surveys have been carried out in the Kalava east and south block.

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EXPLORATION & DEVELOPMENT

Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
<b>Bihar</b> Gaya	Majhauri-Ghansura-Ajaynagar area	Drilling, geophysical survey, and analysis	G4 stage investigation was carried out in Majhauri-Ghansura-Ajaynagar to identify zones of gold mineralisation. Surface work was carried out in Majhauri (Block-B) and Ghansura (Block-C) and West Ajaynagar (Block-D) were explored by scout drilling. Three boreholes, NB-07, NB-08 & NB-09 were targeted in Majhauri block (Block-B). The main lithology intersected along these boreholes includes tuff with associated very thin BIF bands (<30 cm), phyllite and gabbro sill. From the analytical results so far received a total of 14 samples yielded low range anomalous Au value ranging from 50 ppb to 295 ppb. Three zones of one metre thickness each, were identified in borehole NB-09 at 69.35 to 70.35 (Average Au=210 ppb), 70.95 to 72.3 (Average Au=65 ppb) and 73.7 to 74.5 m (Average Au=75 ppb) along borehole. Four boreholes, NB-10 to NB-13, were put in Ghansura block (Block-C). Geophysical survey (IP-SP) of 61.121 km carried out in the Block-D helped in delineating two prominent anomaly zones, (zone-I and zone-II) characterised by high chargeability and low SP. The depth to the top of the causative body estimated from the IP/resistivity pseudo depth section is at about 15m to 20m from the surface. Nine samples from Block-D yielded anomalous Au value ranging from 60 ppb to 950 ppb (Avg. 277 ppb; n=9).
<b>Jharkhand</b> Ranchi	Sindauri-Ghanshyampur area	Drilling and delineation	G3 stage investigation was carried out in Sindauri-Ghanshyampur area within Dalma volcanics and Singhbhum Group meta-sedimentaries to assess their gold potentiality. Four boreholes were drilled in this block. The rock types intersected in these boreholes were magnetite-quartz-biotite-sericite schist, phyllite, buff/grey quartzite, calc-quartzite/ferruginous quartzite, quartzo-felspathic phyllite, amphibolites of Upper Singhbhum Group. The sulphide mineralised zones intersected in boreholes comprise stringers of arsenopyrite, pyrrhotite, pyrite, chalcopyrite along with suspected gold grains. A number of mineralised zones have been delineated based on visual estimate of sulphides namely pyrite, arsenopyrite, pyrrhotite etc. (2-3%). The investigation is completed.

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EXPLORATION & DEVELOPMENT

Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
Sareikela-Kharsawan	Largadih and Largadih East blocks	Trenching drilling and analysis	G4 stage investigation was carried out for assessment of gold and REE-RM potentiality. The sulphide mineralised zones intersected in boreholes comprise dissemination and stringers of pyrite, arsenopyrite, chalcopyrite and sphalerite. Analytical results of core and trench samples received so far show Au values <50 ppb. Few mineralised zones have been delineated based on visual estimate of sulphides (2-3%).
<b>Karnataka</b> Dharward	Bangaragatti area	Trenching, drilling and sampling	G3 stage investigation was carried out to assess gold mineralisation. Geologically, the area consists of metasedimentary rocks like argillite and banded iron formation (BIF). The BIF is interbedded with argillite rock and they are structurally likely disturbed at folded portions; the band thickness varies from half metres to six metres at places. Total cumulative length of BIF is 800 meter. 24 cubic meter of trench excavated. A total of 35 BRS, 7 samples for petrological studies and 6 for ore microscopic study were collected. Ten boreholes each of 100 m depth are planned in the central band to establish the sub-surface behaviour of about one km long mineralised zone during the 2014-15. The exploration by drilling in the Bangaragatti area commenced from the northern side of the block. The area is located at a distance of 2.5 km west of Hullambi village. All the boreholes intersected the zones with various widths and thicknesses. The zone is characterised by disseminations of sulphides.
-do-	Hulkoppa area	Trenching and sampling	G4 stage investigation for gold was carried out in Hulkoppa block. The mapped area exposes argillite-greywacke assemblage with BIF bands, traversed by younger gabbro dykes and quartz veins of different generations. During the period five BMQ bands were delineated in the area and were named as band nos. I, II, III, IV & V. A total cumulative strike length of 3,100 m is established in five BMQ bands. The mineralisation here is mainly confined to quartz carbonate veins/veinlets hosted by the sheared BMQ that contains sulphides, mainly pyrite and pyrrhotite and few specks of arsenopyrite. Trenches are excavated across the BMQ bands at 100-150 m intervals. Total 39 nos of trench samples and 75 nos BRS collected across the BMQ bands submitted for chemical analysis.

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Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
Shivamogga	Parts of Shimoga Schist Belt	Mapping	G4 stage investigation was carried out in parts of Shimoga schist belt for assessment of gold mineralisation. The gold mineralisation in the area is confined within the metabasalt and quartzcarbonate veins hosted by metabasalt. A parallel zone is identified 25 to 30 m west of main mineralised zone near the small hillock north of UNESCO pillar at Kudrekonda. To the southern part of Kudrekonda block evidences of shear and mineralisation is observed 30 metres east of main zone (which is marked by the alignment of old workings). This zone is traceable for 100 metres and characterised by pyrrhotite and chalcopyrite. The quartz rubble from this part shows malachite stains as well. The BIF bands NW of Maddapuratanda are found sulphidiferous and are sampled for the entire strike length to identify potential zones.
-do-	N-W of Musinhal village	Mapping	G4 stage investigation was carried out to assess gold mineralisation. Layered carbonated metabasalt with sulphide grains i.e. pyrite, chalcopyrite are observed atop 774 ridge, 2 km NW of Musinhal village on the way to Palavanahalli village. NW of Musinhal village highly sheared metabasalt and quartz-chlorite-sericite schist are observed. This shear zone is marked by intense shearing and alteration in the form of carbonatisation, silicification, chloritisation, tourmalinisation, fuchsitisation, and carrying sulphide mineralisation as stringers and disseminations of pyrite and minor chalcopyrite. This shear zone is forming a parallel zone to the trend of Kudrakonda old working mines. Pounding marks are observed on massive outcrop along the slope of ridge at Birnakere Reserve Forest. A zone of titaniferous-vanadiferous magnetite (TVM zone) of 3 km length and 250 m width is traced with discontinuous patches, 1 km SE of Yadavala village to 2 km east of SE of Tyjavalli village. Small pockets of manganese are discovered at 3 km west of Birnakere village in and around 852 peak/ridge.
Tumakuru	Ajjanahalli block-G	Drilling, sampling and analysis	G3 stage investigation was carried out for assessment of gold mineralisation. In Block-G, a total 255 nos of borehole core samples and one bed rock sample were collected during the field season. Chemical analysis of 172 nos samples (collected from boreholes AGG-1 to AGG-3 & 11 nos of samples of AGG-4) has been received so far. In AGG-1 average gold value is of 0.19g/t/1.0 m whereas in borehole AGG-2 the same mineralised zone continues with values of 0.63 g/t/1.0 m and 0.90 g/t/0.5 m in the targeted BIF band. In AGG-3 gold values are of 0.30g/t/0.5m and 0.5g/t/0.5m. In borehole AGG-4, the average gold value is of 0.18g/t/1.0 m in the targeted BIF band. The length of mineralised zone will be calculated after receiving all the chemical analyses. The mineralisation is confined to sheared silicified BIF hosting thin quartz-carbonate veins and veinlets.

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EXPLORATION & DEVELOPMENT

Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
Tumakuru	Ajjanahalli area	Mapping, trenching, sampling and analysis	G4 stage investigation was carried out to delineate gold mineralised zones. In Ajjanahalli H-block, the detailed geological mapping has been completed and 57 bed rock samples, 66 cu m of trenching and 45 trench samples have been generated. One carbonated BIF band with four major BIF bands and other two minor BIF bands between BIF-II & III were delineated. The carbonated BIF band, with a total strike length of 550 m, is partly massive and partly brecciated. The BIF band-I, with strike length of 1050 m, shows partly massive and partly brecciated and silicified, along which band so far three trenches were excavated at 75 m to 100 m interval. BIF band-II & III, are partly massive and some partly brecciated and silicified in nature. BIF band-IV, with a strike length of 600 m is very thin having a width of maximum 2 m. So far received out of the analytical results of 58 nos of samples (BRS+PTS), 5 nos samples show Au values varying from 0.04 g/t/1m to 0.15 g/t/1m.
<b>Kerala</b> Palakkad	Attapady Valley	Mapping, trenching, Panning etc.	G-4 stage investigation for gold was carried out with an objective to trace the granite-supracrustal relationship and to delineate the mineralised zones by bedrock and soil geochemical survey. The method of panning the first order and second order streams in the area for gold was adopted for preliminary and rapid assessment of gold mineralisation. A total of 130 first-order streams were panned to establish the lithological control of mineralisation. Out of 130 locations, 61 yielded gold specks. Based on the results of gold panning, an ENE-WSW trending zone extending from around Puttumala to Kurukkankundu was identified as one of the target zones for soil sampling. Two other areas, one near Ommala and another between Jellippara and Mundanpara were also covered by soil sampling in 100 × 25 m grid pattern. Sulphide-bearing samples were collected from the trenches to understand the mode of mineralisation. Granites around Puttumala and Sholayur area have been considered for detailed geochemical study including major, trace and REE elements to decipher their origin and role in gold mineralisation. Twelve soil samples and 8 trench samples from these target zones yielded Au value above 25 ppb. Within this, the highest value of 800 ppb was yielded from a trench sample in the Puttumala area. The trench samples from the interface between soil and bedrock yielded anomalous values. Due to the huge thickness of soil cover (more than 20 feet), sampling from the 'B' and 'C' horizons of in situ soil developed over the bedrock is a tough task to precisely target the mineralised zone.

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Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
<b>Madhya Pradesh</b>			
Betul	Amla, Belnadi, Jambara, Sontalai areas	Stream sediment sampling	G4 stage investigation was carried out in Amla along Belnadi, Jambara, Sonatalai and surrounding areas in Betul district. BRS and stream sediment samples were collected in 200 × 200 grid for analysis. The rocks are intruded by younger dolerite dykes, granitoids and associated aplites, quartzofelspathic veins and quartz veins. Opaque minerals occur in significant proportions in quartz biotite gneiss (meta-rhyolite) in the study area. Chalcopyrite occurs in close association with covellite and the covellite appears to be an alteration product of chalcopyrite. Pyrite is the dominant sulphide mineral phase and occurs as euhedral grains, as fracture fillings and in disseminated pattern.
<b>Maharashtra</b>			
Sindhudurg	Kudal-Kankavle-Vagre areas	Mapping and sampling	G4 stage investigation was carried out in the Precambrian terrain of Kudal-Kankavle-Vagre areas. The predominant rock types exposed in the area are BIF, serpentinite, amphibolite which occur as dismembered enclaves within TTG gneiss. This suite of rocks is intruded by granitoid, gabbroid, pegmatite and quartz veins. Felsic intrusives with pyrite and chalcopyrite were noted near the contact zone between serpentinite and granitoid. DM (1:5000) of an area of 1 sq km has been carried out in Dabachiwadi area. Dabachiwadi exposes serpentinite/ dunite, BMQ, TTG gneiss, foliated granite gneiss, grey quartz vein, pegmatite and felsic intrusive with pyrite-chalcopyrite disseminations (exposed dimension is 75 m × 80 m). The presence of granite mylonite close to the sulphide rich occurrence possibly indicates a shear zone. The serpentinite/ dunite exposed in the area exhibits chrome concentration as black sub metallic mineral along weak planes. Few nickel sulphides were also seen in these rocks. These bodies appear to be potential sources for Ni-Cr-PGE. There are many reported economic concentrations of Au in such bands. These have been sampled for Au analysis. Number of pegmatites seen close to the granitoid bodies could be host for REE.
<b>Odisha</b>			
Kendujhar and Angul	Jamphirposi-Shankakhhol block	Sampling and panning	G4 stage investigation was carried out in search of gold mineralisation. BRS samples of metabasalt have shown gold value of 200 ppb, 210 ppb and 540 ppb, whereas panned concentrate of SSS yielded up to 300 flakes of visible gold/nugget from 1 <sup>st</sup> and 2 <sup>nd</sup> order nalas. The sulphides occur in the form of lenses, veinlets and disseminations. The laterites with crisscrossing smoky/white quartz veins and Quartz Pebble Conglomerate (QPC) horizons are sampled for possible gold occurrence.

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Table - 6 (Concl.d.)

State/District	Location	Details of work done	Results obtained/Remarks
<b>Rajasthan</b>			
Banswara,	Gundelpara West block	Drilling, sampling and analysis	G3 stage investigation was carried out to test the sub-surface continuity of the three parallel to sub-parallel mineralised zones (numbered I, II and III from east to west), delineated during 2012-13 on the basis of surface geological and geochemical attributes. A total of 9 boreholes have been drilled, so far, to intersect the mineralisation zones I to III at 100 m interval. All the boreholes proved the subsurface continuity of the mineralised zones. Study of the borehole cores shows that primary sulphides occur mainly in dolomite marble, albite rich rock and amphibolite in order of decreasing abundance. The width of sulphide zones along boreholes varies from 1.00 m to 14.15 m and visual estimate of sulphides ranges from 5 to 8%. Sub-surface exploration has established 100 m, 200 m and 500m strike continuity of mineralised zones - MZ-I, II and III. Analytical results of the core samples of boreholes GW-1 to 4 revealed the presence of copper zones varying in width along borehole from 1.10 m to 4.05 m, with average grade of copper ranging from 0.13 to 1.08% at 0.10% cut off and 1 m stoping width.
Banswara Dungarpur and Udaipur	Between Khamera and Devalapal	Mapping, and sampling	G4 stage investigation was carried out to assess the nature and potentiality of gold-copper mineralisation. Five mineralised zones (100 to 650 m long) are demarcated in the mapped area. Analytical results of a 12 m long channel at contact of grey marble and grey schist near Sarpotia village indicated presence of 0.34% average Zn. Four bed rock samples from Mokhampura, Ganera, Hirawa and Dhauli Magri villages show Cu values 2,012 ppm, 1,528 ppm, 1,074 ppm and 1,105 ppm, respectively. Two bedrock samples collected from ferruginised grey marble and from an old working at Ganera and Mokhampura villages have analysed anomalous Ni (1,028 ppm and 1,711 ppm). One bedrock sample collected from an old working within grey marble near Sarpotia village has analysed anomalous Pb (1,402 ppm). Similarly another bedrock sample from white dolomitic marble from near to Dhauli Magri village have analysed anomalous Ba (1,649 ppm).
Dungarpur,	Mahurikhera area	Channel sampling and analysis	G4 stage investigation was carried out to assess the nature and potentiality of gold-copper mineralisation. Seven mineralised zones (MZ-I to VII) have been demarcated on the basis of surface evidences of mineralisation in the form of old-workings, gossan zones, sulphides including chalcopyrite and pyrite disseminations, malachite stains, silicification, hydrothermal alterations, presence of ore grinding implements and slag dumps in the area. Analytical results of channel samples received so far indicated presence of 1 m to 12 m thick gold zones with average grade 0.10 ppm to 1.11 ppm at 0.10 ppm cut-off. At 0.10% cut-off, width of copper zones varies from 1 m to 18m with average copper content 0.10% to 0.45percent.

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**MECL**

During 2014-15, MECL carried out exploration for gold ore in Parasi (East Block, Ranchi distt, Jharkhand involving: mapping- 0.50 sq km area on 1:1000 scale; drilling - 3, 193 m in 19 boreholes; sampling & chemical analysis- 100 nos primary, 133 nos check & 51 nos composite samples; fire assay - 2,574 nos; petrographic studies - 50 nos; mineragraphic studies - 50 nos; specific gravity determination - 60 nos and estimation of 2.07 million tonnes of gold ore with 1.26 g/t Au at 0.50 g/t Au cut off & 1.06 million tonnes with 1.89 g/t Au at 1.00 g/t Au cut off under 332 & 333 categories. Similarly in Pahardia Gold Prospect, West Singhbhum distt,

Jharkhand exploration for gold ore conducted by: mapping - 1.00 sq km area on 1:1000 scale; drilling - 2,527 m in 13 boreholes; sampling & chemical analysis - 1,247 nos primary samples for fire assay for Au, 50 nos for three radicals, 60 nos check samples & 39 nos composite samples; petrographic studies - 30 nos; mineragraphic studies- 30: specific gravity determination - 40 nos; beneficiation study of one bulk sample and estimation of 1.16 million tonnes gold ore with average grade of 2.12 g/t Au at 0.50 g/t cut-off & 0.58 million tonnes gold ore with average 3.60 g/t Au at 1 g/t Au cut-off (331&332).

**Table –7: Exploration for Gold by HGML, 2014-15**

State / District	Location	Agency	Details of work done	Results obtained
<b>Karnataka</b>				
Raichur	Hutti	HGML	Underground mapping - 2,045.10 m on 1:400 scale; trenching 02 nos- 156 cu m; surface drilling - 3,865.85 m (19 boreholes); underground drilling - 3,917.70 m (29 boreholes); collection of samples 10,005 nos; and exploratory mining - 2,814.76m.	As on 31-03-2015, reserves of gold ore were estimated at 9.21 million tonnes with 5.28 g/t Au under proved and 7.23 million tonnes with 4.83 g/t Au under probable category.
-do-	Hira-Buddini	HGML	Exploratory mining - 177.50 m and samples analysed - 1,081	About 0.502 million tonnes of proved reserves of gold ore with 3.94 g/t Au were computed.
-do-	Uti	HGML	Exploratory mining - 491.20 m and samples analysed - 1,628	Total mineable reserves were estimated at 2.18 million tonnes ore with 2.59 g/t Au.

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**Table - 8: Exploration for Industrial Minerals by GSI, DGMs and Central/State Undertakings, 2014-15**

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>Geological Survey of India</b>							
<b>ANDALUSITE</b>							
<b>Uttar Pradesh</b>							
Sonbhadra	Banwarjharia- Mairpur area	-	-	-	-	-	G4 stage investigation resulted with two andalusite occurrences viz. Rantola-Katauli in west and Banwarjharia-Kurgi on east. Andalusite occurs as porphyroblasts within phyllite and schists of Parsoi Formation of Mahakoshal Group. Andalusite is also noted within pegmatite and quartz veins intruding phyllite. The andalusite bearing phyllite and schist forms a linear ridge in ENE-WSW direction occupying an area of 33.59 sq km. The andalusite noted here is mainly "chiastolite" variety (Al <sub>2</sub> SiO <sub>5</sub> ). The resource estimated per metre depth for 33.59 sq km is 7.7 million tonnes approximately with grade- 8.43% (Wt%) by weighted average method. The resource estimated for placer andalusite is 0.03 million tonnes approximately for average thickness of gravel beds- 1.00 m for an area of 0.15 sq km.
<b>CLAY</b>							
<b>Jammu &amp; Kashmir</b>							
Leh	Lamayuru- Bazgo area	LSM DM	50 05	-	-	381	G4 stage investigation of clay was taken up in Lamayuru-Bazgo area, (on expedition basis). The work carried out includes LSM of 50 sq km in Lamayuru-Khalsi area, Detailed Mapping (DM) of 5 sq km in Lamayurupalaeo lake and section measurement of 75 m in lacustrine deposits of Lamayurupalaeo lake. Lamayurupalaeo lake is a bowl shaped palaeolake located at a distance of 1.5 km east of Lamayuru village. Its clays are fine grained, creamish to brownish coloured, thinly laminated and have been deposited over the weathered hard rocks of undifferentiated KLG. These clays are soft, fragile with good plasticity. Mud cracks, sink hole like features and gullies are prominently noticed features of these clays. This was followed by the systematic collection of clay samples at a regular interval of 25 m along the traverse line. A total of 202 nos bed rock samples (BRS) for geochemical studies, 102 nos of samples for REE studies, 57 nos of samples for clay mineralogy by XRD method and 20 nos of samples for palaeomagnetic studies were collected.

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Table - 8(Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>DUNITE</b>							
<b>Tamil Nadu</b>							
Namakkal	Valasiramani East & West blocks	-	-	08	614.85		G4 stage investigation for reappraisal of dunite was taken up in Valasiramani West Block and Valasiramani East Block. Detailed investigation with scout drilling of 614.85 m have been carried out in boreholes VLS-1 to 8 in Valasiramani East Block. The analytical data of 22 nos of core samples belonging to BH.No. VLS-1, show the presence of SiO <sub>2</sub> (33.5-41.5%; Avg. 37.38%), MgO (36.62- 44.26%; Avg. 40.47%), Al <sub>2</sub> O <sub>3</sub> (0.30-1.26%; Avg 0.51%), CaO (0.64-2.76%; Avg. 1.13%), Fe <sub>2</sub> O <sub>3</sub> (5.90-8.27%; Avg. 7.07%) and LOI (6.58-14.90%; Avg. 11.91%). Similarly, the analytical data of 16 nos of core samples belonging to BH.No. VLS-3, show the presence of SiO <sub>2</sub> (28.70-41.50%; Avg. 35.30%), MgO (28 -47.20%; Avg. 38.97%), Al <sub>2</sub> O <sub>3</sub> (0.30-6%; Avg 1.39%), CaO (0.64-12.80%; Avg. 2.43%), Fe <sub>2</sub> O <sub>3</sub> (5.90- 11%; Avg. 7.58%) and LOI (6.58 . 19.30%; Avg. 12.66%). The MgO/SiO <sub>2</sub> of the rock types is more or equal to 1 indicating higher Mg content, with exception to pyroxenite bands occurring within the dunite/peridotite which is marginally less than 1 (i.e. higher silica, and lower MgO).
<b>GLAUCONITE</b>							
<b>Gujarat</b>							
Kachchh	Guneri village	1:5000	7.5	-	-	183	Detailed Investigation for potash in glauconite bearing shale and sandstone was carried out. The area was divided into 114 grids of 250 m × 250 m and sampling was carried out by pitting and from exposed sections. Pitting of 150 cu m was carried in grid pattern. A total of 151 samples were collected and sent for chemical analysis. 24 samples were collected for petrographic studies and 09 samples were collected for XRD studies. Section measurements were carried out at 5 sections. Glauconite is fine to medium grained, very light to dark green and occurs as small discontinuous bands within ferruginous sandstone. Occurrences of other economic minerals like

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>Madhya Pradesh</b> Sidhi	-	-	-	-	-	-	gypsum, bauxite and bentonite as small veins/pockets/patches were observed around Guneri and Umarsar areas. Glauconite occurs in three different forms in the study area; viz; hard and compact glauconitic sandstone, sandy to clayey soft glauconite, and intercalation of glauconite with fine grained ferruginous sandstone/siltstone. The bands are discontinuous, average thickness varies from few cms to 0.5 m. Based on the observation from pits and well sections, glauconite occurred at 0 to 4 m depth.
<b>Uttar Pradesh</b> Sonbhadra	Newari-Semiyan area	-	-	-	802.35	-	G4 stage investigation for glauconitic shale/ sandstone was taken up in Vindhyan Supergroup. Based on field observations three types of association of glauconite beds have been recorded. The analytical results of the samples indicate that glauconitic shale associated with Fawn limestone is the potential host of glauconite. Analytical results of 12 samples give K <sub>2</sub> O content between 3.85% -11.52 percent.
							G4 stage investigation was carried out by LSM, detailed mapping and scout drilling. Study of drilled cores together with borehole geophysical data of Semiyan block reveals glauconite mineralisation is occurring at three different levels in depth. 1.33million tonnes of resource was estimated on the basis of data of boreholes NSH-1, 2 & 3 in Semiyan block with an average grade of K <sub>2</sub> O- 4.86%. Glauconite bearing zone with a strike length of 650 m and average width of 30-50 m was delineated in the Barawadih area. Analytical results of 40 nos bed rock samples of Barawadih area show K <sub>2</sub> O value ranges 0.61% to 6.56 % with an average value of 4.31%. Analytical results of some spot samples of Kurccha block show maximum value for K <sub>2</sub> O is 11.09 percent.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>GRAPHITE</b>							
Andhra Pradesh	Burugubanda area	-	-	-	-	-	G3 stage investigation for graphite and tungsten mineralisation was carried out by drilling five boreholes. Core samples studied under UV-lamp indicated the presence of disseminated scheelite mineralisation in quartz-rich pegmatite portions. One core sample of borehole BBD-1 analysed 13.9% of fixed carbon and 750 ppm of tungsten. Borehole BBD-6 planned to drill in the eastern lens has been fixed on the ground and the same is planned in the area; the BBD-7 is in between the two lenses to test the strike continuity of the mineralisation whereas BBD-8 is to test the depth persistence of the mineralisation, at 90 m vertical depth. Due to non-availability of laboratory facility in GSI, SR for analysing fixed carbon, 50 core samples have been submitted to IBM, Ore Dressing Division, Nagpur.
<b>Arunachal Pradesh</b>							
Siang	Khitabari and Ragidoke	1:12500 1:2000	55 0.75	02	400	-	G4 stage investigation for graphite deposits was carried out by total of 55 sq km of LSM, 0.75 sq km of DM, 50 cu m of pitting and trenching along with 400 m drilling. In first borehole TA-1, graphite schist with carbonaceous phyllite was intersected at depths of 12.5-13.0 m, 16-20 m, 21-29 m, 36-36.70 m, 40-41 m and 103-106 m along the borehole and at vertical depths from 8-30 m and 55 m. Small specks of pyrite, pyrrhotite, chalcopyrite and occasional arsenopyrite occur associated with quartz-carbonate veins at various depths from 126-195 m, however, more concentrated at 174.5-184 m along borehole

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
							depth. In second borehole TA-2, rich zones of graphite schist were intersected at 9.5-10.5 m, 12-15 m, 16.5-18.0 m, 28.5-30 m, 32-36 m, 42-48 m, 56-59 m, 63.5-69 m, 71-76 m and 83-91 m along the borehole depths and at vertical depths varying from 8-76 m. Available results of spot bedrock sample of carbonaceous phyllite associated with graphite schist indicate 10.59% to 11.70% fixed carbon.
<b>Tamil Nadu</b>							
Sivaganga	Arsanur block	-	-	07	-	398	G3 stage investigation for reappraisal of graphite was carried out by drilling and boreholes GRAR-1 to GRAR-7 were completed. Core sampling was carried out to know the fixed carbon, volatile matter and moisture content. Petrological studies of borehole samples that the area has suffered intense deformation; graphite mineralisation occurs both as primary and secondary. From the core logging and sampling of borehole GRAR-1, 2, 3, 4, 5, 6 it is inferred that the graphite mineralisation is not strata bound. The graphite mineralisation is structurally controlled in Arasanur block.
<b>GYP SUM</b>							
<b>Chhattisgarh</b>							
Bemetara	Akola-Patora-Bhusandi-Karesara area	-	-	03	730.5	-	G4 stage investigation for gypsum was taken up by detailed mapping, sampling and drilling. In CBA-1, bedded gypsum with 1mm to 6 cm thickness and small pockets of gypsum have been intersected at the depth of 33.5 m and further in depth. In CBA-2, gypsum bands of 1mm to 2.07 m thickness were intersected at the depth of 6.5 m and below. 2.07 m thick massive type gypsum is intersected at 166.85-168.92 m depth. In CBA-3 gypsum of 1 mm - 4 cm thickness was intersected

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
							at a depth of 81.4 m and below at Dudhia village. Gypsiferous shale is the major litho unit intersected in the CBA-3, where gypsum horizon with varying thickness from 1mm to 3 cm is intersected from 5.85 m depth onwards. CBA-4 is located at Khursbod village and it has drilled 100.5 m so far. Gypsum bands with 1mm to 1.5 cm thickness are intersected in this borehole at a depth of 42.6 m and below.
<b>LIMESTONE</b>							
<b>Himachal Pradesh</b>							
Sirmour	Saindhar syncline	-	-	-	-	-	G4 stage investigation for assessment of limestone/dolomite was taken up in lower member of Kauriyala Formation (Krol 'C') of Krol Group to assess the grade and reserves for the use in cement, steel, fertiliser, poultry grit and glass industries etc. The analytical results of the channel samples are not encouraging to categorise the commodity for any particular industrial use.
<b>Meghalaya</b>							
East Khasi Hills	Mawlong-Ishamati block	-	-	-	822.60	-	G3 stage investigation for limestone was taken up in the extension area of Mawlong-Ishamati Block of Shella-Bholaganj Belt, by drilling. The analytical results of core samples have two zones of chemical grade limestone viz. 0.0 m to 70.05 m=70.05 m, with CaO 50.15%, MgO 1.24%, SiO <sub>2</sub> 3.1% and 79.20 m to 140.40 m=60.10 m, with CaO 50.80%, MgO 1.30%, SiO <sub>2</sub> 3.15 percent.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
Jaintia Hills	North of Larket block	-	-	07	768.05	-	3 stage investigation for limestone was taken up in north of Larket Block, Litang valley by drilling. The maximum thickness (120m) of limestone (Prang limestone) has been intersected in borehole JNLK-6. Kopili Formation and Prang limestone contain microfossils like Numulites, Alviolina, Discocyclina etc., bivalves like Pecten, Oyster and gastropod like Conus, Fusus, Oliva etc. On the basis of the analytical results received for the samples of three boreholes indicate presence of 38 m thick SMS grade limestone.
<b>Rajasthan</b> Jaisalmer	Minyun-ki-Dhani, (West)	-	-	18	900	616	G4 stage investigation for limestone was taken up by drilling. Out of analytical results of 274 nos core samples, the results of 60 nos indicate the grade matching with SMS (LD) grade with maximum CaO-55.06% and minimum CaO-50.35% and the grade of 62 nos are matching with the SMS (OH).
-do-	Bandah area	-	-	10	334.50	213	G4 stage investigation for low silica SMS grade limestone was taken up by drilling. Analytical results of 63 nos samples show an average SiO <sub>2</sub> -1.24%, CaO-53.7, MgO-0.38, Fe <sub>2</sub> O <sub>3</sub> -0.53 & Al <sub>2</sub> O <sub>3</sub> -0.19, respectively. These results match with the specification of chemically SMS grade limestone and 11 nos samples show on an average SiO <sub>2</sub> -5.83%, CaO-50.89, MgO-0.35, Fe <sub>2</sub> O <sub>3</sub> -0.74 & Al <sub>2</sub> O <sub>3</sub> -0.39, respectively, which matches with the specification of cement grade limestone.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Metreage		
<b>PYROPHYLLITE</b>							
<b>Uttar Pradesh</b>							
Lalitpur	Dongrakhurd-Gatholikalan area	-	-	05	518.22	-	G4 stage investigation for pyrophyllite- diaspore was taken up in Dongrakhurd-Gatholikalan area. LSM has been carried out in Gatholikalan, Pyasa, Kusmar, Dongrakhurd, Baron, Gona, Uldana Kalan and Saidpur areas and detailed mapping on 1:2000 scale was carried out in Tikra and Loharra areas. Scout drilling with a metreage of 518.22 m in 5 boreholes was carried out in Kherpura, Jhankar and Tikra areas. Pyrophyllite mineralisation was observed in quartz-sericite-pyrophyllite schist at various depths in drill hole KH-1, KH-2, JH-1 and JH-2 at Kherpura and Jhankar areas.
<b>QUARTZITE</b>							
<b>Jammu &amp; Kashmir</b>							
Udhampur	Sudh Mahadev area	-	-	-	-	-	G4 stage investigation was carried out in Sudh Mahadev area to assess the quartzite suitable for glass industry of Gamir Formation in Parautochthonous zone. Total 150 nos of bed rock samples were collected from the area for quality check of the quartzite. On the basis of the study of analytical results of 128 numbers of bed rock samples (so far received), it is noticed that 14 samples contain more than 100% silica, 87 samples contain 95-100% silica, 16 samples contain silica between 90-95% and 9 samples contain silica between 85-90%. The analytical results show that the quartzite exposed in the area is suitable for glass industry after suitable beneficiation.
<b>Mineral Exploration Corporation Ltd,</b>							
<b>LIMESTONE</b>							
<b>Nagaland</b>							
Kiphire	Mini Pyakatsu block	1:1000	4.50	05	531.50	475	Total 167.77 million tonnes of limestone resources (332 & 333) with average grade: SiO <sub>2</sub> - 1.11%, CaO - 55.93%, MgO - 0.39%, Fe <sub>2</sub> O <sub>3</sub> - 0.39%, Al <sub>2</sub> O <sub>3</sub> - 0.28% and LOI - 42.42% was estimated.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>Gujarat Mineral Development Corporation Ltd</b>							
<b>BALL CLAY &amp; SILICA SAND</b>							
<b>Gujarat</b>							
Bharuch	N/v Amod, Maljipura and Bhuri	-	-	-	-	-	Production of ball clay and silica sand was at 1.46 lakh tonnes and 2.09 lakh tonnes, respectively.
<b>M.P State Mining Corporation Ltd</b>							
<b>ROCK PHOSPHATE</b>							
<b>Madhya Pradesh</b>							
Jhabua	N/v Kachaldhara	-	-	07	282	121	No additional reserves was established.
<b>Rajasthan State Mines &amp; Minerals Ltd</b>							
<b>ROCK PHOSPHATE</b>							
<b>Rajasthan</b>							
Udaipur	Jhamarkotra Mines	-	-	14	1629	293	As on 1.4.2015, the balance resources and reserves are placed at 48.024 and 27.388 million tonnes, respectively.
<b>State Directorates of Geology and Mining</b>							
<b>ALUMINOUS LATERITE/CHINA CLAY</b>							
<b>Kerala</b>							
Kannur	Vaipiriyam area, Kankol village	-	-	07	250	-	Reserves of china clay was estimated at 10 million tonnes (121).
-do	Kannadipoyil area, Perinthatta village	-	-	04	97	-	Reserves not yet estimated.
-do	Korom area Kankol village	-	-	09	354	-	Reserves of china clay was estimated at 16 million tonnes (121).
-do-	Karinthadam area	-	-	05	140.5	-	Reserves not yet estimated.
Kasaragod	Nileswaram area	-	-	05	113.5	-	Reserves of china clay was estimated at 52,000 tonnes(KCCP area).
<b>APATITE</b>							
<b>West Bengal</b>							
Purulia	N/v Kutin	-	-	03	158	-	Exploration was in progress.
<b>BENTONITE, SILICEOUS EARTH, SILICA SAND, SAND STONE &amp; WHITE CLAY</b>							
<b>Rajasthan</b>							
Barmer	Jasse-Ka Gaon, 1 cm=500 m		100	-	-	12	Reserves not computed.
	Rawat Ka Gaon 1 cm=100 m		05	-	-	-	
	etc. 1 cm= 20 m		03	-	-	-	
<b>CHINA CLAY</b>							
<b>Kerala</b>							
Kollam	N/v Mulavana	-	-	12	447	-	A tentative reserves of dull white to greyish sandy clay was estimated at 9.6 million tonnes

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>DOLOMITE</b>							
<b>Chhattisgarh</b>							
Bastar	Bamhani area	1:50000 1:4000	305 1.01	-	504.4	264	Total 10 lakh tonnes of dolomite was estimated.
Jangir-Champa	Pachri- Bhalwahi	1:50000 1:4000	20 0.40	-	31	39	Total 50 lakh tonnes of BF grade dolomite was estimated.
<b>DOLOMITE, MASONRY STONE, QUARTZ &amp; FELSPAR</b>							
<b>Rajasthan</b>							
Rajsamand	Area of Bhim & Nathdwara Teh.	1:10000 1:4000	20 03	-	-	35	Recommended for future investigation.
<b>FLUORITE</b>							
<b>Rajasthan</b>							
Sirohi	N/v Wan, Andor & Sardarpura	1:10000 1:4000	05 05	-	-	10	Reserves not calculated
<b>GLAUCONITE (POTASH)</b>							
<b>Rajasthan</b>							
Chittorgarh	N/v Amalda, Jalampura etc.	1:50000 1:10000	100 05	-	-	20	Prospecting work completed.
<b>GRAPHITE</b>							
<b>Jharkhand</b>							
Palamu	Dhangaon, Sons, and Koiri Patra areas	1:25000 1:4000	50 1.10	-	-	27	Total 46 cu m pitting/ trenching have been done and analysis have shown 6- 27% fixed carbon. Resources estimated at 1.19 million tonnes (G-4).
<b>LIMESTONE</b>							
<b>Chhattisgarh</b>							
Janjgir-Champa	Dhabadih area	1:50000 1:4000	408 2.06	42	1317.7	1121	Total 450 lakh tonnes of limestone was estimated.
Raipur	Kesla area	1:50000 1:4000	77 1.598	37	1111.55	1056	Total 514.68 lakh tonnes of limestone was estimated.
Rajnandgaon	Tekapur- Kalkasa	1:50000 1:4000	29.6 01	34	1015.15	951	Total 589.70 lakh tonnes of limestone was inferred.
<b>Jharkhand</b>							
Ramgarh	Haribandhi and areas between Gola and Saturi	1:25000 1:4000	10.25 02	-	-	135	Limestone samples analysed as CaO:35.84- 52.64%, SiO <sub>2</sub> : 4.64 - 32.70% and MgO:< 4 percent.
-do-	North of Beecha-Sutharpur and nearby areas	1:4000	01	-	-	45	Limestone samples analysed as CaO : 36.40 - 47.60%, SiO <sub>2</sub> : 11.51- 30.54% and MgO: 0.8-10 percent.
<b>Meghalaya</b>							
East Khasi Hills	Hatmawdon Nongtraia area	1:50000 1:4000	109.2 19.9	2	188.2	309	Total 72 cu m pitting/ trenching carried out.
-do-	Balat area	1:50000 1:4000	13.2 2.8	2	103.9	126	Total 09 cu m pitting/ trenching carried out.
West Khasi Hills	Nongnah area	1:10000 1:4000	10 2.58	-	-	70	Total 30 cu m pitting/ trenching carried out.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>Rajasthan</b>							
Ajmer	N/v Shyamgarh, Pakriyawas etc.	1 :10000	10	-	-	105	-
		1:2000	04	-	-	-	-
Ajmer & Nagaur	N/v Pilwa, Chinwali etc.	1:50000	150	-	-	25	Dolomitic/crystalline lime stone was observed.
		1:10000	10	-	-	-	
		1:2000	04	-	-	-	
Chittorgarh	N/v Anjankhera, & Nilod	-	-	09	527	349	Prospecting work completed.
-do-	N/v Rasulpura, Bansa etc.	1:4000	03	03	163	82	Prospecting work was under progress.
Dungarpur	N/v Rama, Dad Munger etc.	1:50000	150	-	-	100	Reserves will be computed after completing exploration.
		1:10000	10	-	-	-	
		1:4000	02	-	-	-	
Jaipur & Alwar	N/v Bithloda, Mandha etc.	1:4000	04	10	966	178	Anticipated resources are 50.17 million tonnes.
Jaisalmer	N/v Sham	1:50000	100	29	1282	703	Total 239.5 million tonnes of limestone estimated.
		1:10000	15	-	-	-	
		1:2000	4.5	-	-	-	
Nagaur	N/v Pitasar, Khetolav etc.	1:2000	03	12	553	700	Total 66.70 million tonnes of limestone was inferred.
-do-	N/v Tadas- Bhawanada	-	-	23	866	6.88	Total 343.11 million tonnes of limestone was inferred.
Pali	N/v Bherla- Serva & Aml Karavava	1:10000	10	-	-	24	Reserves not assessed.
Tonk	N/v Khalilpura, Dodwari etc.	1:50000	150	-	-	40	Reserves not assessed.
		1:10000	10	-	-	-	
		1:2000	03	-	-	-	
Udaipur	N/v Sayra- Padarda- Rabachh	1:50000	300	-	-	52	Reconnnaissance survey has been done.
		1:10000	20	-	-	-	
		1:4000	2.5	-	-	-	
<b>LIMESTONE, CLAY &amp; BENTONITE</b>							
<b>Rajasthan</b>							
Jhalawar	N/v Gadiya, Semli Bhawani etc.	1:50000	150	-	-	40	Total reserves estimated at 2.141 million tonnes of limestone, 37,500 tonnes of bentonite and 80,813 tonnes of chert.
		1:10000	16	-	-	-	
		1:2000	2.70	-	-	-	

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Table - 8 (Concl'd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>QUARTZ</b>							
<b>Meghalaya</b>							
South West							
Khasi Hills	N/v Nongtynger	1:50000	10	-	-	86	Progressive survey carried out.
		1:4000	3.59	-	-	-	
<b>QUARTZ, CLAY &amp; OTHER ECONOMIC MINERALS</b>							
<b>Rajasthan</b>							
Bundi	N/v Jajawar,	1:50000	155	-	-	42	Total reserves of quartz are calculated at 0.11 million tonnes.
	Hanumanpura	1:10000	16	-	-	-	
	etc.	1:2000	2.5	-	-	-	
<b>QUARTZ &amp; FELSPAR</b>							
<b>Jharkhand</b>							
Deoghar	Bhainsia	1:25000	124	-	-	76	Quartz samples are analysed with 97-98% silica. Resource estimated at 51.68 million cu m.
	Pahari,	1:4000	0.96	-	-	-	
	Devipur block						
<b>RED OCHRE, LATERITE &amp; OTHER ECONOMIC MINERALS</b>							
<b>Rajasthan</b>							
Pratapgarh	N/v Achalpuriya,	1:50000	100	-	-	04	-
	Amlawad	1:10000	10	-	-	-	
	etc.	1:2000	1.5	-	-	-	
<b>SILICA SAND &amp; CLAY</b>							
<b>West Bengal</b>							
Bankura	N/v Brindabanpur, 1:12000 and Chandar		35	-	-	36	Three nos trenching and 10 nos of pitting have been carried out.
-do-	N/v Dhunara, 1:12500 Ainagobindapur etc.		37	-	-	38	Ten nos of pitting have been carried out.
<b>SILICA SAND, QUARTZ &amp; MASONRY STONE</b>							
<b>Rajasthan</b>							
Alwar	N/v Jat-ka-Har,	1:10000	15	-	-	20	Reserves not yet calculated.
	Toda etc.	1:4000	1.5	-	-	-	
<b>SOAPSTONE, MAGNESITE &amp; SERPENTINITE</b>							
<b>Rajasthan</b>							
Dungarpur	Between	1:50000	100	-	-	05	Work is to be continued.
	Surata,	1:10000	10	-	-	-	
	Wasiya	1:4000	05	-	-	-	
	etc.						

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**Table - 9 : Exploration for Granite and Other Dimension Stones  
State Directorates of Geology & Mining in 2014-15**

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>BUILDING STONE</b>							
<b>Jharkhand</b>							
<b>Deoghar</b>	Devipur block	1:25000	124	-	-	-	A total 32 nos of stone deposits with 178.31 million cu m reserves have been identified.
<b>DECORATIVE STONE/MASONRY STONE</b>							
<b>Rajasthan</b>							
	Parts of Jaipur,	1:50000	100	-	-	-	-
	Sikar &	1:10000	10	-	-	-	
	Jhunjhunu	1:4000	02	-	-	-	
<b>GRANITE</b>							
<b>Chhattisgarh</b>							
Bastar/Kanker	Mudpar-Bundeli-Bhanbhera area	1:50000	30	-	-	-	About 54,000 cu m resources inferred.
<b>Rajasthan</b>							
Bhilwara	N/v Phakoliya, Bhagjana etc.	1:10000	10.50	-	-	-	-
		1:4000	01	-	-	-	
Jalore	N/v Bala, Sugalia etc.	1:2000	03	-	-	04	Resources not calculated.
<b>MARBLE</b>							
<b>Rajasthan</b>							
Banswara	N/v Paloda & Oda-bassi	1:10000 1:2000	10 1.5	- -	- -	14 -	-
<b>MASONRY STONE</b>							
<b>Rajasthan</b>							
Alwar	N/v Bhupseda-Kalyan Nagar etc.	1:4000	1.5	-	-	06	Two nos of plots of masonry stone delineated.
Sirohi	Parts of Sirohi Teh.	1:10000 1:4000	05 0.5	- -	- -	- -	Reserves not calculated
<b>RHYOLITE/GRANITE</b>							
<b>Rajasthan</b>							
Barmer	N/v Derasar, Sura, Basra etc.	1 cm=500 m	250	-	-	-	Total five plots of masonry stone delineated.
		1 cm=100 m	15	-	-	-	
		1 cm= 20 m	04	-	-	-	
-do-	N/v Thob & Patodi	1 cm=500 m 1 cm=100 m 1 cm=20 m	200 25 04	- - -	- - -	- - -	Total five plots of masonry stone was delineated.
<b>SAND STONE</b>							
<b>Rajasthan</b>							
Bhilwara	N/v Sukhpura & Barisal	1:10000	10	-	-	-	Reserves are not estimated.
		1:4000	01	-	-	-	
Dholpur	N/v Bhiramad, Pipret etc.	1:50000	250	-	-	-	Total reserves of 14.11 million tonnes of splittable sand stone was estimated.
		1:10000	10	-	-	-	
		1:4000	4.05	-	-	-	

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EXPLORATION & DEVELOPMENT

Table - 9 (Concl.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
Jaisalmer	N/v Dhurasar	1:50000	100	-	-	12	Project is completed.
		1:10000	10	-	-	-	
		1:2000	01	-	-	-	
Jodhpur	N/v Bara Kotecha	1:10000	10	-	-	06	Reserves not assessed.
		1:2000	02	-	-	-	
Karauli	Parts of Mandrayal, Sapotra & Teh.	1:50000	250	-	-	04	Total 9.87 million tonnes of sand stone (splittable) was estimated.
		1:10000	10	-	-	-	
		1:4000	04	-	-	-	
<b>SANDSTONE &amp; RIVER SAND</b>							
<b>Mizoram</b>							
Aizawl	-	-	-	-	-	-	Reconnaissance survey only.
<b>YELLOW LIMESTONE/DIMENSIONAL STONE (MARBLE)</b>							
<b>Rajasthan</b>							
Jaisalmer	N/v Amarsar	1:50000	50	-	-	08	Twenty plots of yellow marble have been delineated.
		1:10000	10	-	-	-	
		1:2000	02	-	-	-	