

EXPLORATION & DEVELOPMENT



# Indian Minerals Yearbook 2016

(Part- I : GENERAL REVIEWS)



**55<sup>th</sup> Edition**

**EXPLORATION & DEVELOPMENT**

**(ADVANCE RELEASE)**

**GOVERNMENT OF INDIA  
MINISTRY OF MINES  
INDIAN BUREAU OF MINES**

Indira Bhavan, Civil Lines,  
NAGPUR – 440 001

PHONE/FAX NO. (0712) 2565471  
PBX : (0712) 2562649, 2560544, 2560648  
E-MAIL : [cme@ibm.gov.in](mailto:cme@ibm.gov.in)  
Website: [www.ibm.gov.in](http://www.ibm.gov.in)

**March, 2018**

# 4 Exploration & Development

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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 has laid enormous thrust on the various aspects of the Mineral Industry, such as regulation of minerals, role of State in mineral development, survey & exploration, database of mineral resources & tenements, strategy of mineral development, etc. Among other things, strong emphasis has been laid on the following:

- \* Judicious exploitation and utilisation of the country's mineral potentialities; carry out systematic regional and detailed exploration using state-of-the-art techniques in a time bound manner; Emphasis on zero-waste mining and raise this endeavour as a national goal; and upgrading of mining technology in order to ensure exploration and utilisation of entire run-of-the-mine.
- \* To make regulatory environment conducive for private investment; procedures for grant of mineral concessions, such as Reconnaissance Permits, Prospecting Licences and Mining Leases shall be made 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 processes.
- \* With a purpose to attract large investments and innovative technology, a new concession, namely, Large Area Prospecting Licence (LAPL) would be introduced. Simultaneously, 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 encompass 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 areas of 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 in supersession to the existing 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 as 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. Further, in light of the amendments in MMDR Act an emergent need to provide an impetus to exploration in the country has prompted a thorough review of exploration policy and

strategy. A new exploration Policy namely National Mineral Exploration Policy (NMEP) therefore has been formulated and adopted in 2016.

## 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 2015-16.

The Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL), the two National Oil Companies (NOC) and a few private and joint venture companies were engaged in exploration and production activities of oil and natural gas, including Coal-bed Methane in the country.

## 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 2015-16, IBM prepared 100 multi-mineral leasehold maps for the states of in respect of Andhra Pradesh (12), Tamil nadu (86) and Kerala (2).

To encourage value addition and mineral conservation, IBM conducted 56 ore dressing investigations, chemical analysis in respect of 35,376 radicals, and 2,423 mineralogical examinations.

Sustainable Development Framework was rolled out at Sukinda Chromite mine of TISCO. Two Technical Consultancy assignments and one Mining Research assignment was also completed.

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. Updating of NMI as on 1.4.2015 has been completed for 71 minerals.

## GSI

GSI pursued its systematic geological mapping in 2015-16 and had completed 5,924.98 km<sup>2</sup> large-scale mapping, 106.03 km<sup>2</sup> detailed mapping and 1,13,202 m drilling as against preceding year's achievement of 5,450.84 km<sup>2</sup> large-scale mapping, 73.543 km<sup>2</sup> detailed mapping and 87,465.87 m drilling. Out of the total mappable areas of 3.14580 million km<sup>2</sup> of the country, 3.09965 million km<sup>2</sup> has been covered so far by systematic mapping bringing the total coverage to 98.53%.

## Reserves Established

Resources augmented by GSI during 2015-16 are furnished below:

i) A total of 62.97 million tonnes of (Fe: > 55%) and 11.90 million tonnes of (Fe: -45% - 55%) of iron ore resources in Sundargarh distt., Odisha .

ii) A total of 14.66 million tonnes of 0.33% Cu at cut-off of 0.2% Cu in Sikar districts, Rajasthan.

iii) A total of 99.46 thousand tonnes of gold ore with an average grade of 2.17 g/t (cut-off grade 1.0 g/t). For 0.5 g/t cut-off grade, a tentative resource of 2,13,524 tonnes of ore with an average grade of 1.45 g/t. An inferred resource of 0.21 mt of gold ore (approx. 186.9 kg of Au metal) has been estimated with an average grade of 0.90 g/t (UNFC-333) in Ajjanahalli Block-C, Tumkur district, Karnataka

v) A total of 159.45 million tonnes of limestone (CaO: 38.38-47.29%) in Garhi-Upcha block, 129.5 million tonnes (CaO: 34.65%-46.03%) in Badretha block and 20.57 million tonnes (CaO: 37.68%-38.99%) in Hirawale block in Morena and Shivpuri districts, Madhya Pradesh.

vi) A total of 6.25 million tonnes of graphite (average FC - 8.79%) in Betul distt., Madhya 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.

Marine and Coastal Survey Division (MCSD) has completed seabed mapping of 1,32,585 km<sup>2</sup> out of 1,50,000 km<sup>2</sup> in 5 km × 2 km grid within TW and 18,55,614 km<sup>2</sup> out of 18,64,900 km<sup>2</sup> in the EEZ beyond Territorial Waters on reconnaissance scale. Besides, an area of 1,164 km<sup>2</sup> within the contiguous zone was mapped on reconnaissance scale with sampling grid of 5 km x 2 km. Total EEZ coverage including TW is 19,88,199 sq. km out of a total EEZ area of 20,14,900 sq. km.

R.V. Samudra Ratnakar covered an area of 55,232 sq km by high resolution seabed mapping by multi beam bathymetry and 15,867 sq km for mineral investigation. Under different themes, R.V. Samudra Ratnakar collected 74,211 km single beam bathymetry, 6,880 magnetic, 17,996 gravity, 1,038 multichannel seismic, 1,60,701 km sub-bottom profile and 5 Conductivity-Temperature-Depth (CTD) profile data and also sediment samples from 82 locations and water samples from 35 stations. During 2015-16, a total of nineteen cruises were undertaken using three vessels. i.e. 6 cruises of Ratnakar, 7 cruises of R.V. Samudra Kaustubh and 6 cruises of R.V. Samudra Shaudhikama. The 22 coastal and lab items taken up under Eastern, Western and Southern Region includes 4 mineral investigation, 6 geo-environmental, 7 data compilation 4 research items and 1 mapping project.

The following marine geoscientific surveys were carried out during 2015-16 Field Season:

#### **R.V. Samudra Ratnakar**

1. SR-013: Study of Geomorphology and Geology of the Seabed in the Narcondam-Barren Basin, North Andaman Sea.
2. SR-014A: Special cruise for National Investigation Agency.
3. SR-019: Study of tectonic set up of Bay of Bengal and Andaman-Nicobar subduction complex within EEZ of India by systematic multi-channel seismic survey.
4. SR-021: Swath bathymetric survey of the sea bed off Pudimadaka to Gopalpur, within EEZ of Andhra Pradesh and Odisha.

#### **RV Samudra Kaustubh**

1. ST-244: Parametric Survey within the Territorial Waters off Visakhapatnam, Andhra Pradesh Coast.

2. ST-246: Systematic magnetic survey within Territorial waters in the shelf area off Chilka Lake, Odisha.

3. ST-247: Study of seabed morphology off Ganga Delta in the mid to outer continental shelf off West Bengal.

4. ST-249: Parametric Survey Within Territorial Waters Off Covelong, Tamil Nadu Coast.

#### **RV Samudra Shaudhikama**

1. SD-262: Characterisation of paleo channel off Periyar River Estuary, Kerala Coast.

2. SD-263: Mapping of the seabed off Kadol, Gujarat.

3. SD-265: Characterisation of paleo channels within territorial waters of Karnataka.

4. SD-267: High resolution mapping of Contiguous Zone beyond territorial water in Arabian Sea off Kochi, Kerala (Block-A).

5. SD-268: High resolution systematic mapping of Contiguous Zone beyond territorial water in Arabian Sea off Kochi, Kerala (Block-B).

#### **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.

The Geological Survey of India in collaboration with international and national agencies has collected a large amount of low altitude aeromagnetic data under the projects Operation Hard Rock (OHR), National Geophysical Research Institute (NGRI) and Twin Otter Airborne Survey System (TOASS) in parts of Andhra Pradesh, Telangana, Karnataka and Tamil Nadu, between the co-ordinates 77°-81°E and 12°30' -18°N.

During 2015-16, the airborne surveys by TOASS were carried out along the west coast in the Ratnagiri – Mumbai stretch, Maharashtra and over the Marwar – Khetri area of Rajasthan. The surveys in both the areas were conducted by engaging magnetic and

spectrometric sensors. a) Ratnagiri-Mumbai area, Maharashtra: The Airborne Geophysical survey over Ratnagiri – Mumbai stretch, West Coast was completed with coverage of 10,1381 km of survey lines and 2,1321 km of tie lines. A total of 5971 km could not be surveyed owing to flying restriction in and around the Mumbai airport. The entire west coast Ratnagiri-Mumbai segment covered by aerogeophysical surveys. b) Marwar-Khetri area, Rajasthan: The airborne surveys were conducted in the sand covered parts towards northwest of Aravalli ranges for locating concealed Cu-Zn bearing VMS type deposits.

### Heliborne Geophysical Survey

The heliborne survey with gravity and magnetic sensors was conducted in Bidasar block in parts of Sikar, Nagaur, Churu districts of Rajasthan. The surveyed area is under thick cover of sand and with the coverage 43811 km of heliborne survey was taken up to delineate the mafic - ultramafic suite of rocks under the sand cover. These exposed rocks show evidences of hydrothermal activity at places in the form of profuse iron oxide veining of serpentinites, malachite staining.

### MECL

The highlights of exploration carried out by MECL during 2015-16 are given below:

- i) The company has carried out 4.02 lakh meter of exploratory drilling for various minerals, out of which 3.35 lakh meter was through departmental resources and 0.6 lakh meter from outsourcing.
- ii) A total of 204 Km<sup>2</sup> area has been covered with detailed geological mapping for various minerals in different parts of the country and also carried out 1.97 lakh meter of geophysical logging.
- iii) In laboratories, a total of 61,554 samples were analysed for chemical analysis and mineralogical analysis, petrographic and ore microscopic studies.
- iv) A total of 21 geological reports of detailed exploration for different minerals were submitted. which led to addition of 2,532 million tonnes of mineral resources.
- v) A total of 2,532 million tonnes of mineral resources were established. Mineral-wise details of resource estimated by MECL during 2015-16 are:

- Coal - A total of 1,849 million tonnes of coal resources were established in Mand-Raigarh & Sonhat & Bistrampur Coalfield, Chhattisgarh.
- Lignite - 91 million tonnes of lignite resources were established in Tamil Nadu.
- Limestone - 477 million tonnes of limestone resources established in Meghalaya.
- Tungsten - 2.046 million tonnes of tungsten resources were established in Kuhl-Khobna, Maharashtra..
- Lead - Zinc - 1.061 million tonnes of lead - zinc resources established in Maurya block, Madhya Pradesh.
- Gold - 0.365 million tonnes of gold ore resources established at Parasi West Block, Ranchi, Jharkhand .
- Iron Ore - 110 million tonnes of iron ore resources established at Sandur Schist Belt, Bellary and Chitradurga districts, Karnataka.

### MINERAL-WISE EXPLORATION ACTIVITIES

#### PETROLEUM AND NATURAL GAS

A number of new initiatives have been taken to promote Exploration and Production activities in the country. A multidimensional approach has been adopted for furthering the objective of enhancing energy security of the country through increased domestic production and improved investment climate in the country. Some of the policy initiatives taken by the Government for exploration and development of oil and gas in the country are as under:

The operator can explore and produce conventional as well as un-conventional hydrocarbon such as Coal Bed Methane (CBM), Shale etc under a single license.

Opening up of India's sedimentary basins through open acreage policy will provide option for the companies for selection of Exploration blocks. They will also not be required to wait till the formal bid round is launched by the government as the open acreage area will be available throughout the year for bidding.

Exploration will be allowed through-out the contract period: One of the major restrictions under Production Sharing Contract (PSC) was regarding exploration after the completion of exploration phase. The Hydrocarbon Exploration Licencing Policy (HELP)

addresses the same and allows exploration throughout the contract period.

Exploration Phase for onshore areas have been increased from 7 years to 8 years and for offshore increased from 8 years to 10 years.

As on 31.3.2016, there were in all 427 oil/gas fields under these companies in the country including offshore areas.

As per policy guidelines, ONGC Ltd. and Oil India Ltd have to carry out Shale Gas and Oil exploration in 50 and 5 blocks respectively for assessment under Phase-I. ONGC is carrying out Shale Gas and Oil exploration activities in Cambay, Cauvery, Krishna-Godavari and Assam and Arakan Basins. Oil India is carrying out Shale Gas and Oil exploration activities in Assam and Rajasthan basins. ONGC has completed drilling of 14 wells. OIL is carrying out data collection and G&G studies for the well location.

In Public Sector, ONGC's jurisdiction extended to 348 fields – Cambay basin (Gujarat) – 84 oil/gas fields; Upper Assam – 36 fields and Assam & Assam Arakan – 7 fields; Jodhpur (Rajasthan) – 8 fields; Krishna-Godavari basin (Andhra Pradesh) – 64 fields; Cauvery basin (Tamil Nadu) – 29 fields; Assam & Assam Arakan in Tripura – 10 fields and Assam & Assam Arakan in Nagaland – 2 fields; besides, 80 offshore fields in the Mumbai offshore; 4 in Kachchh and 2 in Cambay basin in West Coast and 22 offshore fields in Cauvery and Krishna-Godavari basins (shallow and deep) in East Coast. OIL, a Public Sector Company was engaged in 19 fields – Upper Assam basin in Assam (14 fields) and Arunachal Pradesh (1 field); Jaisalmer basin (3 fields) and Bikaner-Nagaur basin (1 field) in Rajasthan. Private/Joint venture companies were engaged in 60 oil/gas fields - Cambay basin (Gujarat) at 34 fields; Kharsang basin (Arunachal Pradesh) at 1 field; Amguri basin (Assam) at 1 field; Jharia & Bokaro (Jharkhand) at 1 field (CBM) each; Sohagpur (Madhya Pradesh) at 2 fields (CBM); Rajasthan at 7 fields and Raniganj East basin (West Bengal) at 2 fields (CBM) in onshore areas. In offshore areas, these companies covered 2 fields in Cauvery basin and 4 fields in Krishna-Godavari basin on the East Coast and 3 fields in Mumbai basin and 2 fields in Cambay basin on the West Coast.

During 2015-16, a total of 7816.12 GLKM of 2D seismic data was acquired, mostly of which is in offshore region by Private/JVs. A total of 6236.12 SQM of 3D seismic data was acquired, majority of which was carried out by ONGC in its offshore nomination areas. A total of 138 exploratory wells and 363 developments wells were

drilled in 2015-16. Majority of the development wells were drilled by ONGC in its onland nomination areas.

The ultimate reserve (2P) accretion of oil and oil equivalent gas (O+OEG) in 2015-16 in domestic assets of ONGC was 65.58 million tonnes.

During 2015-16, OIL carried out seismic survey in the inland area and acquired 175.8 (GLKM) of 2D & 1.13 (SKM) of 3D seismic data. OIL carried out 60,211 meterage drilling in 11 exploratory wells and 82,550 meterage drilling in 33 development wells in the inland area.

During 2015-16, Oil India Ltd has carried out 2D & 3D Seismic Survey to identify New Prospects in the Petroleum Mining Lease areas of Upper Assam Basin, including spreading exploratory efforts by drilling 5 wells in the NELP Blocks MZ-ONN-2004/1, RJ-ONN-2004/2 & RJ-ONN-2005/2.

Oil India Ltd has made six (6) oil and gas discoveries in the Upper Assam Basin during the year 2015-16. The discovery of oil & gas has opened up new avenue for exploration and exploitation of oil & gas within the respective area of well and the adjoining areas. Details of the discoveries are highlighted below:

**i) Samdang-4 (DGP):** The well is located in Samdang-I structure under Dumduma PML and has been drilled down to 3620 m to probe the hydrocarbon prospects within the Barail and Tipam Formations. The well has encountered few prospective sands within Barail and Tipam Formations, and produced oil from one of the tested sands within Barail Formation. Presently, the well is kept shut-in.

**ii) NHK-625 (Loc. HXY):** The well is located in Lohali-Deohal Structure under Hugrijan PML and has been drilled down to 2760m to probe the hydrocarbon prospects within the Barail Formation. The well has encountered few prospective sands ranges within Barail Formation, and produced gas from one sand tested within Barail Formation. Presently, the well is producing @ 35,000 scmpd gas with 8 klpd oil.

**iii) South Baghjan-1 (Loc. BGJ):** The well is located in the South Baghjan structure under Baghjan PML and has been drilled down to 4154 m to probe the hydrocarbon prospects within Palaeocene-Eocene Formations. The well encountered few prospective sands within Palaeocene-Eocene Formations, and produced oil from two sands tested within Palaeocene-Eocene Formations. Presently, the well is producing @ 92 klpd oil. Further seismic data acquisition and

appraisal drilling have been planned to ensure realization of full potential from this new find.

**iv) Sapkaint-2 (Loc. DGK):** The well is located in the central part of Sapkaint Structure under Dumduma PML, and was drilled and completed during year 2011. During 2015-16, oil has been discovered in new/un-appraised Tipam sand by testing through work-over operations. Presently, the well is producing @ 22 klpd oil.

**v) NHK-173 (Loc. NDC):** The well is located in the South Chalakataki Structure under Nahorkatiya Extension PML, and was drilled and completed during year 1965. During 2015-16, gas has been discovered in new/un-appraised Girujan sand by testing through work-over operations. Presently, the well is kept shut-in.

**vi) NHK-447 (Loc. NJY):** The well is located in the Nahorkatiya Main Structure under Nahorkatiya Extension PML, and was drilled and completed during year 1990. During 2015-16, gas has been discovered in new/un-appraised Upper Tipam sand by testing through work-over operations. Presently, the well is producing @ 12,500 scmpd gas.

#### RIL's Performance

**KG D6 :** As a part of the appraisal programme for the D-55 discovery, continuous evaluation of results of 3 wells were carried out extensively. In addition, enhanced imaging for reservoir characterisation and conceptual engineering/Pre Front-End Engineering Design studies has also been completed. Based on these appraisal efforts, the Commerciality Report has submitted to Management Committee for its review, leading to a reserves accretion of about 1 TCFe in the current fiscal.

#### SHALE GAS AND OIL

As per Govt. Policy guidelines, ONGC and OIL are required to carry out exploration for shale gas and oil in 50 and 6 blocks, respectively.

During 2015-16, ONGC has carried out shale gas and oil exploration in four onland basins namely, Cambay, KG, Cauvery, Assam and Assam-Arakan. As on date, a total of twelve (Cambay: NGSGA, NJSKA, PJSGA, NDSGA, WRSKA, LJSKA, PLSKA; KG: MGSGA, WGSGA, MDSKA; Cauvery: KUSKA, TKDSKA) exploratory locations for shale gas and oil are available for drilling. ONGC has drilled 18 wells so far and one well is under drilling. So far 69 crores have been collected in 17 wells. ONGC has completed coring and other data collection programme in six wells (four in Cambay and one each in KG and Cauvery basins) in different blocks. These data will help in assessment of the shale gas and oil potential of respective blocks. Three of these wells GNSGB, GNSGC and GNSGD were drilled in Cambay basin exclusively for shale gas and oil.

OIL carried out shale gas and oil exploration in two onland basins namely Assam & Arakan and Jaisalmer basin. OIL has initially identified five Blocks, viz. Dibrugarh, Chabua, Dumduma, Jaisalmer and Jairampur from its Nomination acreages and later on identified one more block (Deomali PEL). OIL has completed Geology & Geophysics (G&G) evaluation of four Blocks i.e. Dibrugarh PML, Chabua PML, Dumduma PML and Jaisalmer PML. OIL has planned to drill three core holes up to a maximum depth of 2000 m in Jairampur Extension PEL and Deomali PEL, Upper Assam basin to acquire additional G&G information.

**Table - 1: Area wise Development of Wells & Meterage Drilled by ONGC, OIL & Private/ Joint Ventures 2015-16**

Agency	Onshore		Offshore		Total	
	Wells (Numbers)	Meterage (in'000)	Wells (Numbers)	Meterage (in'000)	Wells (Numbers)	Meterage (in'000)
<b>(A) ONGC</b> (Nomination)	52	152	20	50	72	202
<b>(B) OIL</b> (Nomination)	11	60	-	-	11	60
<b>(C) Private/JVs</b>	40	101	15	40	55	142
<b>Total</b>	<b>103</b>	<b>313</b>	<b>35</b>	<b>90</b>	<b>138</b>	<b>404</b>

Source: Director General of Gas & Hydrocarbons Annual Report 2015-16 (48P).

**COAL**

The agencies engaged in exploration for coal during 2015-16 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 Andhra Pradesh, Assam & Meghalaya, Chhattisgarh, Madhya Pradesh, Odisha, Telangana and West Bengal.

In Andhra Pradesh, regional investigation of coal was carried by scout drilling in south of Somavaram Block, southern sub basin of Godavari Valley Coalfield, Krishna district. A total area of about 300 sq km was covered by large-scale mapping along with scout drilling. The main objective of exploration is to update the lithostratigraphy and delineate coal-bearing formation in coastal Krishna Godavari basin, Krishna district. The mapped area is entirely covered by rocks of Upper Gondwana Group except in the northern part which exposes a patch of Kamthi Formation of Lower Gondwana Group. During 2015-16, 108 sq km out of 300 sq km was geologically mapped and 3 boreholes drilled. The rocks exposed in the area consist of metamorphics as basement overlain by Kamthi Formation of Lower Gondwana and Gollapalle Formation of Upper Gondwana. The contact between the basement and Gondwana Supergroup is recorded as sharp and faulted in the northwestern part of the area. In general the contact between the different Gondwana formations seems to be gradational. The first borehole (total depth: 270.75 m) has intersected both Gollapalle Formation and Kamthi Formation and the metamorphics. A few coal streaks and stringers were noticed in the Kamthi Formation. The second borehole has closed at a shallow depth 97 m and has intersected Gollapalle Formation followed downwards by basement metamorphics. The third borehole is closed within the Gollapalle Formation at the depth of 215.00 m due to non-encouraging results. Kamthi Formation is exposed in northwestern part as a small patch consisting of grey-coloured feldspathic sandstone. The contact between khondalites and Kamthi in this area is faulted. The contact between metamorphics and Kamthi Formation is also recorded as faulted in first borehole at the depth of 235.70 m. The Gollapalle Formation exposed in the area consists mostly of arenaceous and less amount of argillaceous facies. It is laminated sandstone and pebbly in nature. A thick column of dark grey-coloured siltstone is recorded in third borehole. The general strike of Gondwana sediments is NE-SW dipping due southeast. The variations in dip of the beds are noticed ranging from 30 to 45°. Sedimentary structure like trough cross-bedding in Kamthi Formation and tabular cross-stratification is seen in Gollapalle Formation. Drilling data from adjoining block of M/s MECL and data from

3 boreholes drilled by GSI reveal that around Chintalvalli village, basement occurs at shallow depth. The intersection of basement at shallow depth (85.00 m) supports the idea of basement high. The swerving of dip of beds in MECL block on either side from north to south also suggests a different sedimentary basin fringed by metamorphic basement. Absence of coal within the Kamthi Formation in Somavaram Block of GSI suggests that coal forming environment was not favourable in Somavaram. The exploration was closed due to non-encouraging results in the area.

In Assam, a G3 stage exploration of Gondwana Coal was carried out in and around Bhutidanga area, Singrimari Coalfield, Dhubri district, Assam. An area of 2.5 sq km has been covered by large-scale mapping and 570.35 m was drilled. One coal-carbonaceous zone of thickness 3.21 m having two split sections of 1.55 m and 1.65 m thickness occurring at 238.00 m and 241.20 m depths respectively were intersected, which is correlatable with seam-IV as prepared in Phatapara area drilled in previous field session. This zone is associated with carbonaceous shale grey shale-mudstone intercalation. In borehole SB-02, a thin coaly band of 0.48 m was intersected at 178.58 m depth. Seam correlation between Phatapara area and Bhutidanga area suggests a downthrow of about 50 m across a NNWSSE- trending fault. Core recovery is very poor in the coal carbonaceous zones and cores are completely crushed. All the coal samples were analysed by CSIR-Lab Jorhat, Assam. Proximate analysis shows moisture (9.29-13.86%), ash (53.51-62.73%), volatile matter (21.60-23.50%) and fixed carbon (6.38-9.92%) with substantially high sulphur (9.92-10.3%), caking index below 3 and coke type A. Overall analysis of the samples indicate ash + moisture content varying from 67.37% to 72.02% revealing that the samples are carbonaceous shale in nature.

In Chhattisgarh exploration was carried out in the following blocks of Mahanadi Valley Coalfield: Mand-Raigarh Coalfield:

1) Purunga Block: Twelve boreholes of cumulative length 6018.45 m have been drilled through Barakar sediments to intersect coal seams both along strike and dip directions. The lithounits intersected are greyish white, fine- to very coarse-grained feldspathic sandstone, siltstone-shale heterolithic sequence and thick coal seams representing Barakar Formation. Total twelve regional Barakar coal seams/zones have been intersected between the depths of 48.10 m and 756.36 m. Thickness of coal seam/zone varies from 0.51 m to 12.85 m Seam IV is the thickest one with cumulative thickness ranging from 8.15 m (in 4 split sections) to 12.85m (in 5 split sections). It has been intersected between depth range of 229.94 m (MRPR-11) and 525.36m (MRPR-12). An area of 8 sq km was geologically mapped on 1: 10,000 scale. The general strike of the sedimentary strata is WNW-ESE with an average dip of



3° towards SSW. A total of five faults have been interpreted in this block, out of which three major faults trending E-W to ENE-WSW traverse in the central and southern parts of the explored area. They are successively downthrown towards south with throw ranging from 20 m to 65 m. The other two faults trending NW-SE and E-W with throw of 20 m and 50 m respectively are interpreted in the northern part of the block. So far, 3.5 km strike extension and about 4.8 km dip extension have been established in the explored area. A total of 3638.52 m geophysical logging has been carried out.

Son Valley Coalfields (East) - Tatapani-Ramkola Coalfield:

2) Pipraul Block: Major portion of the block area is covered with rocks of Barakar Formation whereas rocks of Panchet Formation are exposed over a small area in north-western part. Five boreholes of cumulative length 2795.40 m have been drilled. During this period, eight regional Barakar coal seams (Seam - I to VI & Seam - XII & XIII in ascending order) and a few local seams with thickness ranging from less than a metre (0.50 m, Seam - XII) to 20.88 m (Seam - III) have been intersected between the depth of 179.89 m (Seam - XIII) and 894.15 m (Seam - III). Seam - III, which occurs in two splits, is most important regional Barakar coal seam in terms of thickness (cumulative thickness 20.88 m) and regional persistency. Large-scale mapping (1: 10000 scale) of 4 sq. km has been carried out. CBM study for baseline data generation has been completed in borehole TRP-10. Exploration in this block leads to establish a major E-W- trending fault in north-central part of the block. Exploration in this block was concluded.

3) Sendur Block: Two boreholes of cumulative length of 981.25 m drilling have been drilled. Three regional Barakar coal seams (Seam-I to III in ascending order) with thickness ranging from 1.65 m (Seam-II) to 19.27 m (Seam-III) have been intersected between the depths of 657.83 m (Seam-III) and 745.98 m (Seam-I). Rocks of Panchet, Barakar and Talchir formations have been intersected in these boreholes. Large-scale mapping (1: 100,000 scale) of 2 sq km has been completed. Major part of the area is covered by Barakar Formation. Panchet Formation is restricted in the south-western part lying unconformably over Barakar Formation. The general strike of the sedimentary sequence is NNW-SSE to N-S with 10° to 15° dip towards west.

In Madhya Pradesh - Pench Valley Coalfields:

4) Dhorakuhi Sector: LSM of 5 sq km area has been completed which revealed that the area is covered with Deccan trap flows of Khampa and Amarwada formations of Amarkantak Group. All five boreholes drilled to a cumulative length 1398.90 m have intersected maximum of five flows of Amarwada Formation. These are represented by dark grey to grey, hard and compact basic rock. The thickness of Deccan trap ranges from

187.75 m to 277.85 m and the thickness of Jabalpur Formation intersected in the different boreholes varies from 6.15 m to 17.10 m. The total thickness of Motur Formation intersected in PDK-2A is 154.50 m, however; it has drastically been reduced to 21.88 m in borehole PDK-4. Sudden reduction of Motur Formation in this borehole indicates proximity of peripheral part of the basin. The thickness of Barakar Formation varies from 65.76 m to 93.62 m while intersected. Thickness of Talchir Formation varies from 4.24 m+ to 23.60 m+. Five regional Barakar coal seams (I to V in descending order) have been intersected in four boreholes between the depths of 324.21 m and 436.70 m. The cumulative thickness of coal seam varies from 16.14 m to 13.02 m. Thickness of individual coal seam varies from 0.64 m (Seam-II,) to 6.53 m (Seam-IV).

Son Valley Coalfield (East); Singrauli Coalfield:

5) Sarai (west) sector: Four regional Barakar coal seams (Seam-I to IV, in ascending order) have been intersected within the depth range of 403.99 m (Seam-IV) to 492.12 m (Seam-I). The thickness of coal seam/zone varies from 2.35 m (Seam-I) to 6.84 m (Seam-III). Cumulative thickness of coal seam/zone is 13.08 m. The study area is traversed by a few E-W-, NW-SE- trending faults of which two are major faults trending E-W traversing along the middle and southern part of the sector.

6) Pachaur Block: Five boreholes of cumulative length 2691.35 m have been drilled. Four regional (R-I to R-IV) and few local Raniganj coal seams of thickness ranging from less than a metre (0.52 m) to 5.56 m were intersected within depth range of 17.38 m to 149.27 m. Seam R-II (3.15 m to 5.56 m) is the most important amongst the Raniganj coal seams in terms of thickness and regional persistency. Seven regional (Seam I to VII) and few local Barakar coal seams ranging in thickness from less than a metre to 14.40 m were intersected between depth range of 419.78 m and 714.44 m. Barakar Seam-VI is the thickest seam (14.40 m) and occurs in three split sections. Large-scale mapping (on 1: 10000 scale) of 4 sq km area has been carried out in this block. Geophysical logging of 1493.77 m has been done.

Son Valley Coalfield (West); Sohagpur Coalfield:

7) Harri Block: Seven boreholes of cumulative length 3186.35 m drilling has been drilled. Large-scale mapping (1: 10000 scale) of 4 sq km has been carried out. It reveals that the studied area in the north-central part is covered by strata of Raniganj Formation. Five regional Barakar coal seams (Seam-I to V in ascending order) along with few local seams, with thickness ranging from 0.50 m to 7.60 m (cumulative), have been intersected between the depths of 222.75 m and 528.20 m. Regional Seam III is the thickest seam. Besides these, five to seven Raniganj coal seams, with individual thickness ranging from 0.50 to 4.60 m, have also been intersected between the depths of 14.00 and 118.65 m. Investigation in this Block has been concluded.

8) Bandhawa Bara Block: Eleven boreholes of cumulative length 3188.60 m have been drilled. Exploration activity in this block has been concluded on 31.03.2016 with achievement of geological objectives. Large-scale mapping (1: 10000) of 8 sq km has also been carried out. Major part of the studied area is covered with light violet to pinkish grey coloured calcareous sandstone of Lameta Formation. Four regional Barakar coal seams (Seam-I to IV in ascending order) and two local seams, with thickness ranging from 0.50 m to 7.45 m (cumulative), have been intersected between 94.45 m and 264.60 m. Seam-III is the thickest seam in the studied area which is interbanded in nature and generally occurs in two to three split sections. Regional strike of the sedimentary strata is WNW-ESE with very low ( $1^{\circ}$  to  $2^{\circ}$ ) northerly dip.

9) Kirhai Block: Three boreholes of cumulative length 547.20 m have been drilled. Large-scale mapping (1: 10 000 scale) over 2 sq km has been completed during this period. Major part of the block area is covered with light violet to pinkish grey coloured calcareous sandstone of Lameta Formation. The remaining area in the southern part of the block is covered with Deccan Trap. One regional Barakar coal seam (Seam-III) with thickness of 3.95 m and one local seam (L2) of 1.15 m thickness have been intersected between the depths of 135.40 m and 190.60 m. Seam-III occurs as the thickest seam in the block area. Regional strike of the sedimentary strata is WNW-ESE with very low ( $1^{\circ}$  to  $2^{\circ}$ ) northerly dip.

10) Lamru Block: Three boreholes of cumulative length 582.95 m have been drilled. Large-scale mapping (1:10000 scale) of 2 sq km has been completed during this period. Four regional Barakar coal seams (Seam-I to IV in ascending order) and few local seams, (with thickness ranging from 0.50 m to 3.30 m), have been intersected between the depths of 119.55 m and 269.25 m. Seam-III occurs as the thickest seam in the studied area.

In Odisha, regional exploration of coal was carried out in Bandbahal and Bartap Block, Ib-River Coalfield in Jharsuguda district and Ustali sector in Sundergarh district. Two boreholes *i.e.* IBBA-7 and IBBA-8 of cumulative length 691.60 m were drilled. Geophysical logging of 1622 m was carried out. Three regional coal seams of Barakar Formation (Parkhani, Lajkhura and Rampur) were intersected between 481.92 m and 836.50 m. The Lajkhura seam having the maximum cumulative thickness of 72.05 m (IBBA-7) with ten splits is most important for its regional persistence and thickness. The other seams Parkhani (maximum cumulative thickness 16.36m in seven splits in IBBA-8), Rampur (maximum cumulative thickness 32.58m in nine splits in IBBA-7) have regional persistency and are intersected in two boreholes. The exploration in the Bandbahal Block led to increase in cumulative coal thickness of Lajkhura seam zone. The exploration work completed.

Coal can be categorized as 'Sub-bituminous Coal' type of power grade and mostly belongs to E to G grade. Extension of regional coal seams established for about 6 km along strike and 3km along down dip direction. The coal is unsaturated with CBM gas. The block may be proved to be economically potential area for coal resource. In Bartap Block, An area of 3 sq km was mapped on 1:10,000 scale and 2923.80m drilling was carried out and a cumulative coal thickness of 654.28m has been intersected in five boreholes (IBBR-4, 5, 6, 7 & 8). Formational thickness encountered in boreholes is as follows: thickness of Kamthi Formation varies from 0 m to 10 m, thickness of Raniganj Formation varies from 30.83 m to 158.19 m, thickness of Barren Measures Formation varies from 28.51 m to 50.94 m and thickness of Barakar Formation varies from 554.72 m to 582.87 m. Four coal seams of Raniganj Formation (R-IV, R-III, R-II, and R-I from top to bottom) and five coal seams of Barakar Formation (Belpahar, Parkhani, Lajkhura, Rampur and Ib from top to bottom) have been established. R-I (cumulative thickness 16.91 m in IBBR-7) among Raniganj coal seams and Lajkhura (cumulative thickness 62.77 m in IBBR-6) among Barakar coal seams are the thickest. All the coal seams of Raniganj Formation and Belpahar seam zone of Barakar Formation are within 300 m. Remaining coal seams of Barakar Formation continue beyond 600 m. Geophysical logging of 3532 m was carried out in five boreholes. Three PCS and 3 petrological samples were collected for analysis. Rank-wise coal can be categorized under 'Sub - Bituminous Coal' with grade varies from E to G of power grade. Regional extension of coal seams has been established for about 4 km along strike and 2.5 km along down dip direction at places with cross- stratification and vertical burrow. In Ustali sector, a total of 6 sq km area has been mapped on 1: 10,000 scale. Four boreholes of cumulative length 1915.15 m were drilled. Four regional coal seams of Barakar Formation (Belpahar, Parkhani, Lajkhura, Rampur) and Karharbari seam of Karharbari Formation were intersected between 50.91 m and 570.78 m depth. Amongst the Barakar seams Rampur with 14 to 16 splits was the most important seam and intersected at 392.64 m in IBUS-1 and it had the maximum thickness of 98.07 m in IBUS-2. The other seams Belpahar (maximum cumulative thickness of 6.42 m in six splits in IBUS-3), Parkhani (maximum cumulative thickness 21.12 m in nine splits in IBUS-1), Lajkhura (maximum cumulative thickness 44.14 m in seven splits in IBUS-2) have regional persistency and were intersected in all boreholes. Karharbari seam intersected at a depth of 547.88 m in IBUS-1 with a maximum thickness of 8.04 m in IBUS-2. Extension of regional Barakar coal seams has been established for about 3 km along strike and 2 km along down dip direction. Iron oxide layers (limonitized) within ferruginous fine-grained sandstone and normal faults within Barren Measure Formations were also noted.

### Talcher Coalfield

In Odisha, a G3 stage exploration for coal was continued from field session 2015-16 by drilling in Kantaikoliya area, Talcher Coalfield, Angul district. During FS 2015-16, three boreholes [TKK-4, 5 & 6] were drilled to a cumulative length 1218.50 m. Coal samples were collected and coalfield map covering an area of 9 sq km was updated on 1: 50,000 scale. Coal samples were sent to CIMFR, Bilaspur for proximate analysis. Three regional coal seams (IX, III and II) of Barakar Formation have been intersected between the depth range 69.00 m and 334.20 m and no coal seam was intersected in the Karharbari Formation. Coal seams (seams: IX, III and II) of Barakar Formation have been established for 2 km strike length and 0.5 km along dip direction.

In Telangana, regional exploration of coal was carried out by drilling in Pagaderu (East) sector, southern part of main basin of Godavari Valley Coal Field, Khammam district. Exploration was continued from earlier field session work to explore and evaluate coal potentiality of Lower Kamthi and Barakar coal seams in the down-dip side of adjoining Manuguru mining blocks and continuation of adjacent Pagaderu (West) sector. The mapped area of about 6 sq km on 1: 10,000 scale shows outcrops of Upper Kamthi Formation disposed as capping in E-W-trending small mounds towards the northern side of the Pagaderu (East) Sector. Out of the six boreholes in Pagaderu East, two boreholes GPDE-1 (631.00 m) and GPDE-2 (825.50 m) were drilled in FS 2014-15. Four boreholes of cumulative length 1708.15 m were drilled. A total of 58.78 m coal was collected and sampled; geophysical logging was carried out for 762 m, petrography samples were collected and updating of coalfield geological map was done for 3.0 sq km. The coal exploration in Pagaderu (East) sector is under progress and a drilling of about 660 m is required to achieve the geological objectives. Regional exploration of coal was also continued from previous field session by scout drilling in eastern extension of Pagaderu (East) sector, southern part of main basin of Godavari Valley Coalfield, Khammam district with the object to delineate coal-bearing Lower Kamthi and Barakar formations in the surrounding areas of Pagaderu East and West Sectors. A total of 200 sq km was geologically mapped on 1: 25000 scale and 15 petrographic samples were collected to identify the various formations and contact relationships between them. The regional strike of the sedimentary beds varies from North 200 to 800 East, dipping 60 to 150 northwesterly. The rocks exposed in the area consist of Talchir, Barakar, Barren Measures, Upper, Middle and Lower Kamthi formations of Lower Gondwana Group. Regional investigation of coal by scout drilling in the north of Medaram within main basin of Godavari Valley Coalfield, Warangal and Karimnagar districts, Telangana was taken up in north and northeast of

Palampet-Venkatapuram and Govindraopet-Pasra exploration blocks of GSI. This item was taken up in continuation of the exploration work carried out earlier by GSI and exploration work of M/S SCCL in parts of Mulugu coal belt. The main objective of this investigation is to update the lithostratigraphy and delineate coal-bearing formations and also to explore and evaluate coal potentiality of Barakar and Lower Kamthi formations established in the Palampet-Venkatapuram block of GSI which lies in the updip side of the study area and to decipher the structural and stratigraphic setup of the area. Drilling was not carried out and further investigation was suspended due to non-availability of forest permission as the area is under thick forest cover. Mapping reveals existence of a thick pile of Lower and Upper Gondwana Group of rocks. The Lower Gondwana Group is represented by Barren Measure Formation and undifferentiated Kamthi Formation. The Upper Gondwana Group is represented by Yerapalli, Bhimaram and Maleri members of Maleri Formation and Kota Formation. A major part of the area is occupied by lithounits of Upper Gondwana Group. The lithounits of Barren Measure Formation are very well exposed in the southwestern part of the area and are characterized by greenish grey to greyish white, medium- to coarse-grained, feldspathic sandstones with subordinate variegated clays and micaceous siltstones. On the surface, the Barren Measures are composed of light brownish grey ferruginous sandstones with thin bands of hard brick-red siltstones. The lithounits of Kamthi Formation are fully weathered and could not be differentiated from the surface outcrops and hence, in geological map were kept as undifferentiated Kamthi Formation. Lithounits of Kamthi Formation are well exposed in the NNW-SSE-trending high hills in the southern part of the area. The lithounits of Kamthi Formation are characterized by greenish grey to greyish white, medium- to coarse-grained, feldspathic, and calcareous at places, poorly to moderately sorted, cross-bedded sandstone and white clay clasts in the upper part. The lower part of the Upper Kamthi Member is very well exposed in 2.0 km west of Bayyakapeta and is characterized by pebble bed, comprised of pebbles of quartz, quartzite and siltstone. Southwest of Gandikamaram cherty siltstone interbedded with claystone is observed. These siltstones are thinly bedded and claystone bed is tapering at both the ends. The Maleri Formation comprises three members viz. Yerapalli, Bhimaram and Maleri. Yerapalli member is argillaceous in nature and is exposed at few places. Yerapalli sandstone is very well exposed in and around Bayyakapeta and is characterized by greyish white, poorly sorted calcareous sandstone along with purple clay beds. Bhimaram Member of Maleri Formation is characterized by yellowish brown-coloured, coarse-grained, pebbly, poorly sorted sandstone. This

sandstone is profusely cross-bedded and shows abundant clay clasts. This lithounit is very well exposed in the southwest of Singaram village. Maleri Member of Maleri Formation is composed of soft red clays with lenses of greenish to greyish green, buff-coloured, fine- to medium-grained, friable sandstone. This lithounit is very well exposed in south of Singaram village. Kota Formation of Upper Gondwana Group is very well exposed in the northeastern peripheral part of the study area. This lithounit is characterized by grayish white, medium- to coarse-grained sandstone with red clay bands at places. Thinly laminated, cross-bedded sandstone is very well exposed in the isolated mound about 5 km west of Pandipampula. Another common rock type is light purple sandstone streaked with white clay laminae and vice versa. In the lower part Kota Formation contains conglomerate and well-stratified conglomeratic sandstone unit. The general strike of Gondwana sediments in the area is NW-SE. Study of borehole cores of SCCL (borehole ML-1137) which lies in the up-dip side of operational area suggests that the area is promising for deep occurrence of coal seam below 1000 m. In Adilabad district, preliminary investigation of coal in Gondwana (outlier) by large-scale mapping (LSM) and scout borehole in Mangrud area has been carried out in the northern part of NW-SE-trending main basin of Godavari Valley Coalfield. The main objective of the investigation is to delineate coal-bearing Barakar Formation, to test the presence of coal by scout drilling and to revise the litho-stratigraphy of the area. An area of 10 sq km was geologically mapped on 1: 10000 scale. The mapped area shows outcrops of (a) greyish white to buff-coloured dolomitic limestone of Mangruda Formation of Penganga Group, (b) Khaki-green siltstone along with unsorted tillites of shale and pebbles/boulders of limestone of Talchir Formation (c) Greyish white, medium- to coarse-grained, massive, micaceous, feldspathic sandstone of Barakar Formation, (d) Red Bela Shale which is friable, indurated, highly splintery shale along with ferruginous concretion. The general trend of the lithounits in the area is N55°W-S55°E with a dip of 2° to 5° towards NE. The contact between Bela Shale and Mangruda Limestone is faulted in nature. Similarly, sandstone red shale and sandstone-limestone contact in the mapped area also appears to be faulted. Seven boreholes of cumulative length 1083 m were drilled [TSABM-1 (180 m), TSABM-2 (321 m), TSABM-3 (108 m), TSABM-4 (135 m), TSABM-5 (110 m), TSABM-6 (130 m) and TSABM-7 (99 m)]. The borehole TSABM-1 intersected Barakar Formation from 0 to 145.70 m (145.70 m), Talchir Formation from 145.70 m to 168.88 m (23.18 m) and Mangruda Limestone from +168.88 m. The borehole TSABM-2 intersected Bela Formation from 0 m to 310.10 m (310.10 m) and limestone from 310.10 m downwards. TSABM-3 borehole was initiated within the Barakar Formation and continued

down to 69 m (69 m); Talchir Formation was intersected from 69 m to 87.50 m (18.5 m) and Mangruda Limestone from 87.50 m downwards. No coal seam was intersected in borehole TSABM-3. The borehole TSABM-4 intersected Barakar Formation from 0 m to 113.54 m (113.54 m), Talchir Formation from 113.54 m to 125.34 m (11.80 m) and Mangruda Limestone from 125.34 downwards (9.64 m). The boreholes TSABM-5, 6 and 7 intersected coal seams within the Barakar Formation which were classified as Coal seam-I, II and III respectively. Results show shallow occurrence of coal in sandstone (Barakar Formation). These boreholes intersected Penganga Limestone at about 310 m depth below adjacent Bela Shale. About 8.0-m-thick coal has been proved from this sandstone at a very shallow depth of about 20-25 m from the surface.

### **CMPDI**

CMPDI continued its coal exploration activities in 2015-16, 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. A total of 140 to 160 drills were deployed in 2015-16, out of which 62 were departmental drills.

CMPDI deployed its departmental resources for detailed exploration of CIL/Non-CIL 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 2015-16, CMPDI and its contractual agencies took up exploratory drilling in 113 blocks/mines spread over 22 coalfields in six states. Out of 113 blocks/mines, 35 were Non-CIL/Captive blocks and 78 CIL blocks/mines. Departmental drills of CMPDI took up exploratory drilling in 50 blocks/mines, whereas, contractual agencies drilled in 63 blocks/mines.

A total of 9.94 lakh m of exploratory drilling was carried out by CMPDI in 2015-16 through departmental resources (4.08 lakh m) and outsourcing (5.86 lakh m) to State Governments/MECL/Tendering (CIL/Non-CIL blocks). Details of exploratory drilling carried out by CMPDI in 2015-16 are given in Table - 2.

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

During 2015-16, the total production of coal from SCCL mines was at 60.38 million tonnes. With

addition of 325.97 million tonnes proved reserves during the year, the total reserves of coal in Godavari Valley Coalfield are placed at 10,528 million tonnes as on 31.03.2016.

## LIGNITE

GSI conducted investigation for lignite during 2015-16 in the following areas:

### GSI

In Tamil Nadu, regional exploration of lignite in Kalari north Sector, Ramnad sub-basin, Ramnathapuram district was taken up to establish the strike continuity of the regional lignite seams to the south of the previously explored Bogalur east sector and east of Tiyanur sector. A total of 110.00 m thick and 119.00 m thick Quaternary sediments including alluvium were intersected in boreholes TRKN-3 and TRKN-2 respectively. A 30-m-thick paleosol horizon just below the Cuddalore/Tittacheri Formation comprising red and green mottled clay represents break in sedimentation. The paleosol horizon occurs on the uppermost part of Neyveli Formation, which comprises white to grey clay, white fossiliferous argillaceous sandstone, carbonaceous clay and lignite. Lignite seams are present in the upper part of Neyveli Formation. Lignite seam was intersected in both the bore holes TRKN-3 and TRKN-2 between 413.00 m and 447.50 m. The cumulative thickness of the seams is 6.50 m and 8.50 m in boreholes TRKN-3 and TRKN-2 respectively. Regional exploration of lignite in Kalari west sector, Ramnad sub-basin, Tamil Nadu was taken up under promotional scheme, to establish the strike continuity of the regional lignite seams towards the south and east of the previously explored Tiyanur sector and east of Uttarakosamangai sector. Fourteen boreholes of cumulative length 6254.15 m has been drilled out of which 3799.65 m has been drilled during FS 2015-16. A total of 1530.00 m has been

drilled in Quaternary formation, 3078.00 m in Cuddalore/Tittacheri Formation and 1646.15 m in Neyveli Formation. The area is completely covered by recent alluvium. The thickness of these Quaternary sediments including alluvium ranges between 95.00 m (TRKW-3) and 126.00 m (TRKW-14) in the Kalari west sector. The paleosol horizon occurs on the uppermost part of the Neyveli Formation which comprises white to grey clay, white fossiliferous argillaceous sandstone, carbonaceous clay and lignite. Lignite seams are present in the upper part of Neyveli Formation.

In Rajasthan, G-4 stage search of lignite by scout drilling in Charanwala north area in the Palana basin, Jaisalmer and Bikaner districts, was taken up by scout drilling to locate lignite-bearing blocks in the Charanwala north area in the unexplored virgin areas of Palana basin, Jaisalmer and Bikaner districts. Rajasthan, commenced in FS 2015-16 as a sponsored item of Ministry of Coal. Sixteen boreholes of cumulative length 4138.00 m have been drilled in the block. Palana Basin, is an E-W trending elongated basin, extending for about 200 km along its length with maximum width of about 50 km along north-south direction, The Palana Formation comprises grey clay/claystone, variegated clay, carbonaceous clay/claystone, sandstone, very fine to coarse, clayey sandstone, silty clay/claystone, clayey siltstone, siltstone, lignite seams with occurrence of pyrite nodules. The thickness of Palana Formation increases towards the northwest. Lignite seams have been intersected in the central and western parts of the area. Thickness of individual lignite seams varies from 0.10 m to 3.50 m in the depth range of 109.90 m to 196.30 m. The lignite seam is hosted within the Lower Tertiary Palana Formation.

### STATE DIRECTORATES/GMDC/RSMML

Particulars of exploration for lignite as carried out by these agencies are given in Table -3.

**Table - 2 : Exploratory Drilling by CMPDI (Departmental and Outsourcing) in 2015-16**

Sl. No.	Agency	Target (lakh m)	Exploratory drilling achieved (lakh m)	Achieved (%)
1.	Departmental	4.00	4.08	102
2.	Outsourcing			
	i) State Govts.	0.10	0.05	53
	ii) MECL (MoU)	4.00	2.47	102
	iii) Tendering (CIL Blocks)	4.30	2.21	51
	iv) Tendering (Non-CIL Blocks)	2.61	1.13	43
	<b>Total</b>	<b>15.00</b>	<b>9.94</b>	<b>66</b>

EXPLORATION & DEVELOPMENT

**Table-3: Exploration for Lignite by DGMs & Central/State Undertakings, 2015-16**

Agency/State/ District/Location	Mapping		Drilling		Sampling (No.)	Result
	Area (sq km)	Scale	No. of boreholes	Meterage		
<b>DMG, Rajasthan</b>						
<b>Bikaner</b>						
Diyatra Tehsil Kolyat	-	-	11	1843.80	64	DMG, Rajasthan Bikaner estimated Geological reserves of 2.86 million tonnes of lignite and 3.1 million tonnes of lignitic shale. In Diyatra block, out of 11 boreholes, lignite encountered in 4 boreholes with seam thickness varying from 1.50 m to 11.65 m (Average 4.81 m). The average lignite/ overburden ration is 1:31.89.
Gap area between Ambasar, Barsinghsar, Hadla, Tehsil Kolyat & Bikaner	275	1:50000	-	-	-	-
<b>GMDC, Gujarat</b>						
<b>Bhavnagar</b>						
Tagdi village	-	-	-	-	-	Total geological reserves/ resources (111) were estimated at 114.72 million tonnes as on 31.03.2016.
<b>Kachchh</b>						
N/v Panandhro	-	1:5000	-	-	-	Balance reserves of lignite at the end of March, 2016 were estimated at 2.06 million tonnes.
N/v Mata No Madh	-	-	-	-	-	Balance reserves of lignite at the end of March, 2016 were estimated at 35.88 million tonnes.
<b>Surat</b>						
N/v Tadkeshwar	-	-	2268	-	-	-
<b>RSMML</b>						
<b>Barmer</b>						
Giral mine	-	-	-	-	-	Total geological reserves (111) of lignite at 26.553 million tonnes as on 31.03.2016
Sonari mine	-	-	-	-	-	Total geological reserves (111) of lignite at 27.485 million tonnes as on 31.03.2016
<b>Nagaur</b>						
Keshnau-Matasukh mine	-	-	-	-	-	Total geological reserves (111) of lignite at 15.547 million tonnes as on 31.03.2016

## NON-FERROUS METALS BASE METALS

GSI, MECL, DGM and HZL conducted investigations for copper, lead and zinc ores in different parts of the country during 2015-16.

### GSI

The details of exploration activities carried out by GSI during 2015-16 are given in Table-4.

### MECL

During 2015-16, MECL carried out exploration for copper, lead & Zinc in Muariya Block (North of Muariya Block) on the Narera-Bordeh tar road in the Amla Tehsil, Betul district, Madhya Pradesh. The sulphide mineralisation in this area occurs in the form of sphalerite, chalcopyrite and galena. The deposit is predominantly a Zinc deposit with Pb & Cu as associated metal, Cd and Ag concentration reported as 129.79 g/t and 43.63 g/t respectively. Detailed exploration in Muariya block Phase-I involving drilling of 1659.70 m in 7 bore holes; mapping - 1 Km<sup>2</sup> area on 1:2000 scale; sampling and chemical analysis - 211 nos primary and 50 nos of check samples; petrographic studies - 15 nos.; minerographic studies - 11 nos.; composite samples for fire assay of Au & Ag and spectroscopy & XRD -6 nos. each. Total ore resources of 1.061 million tonnes with 6.00% - Zn, 1.43% - Pb and 0.62% - Cu has been estimated at 1% Zn cut off grade and 2 m minimum stoping width.

### HZL

During 2015-16, HZL carried out exploration to delineate the shape of ore body and grade tonnage estimation in Rajpura - Dariba mine, Rajsamand district, Rajasthan by drilling 77 nos. of boreholes for a total meterage of 14474 m, underground mapping on 1:200 scale and collected 3555 nos. of samples for analysis. Resources estimated under proved - 6.39 million tonnes ores with 1.59% Pb & 6.11% Zn, probable - 2.89 million tonnes ore with 1.48% Pb & 6.68% Zn, feasibility - 3.20 million tonnes ore with 1.27% Pb & 7.94% Zn, pre-feasibility - 6.12 million tonnes ore with 2.28% Pb & 6.34% Zn, measured - 7.17 million tonnes ore with 2% Pb & 7.5% Zn, indicated - 6.28 million tonnes ore with 2.35% Pb & 6.86% Zn and inferred - 26.63 million tonnes ore with 1.88% Pb & 6.74% Zn.

### DGM

During 2015-16, DGM Rajasthan carried out exploration of basemetals near village Chenpura, tehsil Bassi, district Jaipur. An area 2.5 sq km mapped on 1:4000 scale and collected 150 samples. Total 8 old workings have been noted in the area. Botryoidal structure is seen at several places in hematite. BHQ is also observed at places. In Jhujhunu district, near villages Bankott, Rasulpur, Modki, Tal ki Dhani, Madhogarh, etc tehsil Khetri an area of 100 sq km, 16 sq km and 1 sq km were mapped on 1:50000, 1:10000 and 1:4000 scale, respectively. Collected 65 samples.

**Table - 4 : Exploration for Base Metals by GSI, 2015-16**

State/District	Name of block	Details of exploration	Results
<b>Andhra Pradesh</b> <b>Base metal</b>			
Guntur	Karempudi(W) To Khandrika(E) Area, Agnigundala Mineral Belt	Mapping, drilling and sampling	G4 stage investigation for iron & associated mineralisation was LSM was done over an area of 81 km. Three sulphide mineralised zone was delineated at Gadimendi & Tod. Two iron formation associated sulphide mineralised bands were also delineated at Karte and Baririgo area. Iron formation with associated sulphide mineralisation at Karte shows an avg. of 24.87% Fe and 71.15 ppm Cu from channel and trench samples. Channel samples from pyrite bearing talc-tremolite schist yielded an avg. 32.25 ppm Cu and 6.09% Fe Channel samples from magnetite bearing chlorite biotite quartz schist at Lama Deke yielded avg. value of 9.31% Fe and 72.90 ppm Cu. Trkench samples from Takam in the haematite goethite quartz band yielded avg. value of 6.61Fe and 33.875 ppm cu. While samples from iron formation at Baririgo yielded avg. value of 28.18% Fe, 367.6ppm Cu, 74.4 ppm Pb and 123.8 ppm Zn.

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## EXPLORATION &amp; DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
Prakasham	Mallapuram block	Mapping, drilling, sampling & trenching	<p>During G2 stage reappraisal of basemetal mineralisation an area of 1 sq km was mapped on 1:1000 scale with the help of total station. A total of 12 boreholes were drilled for a total meterage of 1623 m and 183 core samples were collected. A total of 101 BRS, 26 PS, 17 PCS and 20 ORM were collected. Three types of rocks exposed are phyllite, magnetite bearing quartzite, dolomite and quartz vein. Mineralised zone is mainly concentrated within the dolomite band that occurs west of magnetite-quartzite. The dolomite band shows patchy outcrop pattern with cumulative strike length of 450 m and an average width of 6-8 m. A few old workings (over dolomite) are noticed in the northern part and south-western part of the area. Flaky galena is often noticed in silicified dolomite dump at old working present in northern part of the area. Quartz veins intruding dolomite are seen oriented parallel to and across the bedding plane, which also contains galena. Gossanised calcareous phyllite bands (length 700 m × width 5 m) are noticed in the southern strike extension of the mineralised dolomite bands, which are mainly noticed in the central and south-western part. The gossan zone mainly consists of limonite, jasper, haematite and manganese nodules. The average thickness of the gossan zone is ~5 m and has maximum thickness (33 m) along 1200 old geophysical line. XRD analysis of samples from gossan zone shows that, it mainly consists of quartz, calcite, small amount of pyrolusite and trace amount of goethite. Geophysical exploration led to identification of 2 KM length western mineralised zone, but the highest chargeability anomaly zone has a length of nearly 800 m, in the northern part of the block. This zone shows high chargeability and relatively lower resistivity. On surface, the anomaly zone occurs over grey and ferruginous phyllite and quartz veins. No indication of any mineralisation is seen along this zone on surface. No indication of any mineralisation is found along this zone on surface. Pseudosections along 1040, 1080 and 1160 old geophysical line show depth continuity of this mineralised zone down to 70 m vertical zone. The trenches namely, T-1G, 2G, 3G have been excavated on the western mineralised zone, along 1050, 1080 and 1120 old geophysical lines, respectively. The trenches only expose grey, green and ferruginous phyllite. Borehole APMP12 was drilled to intersect this geophysical anomaly zone which shows specks of pyrite and chalcopyrite discontinuously, both along bedding. and fractured plan from depth of 50-80 m. Borehole APMP 11 also interested this mineralised zone.</p>

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EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Assam</b> Goalpara	Phophonga Hills	Mapping, drilling and sampling	A G-3 stage Investigation of Pb & Zn and associated minerals has been carried out by detailed mapping of 2 sq km and by drilling of 401.30 m. Mineralisation in the form of small stringers, veins and veinlets, fracture-filling and as dissemination, is associated with shear zone. It is found in the retrogressed part of the highgrade rocks of upper amphibolites/granulite grade. The zone is also closely related with granite gneiss. The mineralisation is controlled by structures and metamorphism. Dissemination in sillimanite-biotite gneiss is also seen; however, it is not significant. Continuous and massive type of mineralisation is not seen in the zone. Exposed strike extension is 120 m; however, drilling of 4 test boreholes indicates extension of the mineralisation for more than 400 m. Mineralisation occurs as small stringers, lenses, veins and fracture-filling in a zone ranging in thickness from 2.7 m to 45.8 m. Analytical results are awaited.
<b>Copper Haryana</b> Mahendragarh	Golwa area	Drilling and sampling	A G2 stage exploration was carried in south-east of Golwa area. The rocks of the area comprise tremolite marble with quartz bands, marble, calcareous quartz-biotite schist, and calcareous quartz-biotite schist with amphibole marble belonging to the Golwa-Gangutana Formation. Malachite stains and dissemination of sulphide minerals within the calcareous quartz-biotite schist and amphibole marble are the surface manifestations of the mineralisation. The drill cores indicates mineralisation in the form of specks, dissemination and fracture-filling of chalcopyrite, bornite, covellite, pyrrhotite and pyrite as sulphide minerals, mostly associated with thin veins/veinlet of calcite and rarely with quartz veins. Analytical results of core samples pertaining to borehole GEBH-9 (2nd level) indicate 0.38% average grade of copper (Cu) within 7.5 m (175.50 m-183.00 m) wide mineralised zone. Borehole GEBH-10 indicates 0.25% average copper in 5m (159.50 m-164.50 m)-wide mineralised zone. Borehole GEBH-11 (2nd level) indicates 0.36% average copper in 4-m (189.00 m-193.00 m)-wide mineralised zone. Borehole GEBH-12 (3rd level) indicates 0.35% average copper in 3 m (233.00 m-236.00 m)-wide mineralised zone. Analytical results of 15 channel samples of channel line J across the calcareous quartz-biotite schist and amphibole marble indicate 0.40% average grade of copper (Cu) in 5 m-wide mineralised zone on surface and channel line K indicates copper (Cu) with an average grade of 0.43% in the mineralised zone of 5 m on surface.

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EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Haryana</b>			
Mahendragarh	NW of Islampur	Drilling & sampling	A G3 stage of exploration was carried out for copper mineralisation. The area comprises quartz-biotite schist (QBS), amphibole marble and pegmatite belonging to Golwa-Gangutana Formation. On the basis of field observations, core logging and thin section study suggest presence of pyrite, pyrrhotite and chalcopyrite were established in the calcareous quartz-biotite schist. The sulphide mineralisation occurs in the form of disseminations and specks along the foliation and fracture planes of calcareous quartz-biotite schist. Based on geophysical anomalies, a total of 1038 m was drilled in five first-level boreholes (IBH-1 to IBH-5) to intersect the mineralised host rocks. The analytical results of 32 channel and pit samples show 02 ppm to 129 ppm Cu, 10 ppm to 146 ppm Pb and 11 ppm to 159 ppm Zn. The analytical results of 246 core samples show Au values <50 ppb.
<b>Karnataka</b>			
Raichur	WNW and ESE extension in Machanpur area, Lingsugur Taluka	Mapping, trenching & sampling	A G4 stage preliminary investigation of copper mineralisation was taken up on request from DMG, Karnataka. A total area of 105 sq. km was mapped on large scale and 75 cu m of trench was excavated. Sixty-five trench samples, 90 bedrock samples, PCS, 5 RD, 10 ORM, 5 EPMA samples were collected and analysed for Cu and Au and selected samples were also analysed for REE. The granitoids occurring parallel to the Krishna lineament are known to contain anomalous Cu, Mo, Pb, REE in Machanur and its adjoining areas. The area exposes amphibolite, massive/schistose metabasalt, pillowed metabasalt, quartzite, argillite/phyllite and diorite of Buddine Formation of Hutti-Maski schist belt. A series of basic dykes trending NE-SW & E-W intruded the rocks of schist belt, granitoid and pink granite of Closepet Granite. Quartz vein trending NNW-SSE to NE-SW & E-W intruded all the rock types. Deccan flow occurs above granodiorite and amphibolite in the mapped area. The trend of foliation varies from NNW-SSE to NNE-SSW with steep dips both easterly and westerly. Shearing is also observed in the form of network of quartz veins, development of boudinage in schistose metabasalt. Trend of shearing is NNW-SSE to N-S and Cu mineralisation is restricted within shear zone. Three mineralised zones (Z1, ZII, and Z III) have been delineated in the mapped area. Zone-I has been delineated 0.5 km east of Machanur with an average width of 200 m and a strike length of 5.0 km approx. for copper and REE mineralisation within sheared pink granite. The Cu mineralisation is mainly restricted within sheared pink granite (200 m wide). Chalcopyrites, bornite,

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EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
Raichur (Contd.)			malachite are the main ores of copper with association of pyrite, pyrrhotite, arsenopyrite, specularite and sphalerite. Pb-oxide is also observed within sheared pink granite. In Zone-I, bedrock samples yielded Cu which varies from 405 ppm to 5.2% in sheared pink granite (maximum in BRS-29 and 3.0% in BRS-19). Average Cu content is 0.85%/2 m. In trench samples from MT-1 Cu value ranges from 520 ppm to 0.69% (maximum MT-1/16) average being 0.26%/10 m. Trench samples from MT-2 yielded Cu which varies from 485 ppm to 0.44% and average Cu content is 0.21%/6 m. Zone-II has been delineated 2 km west of Gaudur with an average width of 50 m and strike length of 4.2 km within schistose metabasalt. In this zone Cu mineralisation is associated with ancient inclines, ferruginisation, carbonatisation, limonitisation, shearing, smoky quartz vein, sulphide stain. Chalcopyrite is the main ore of copper with pyrite, pyrrhotite, arsenopyrite within schistose metabasalt. In Zone-II, the bedrock samples yielded 2.0%/2 m Cu (metabasalt), average being 2.0%/2 m. Zone-III has been delineated 4.0 km NNE of Yelagatti with an average width of 8–10 m and strike length of 3.5 km within pillowed metabasalt. In this unit Cu and Au mineralisation is associated with silicification in the form of cherty quartzite band (1–2 m wide), limonitisation, ferruginisation and sulphide stains. Occurrence of tourmaline has been observed to have a positive correlation with enrichment of gold. Chalcopyrite is the main ore of copper with arsenopyrite, pyrite, pyrrhotite and few malachite stains. In Zone-III, bedrock samples yielded 405 ppm to 1.52% Cu (maximum in pillowed metabasalt) and average is 1.51%/2m. Au values range from 45 ppb to 325 ppb. In pink granite (PG of Closepet) REE mineralisation has been found to be associated with shearing, ferruginisation, carbonatisation and emplacement of calcite, epidote-quartz-iron-oxide veins (hydrothermal activity). Samples collected from Zone-II and Zone-III yielded 75 ppm REE on average with 62 ppm LREE. Copper mineralization in schist belt may be both epigenetic and syngenetic type. REE mineralisation along with basemetal (Cu, Pb and Zn), gold (Au) and iron (Fe) indicates polymetallic ore deposits which may be due to epigenetic/skarn/ remobilisation process due to secondary fracture filling and is sheared controlled.

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EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Madhya Pradesh</b>			
<b>Base metal</b>			
Chhindwara	Chhipanala Chhindboh Kohat, Mehlari & Pradhan Ghogri area.	Mapping and sampling	<p>G4 stage exploration for base metals was taken up to assess the base metal mineralisation potential of hydrothermal alteration zones. An area of 100 sq km has been mapped on 1: 12500 scale which comprises eastern part of Betul belt. Main rock types exposed are pink granite/mylonite/ ultra mylonite, grey biotite gneiss and granite gneiss/mylonite of the Lawaghogri shear zone and unaltered metarhyolite, foliated rhyolite, garnetiferous quartzo-feldspathic schist, altered rhyolite, amphibolite, cumulus pyroxenite, quartz veins of Betul Belt, infratrappean and basalt of Deccan traps. Volcanogenic massive sulphide alteration zones have been observed near this block and Nimbukhera villages.</p> <p><b>Chhindboh:</b> Alteration zone of 600 m × 300 m (approx) trending E-W, dipping northerly was observed within altered rhyolite 1 km NE of village Chhindboh. It shows very good development of anthophyllite-garnet-muscovite with surface indications of magnetite and sphalerite. In this location development of garnets of varying sizes ranging from few millimetres to 5 centimetres has been observed. Total 6 soil samples in 100 m × 20 m grid and 52 BRS have been collected and sent for analysis.</p> <p><b>Kohat :</b> Alteration zone of 400 m × 250 m (approx) trending E-W dipping northerly was observed within altered rhyolite 300 m south of village Kohat . It shows development of muscovite -garnet-sillimanite with specs of sphalerite. A total of 138 soil samples in 100 m × 20 m grid have been collected and sent for analysis.</p> <p><b>Chipanala:</b> Alteration zone of 300 m × 200 m (approx) trending E-W dipping northerly was observed within altered rhyolite around 500 m NW of village Chipanala. It is composed of garnet, anthophyllite, muscovite with few specs of sphalerite and magnetite. Another zone of 150 m × 150 m (approx) trending E-W was also observed around 500 m NE of village Chipanala with enrichment of tremolites. Development of garnets within it is less compared to the NW band. A total of 84 soil samples in 100 m × 20 m grid have been collected and sent for analysis.</p> <p><b>Pradhanghogri:</b> Alteration zone of 400 m × 250 m (approx) trending E-W dipping northerly was observed west of village Pradhanghogri with development of garnet, biotite, feldspar and translucent quartz. A total of 84 soil samples in 100 m × 20 m grid have been collected and sent for analysis and analysis results are awaited.</p> <p><b>Mehlari:</b> Alteration zone of 400 m × 250 m (approx) trending E-W dipping southerly was observed SW of village Mehlari with development of garnet, amphiboles and biotite with specs of magnetite and sphalerite. A total of 92 soil samples in 100 m × 20 m grid pattern have been collected and sent for analysis.</p> <p><b>Burena:</b> Alteration zone of 650 m × 450 m (approx) trending E-W was observed 2 km south of village Burena with development of tremolite-anthophyllite</p>

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EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
Chhindwara (Contd.)			<p>tummingtonite)-garnet-muscovite-sericite. Delopment of garnet-uscovitesericite schist, crystals of garnet of varying sizes (ranging from few millimetres to centimetres) were observed. A total of 232 soil samples in 100 m × 20 m grid pattern have been collected.</p> <p><b>Nimbukhera:</b> Alteration zone of 100 m × 50 m (approx) trending E-W was observed 1 km north of village Nimbukhera. Garnet-muscovite-sericite schist, crystals of garnet of varying sizes (ranging from few millimetres to centimetres) were observed. A total of 14 soil samples in 100 m × 20 m grid pattern have been collected and analysis results are awaited. Based on integration of geo-chemical and geological data received so far, a zinc anomaly of 300 ppm of length 100 m and width 60 m has been established in Chhipanala zone. In Kohat, Zn anomaly of 1000 ppm of length 200 m and width 100 m has been established. These high values of zinc are found over altered rhyolites composed of quartz+ sericite+ muscovite+ chlorite+ garnet+ anthophyllite ± cummingtonite and quartz+ sericite+ muscovite+ biotite+garnet in Chhipanala and Kohat zones respectively.The Chhipanala and Kohat areas have spectacular hydrothermal alteration zones and moderate zinc anomaly. Investigation has been completed.</p>
<b>Mahashtra</b> <b>Base metal</b> Bhandara	Silejhari area, Sakoli Fold Belt	Mapping, sampling trenching SEM & EPMA studies.	<p>G4 stage investigation to identify zones of anomalous base metal content viz; zinc and associated metals was taken up. An area of 1.0 sq km has been mapped on 1:2000 scale with collection of 150 soil samples on 100 mx20 m grid, pitting &amp; trenching of 50m3 along with collection of pitting-trenching samples(PTS) and bed rock samples (BRS) for chemical analysis. Disseminations of sulphide minerals, which include mainly pyrite, chalcopyrite, covellite, sphalerite, etc. are observed in chert bands and metabasalt west of Silejhari and north-east of Jhari areas. Pitting and trenching was carried out towards west of Bodra and northeast of Jhari for delineating the dimension and lateral extent of oxidised and mineralised chert bands. Analytical results of 13 BRS samples have been received showing Zn values in the range 92-700 ppm; average value is 473.5 ppm. Pb values in BRS vary from 10 ppm to 2000 ppm; average value is 362.5 ppm. Analytical results of 26 soil samples showed Zn content in soil varies from 71 ppm to 625 ppm; average value is 293.1 ppm. The Pb content in soil varies from 28 ppm to 1100 ppm; average value is 296.7 ppm. Analytical results of 14 PTS samples showed Zn values ranging from 75 ppm to 640 ppm; average value is 404.9 ppm. The Pb content in PTS varies from 73 ppm to 2000 ppm; average value is 584.9 ppm. Sulphide mineralisation occurs both as stratiform and stratabound nature in cherts and phyllites as well as hydrothermal alteration associated with quartz veins. Detailed mapping and</p>

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Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
Bhandara (Contd.)			systematic soil sampling in grid pattern carried out in the area indicate the presence of anomalous zone of basemetal mineralisation. Bedrock samples from different locations of investigated area reveal that the Zn values vary from 10 ppm to 0.12% with average value of 381 ppm, Pb values vary from 10 ppm to 0.23% with average value of 383 ppm and Cu values vary from 10 ppm to 345 ppm with average value of 102 ppm.
Chandrapur	Minjhari area	Mapping, sampling and drilling	G-3 stage investigation was carried out to establish copper and associated mineralisation. The investigation involves detailed geological mapping, 500 m drilling, bedrock and core sampling, pitting and trenching. Detailed geological mapping (1:2000) of an area of 1.5 km was carried out around the Minjhari quartz reefs which reveals basemetal mineralisation (Cu ± Au) in this area is confined to an echelon dilatational quartz veins stretching for 3.0 km strike length. Chemical results of bed rock samples (33) showed Cu values ranging from 26 ppm to 2000 ppm. The first two boreholes (MHCM-1 & MHCM-2) were planned to intersect at 60 m vertical depth of intersection. However, primary mineralised zone was not encountered in both the first level boreholes drilled but intersection of secondary malachite zone with faint chalcopyrite dissemination is noticed. Hence, the third borehole (MHCM-3) was planned between the two first-level boreholes MHCM-1 & MHCM-2 at deeper level <i>i.e.</i> , 120 m vertical depth (98 m R.L.) to encounter the primary-mineralised zone. The targeted mineralised zone (quartz reef) was intersected at 136.20 m depth and continued up to 156.65 m. Chalcopyrite mineralisation in the form of fine dissemination, chunks and stringers is noticed in this zone. Chemical results of five core samples from MHCM-3 showed good copper concentration with a maximum value up to 0.57%. The fourth borehole (MHCM-4) intersected the primary mineralised zone at 145.90 m depth and continued up to 158.00 m depth. Chalcopyrite dissemination and stringers were seen in this zone. Surface evidences, borehole information and petrographic observation in the area revealed the Cu ± Au mineralisation is mainly concentrated in shear hosted quartz-chlorite veins. Drilling in two different subsurface levels indicated deeper oxidation characteristics and deep-seated mineralisation. Based on primary mineralisation and significant copper assay value observed in third orehole (120 m vertical depth), deeper boreholes were recommended in Minjhari area. In the first bore hole (MHCM-1) two mineralised zones are identified <i>i.e.</i> Zone-I from 78.00 m to 83.75 m with 0.23% Cu and Zone-II from 92.25 m to 98.55 m with 0.20% Cu. In the second borehole MHCM-2 two mineralised zones can be demarcated <i>i.e.</i> Zone-I from 63.5 m to 66.5 m with 0.23% Cu and Zone-II from 67.80 m to 69.00 m with 0.20% Cu. In the third borehole MHCM-3 two mineralised zones can be demarcated based on chemical results <i>i.e.</i> Zone-I from 129.20 m to 136.20 m with 0.50% Cu and Zone-II from 142.95 m to 145.05 m with 0.43% Cu. Investigation will be continued.

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EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Rajasthan</b>			
Alwar	Khera SE block	Drilling	G3 stage exploration in Khera SE block of Mundiawas Khera area was carried for copper. The one deep borehole intersected sulphide mineralisation is in the form of occasional specks, foliation parallel stringers, vein-filling, fracture-filling and occasional massive chalcopyrite, pyrrhotite and minor arsenopyrite. The borehole intersected significant sulphide mineralisation between 228.0 m–233.0 m = 5.0 m with Cu (V.E) = 0.2–0.4%, 233.0 m–251.0 m = 18.0 m with Cu (V.E) = 0.2–0.3% ,251.0 m–272.15 m = 21.15 m with Cu (V.E) =0.4–0.6%, 272.15 m–311.0 m with Cu (V.E)= 0.1– 0.3%, 365.0 m–372.0 m =7.0 m with Cu (V.E) = 0.1–0.3% and 390.0 m–395.0 m = 5.0 m with Cu (V.E) = 0.1–0.3%.
Mundiawas-	khera area		
Alwar	Khera main block, Mundiawas Khera area	Drilling	G2 stage investigation was carried out in Khera main block for copper and associated precious metals. Out of seven boreholes planned five boreholes were completed and two are in progress. All the boreholes intersected host rock felsic metavolcanics and dolomitic marble having significant sulphide mineralisation. The sulphides are in form of occasional foliation-parallel specks, stringers, fracture and vein-filled chalcopyrite and pyrrhotite.
<b>Rajasthan Copper</b>			
Alwar	Agar block	Mapping and sampling	G4 stage investigation for copper and associated precious metals was carried out by mapping 52 sq km area on 1:12500 scale. Evidences of mineralisation are observed near Bhaonta village in the form of old working, vertical shafts, dewatering channel, slag heaps and presence of fresh sulphides. A mineralised zone with a strike length of about 1200 m has been delineated. The mineralised zone has an exposed strike length of 350 m within the quartzite hill along a fault zone with presence of old workings and numerous vertical shafts. To check the potential for mineralisation, four trenches were laid across the strike of the zone. The trench samples collected from trench AGTH-2 have analysed anomalous concentration of copper. Nineteen out of 29 samples have given a copper value more than 0.2% with maximum value up to 0.55%. Grab sample collected from the mineralised zone from a well dump has given copper value of 2.53% and gold value of 300 ppb. The grab sample collected from the dumps near an old working at the quartzite hill has given a value of 0.58%. The slag samples analysed from the slag heaps have 0.26% to 0.49% of Cu. The area seems potential for copper mineralisation.

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EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
Alwar	Angari block	Mapping & sampling	G4 stage investigation of copper and associated precious metals was carried out in Angari block. An area of 1.5 Km <sup>2</sup> was mapped on 1:2000 scale. On the basis of surface indications i.e. presence of old workings, malachite stains and fresh sulphides, two mineralised zones have been delineated. The two zones are present in the west-central part of the block; one in banded dolomitic marble and the other is in tremolite-bearing banded dolomitic marble with quartz and carbonate veins. Within the banded dolomitic marble pyrrhotite and arsenopyrite are present as disseminations and along foliation planes. Highly gossanised rock of tremolite-bearing dolomitic marble is observed in two dug wells further north of the Angari block. 213 trench samples and channel samples and 66 BRS were collected. Stromatolitic structures are identified in dolomitic marble at two places, one in the eastern part and the other in the western part of Angari block. Samples of stromatolitic dolomitic marble were powdered and tested for phosphate with Shapiro solution, which gave yellow precipitate indicating presence of phosphate. Bedrock samples from west-central part of the area contain up to 0.17% Cu. Samples collected from the northern part of the block analysed 450 ppm Zn. The analytical results of samples from ferruginised brecciated zone at the eastern side of the block shows 0.24% Zn, 800 ppm Cu and 600 ppm Ni.
Jhunjhunu	Between Bokri and Malwali prospects	Drilling & sampling	G3 stage investigation for Copper and associated mineralisation was carried out in gap area between Bokri and Malwali prospects of Eastern Khetri metallotect. Six boreholes of cumulative length 1002 m were drilled and 509 core samples were processed for the analysis of copper and other basemetals. Surface evidences of mineralisation are in the form of small old working, gossan, malachite stain, pyrite mineralisation, silicification, albitization and epidotization and slag heap. On the basis of detailed mapping two sub-parallel mineralisation zones were established in the area, one within the fault zone breccia and other in silicified quartzite. All the boreholes have intersected the sulphide mineralisation in the form of dissemination and streaks with occasional stringers, veins and fracture-filling of chalcopyrite, pyrite, pyrrhotite and specularite. The analytical data indicated two copper zones (3.5 m × 0.32% Cu, 6 m × 0.4% Cu) in the first borehole.

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EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Base Metal</b> Jaipur & Alwar	Tehla-khoh-Bighota area	Drilling	G4 stage investigation for basemetal and associated precious metals was taken up in Tehla-khoh-Bighota area . Large-scale mapping of 100 sq km on 1:10000 scale has been carried out in Rup Bas-Talab-Losal-Ladla ka Guwara-Katara ka Guwara-Govardhanpura-Rampura-Kundla-Ramsinghpura-Bighota area.The first borehole PBH-1 to the west of Palpur block intersected sulphides in the form of pyrite, pyrrhotite and specks of chalcopyrite at 6.00-75.00 m depth. Significant disseminations of chalcopyrite along with pyrite and pyrrhotite were observed at 40.00-60.00 m depth.The second borehole in Bighota area WBBH-1 has intersected sulphide mineralisation at 7.50-9.00 m within bluish coloured quartzite and at 41.50-49.00 m within actinolite/tremolite-bearing dolomitic marble. Besides, fracture filling of metabasic rock by pyrrhotite and chalcopyriteat 73.00-79.50 m, 80.50-88.00 m, and at 93.50-28.50 m has been observed. The borehole intersected dolomitic marble with amphiboles (actinolite/tremolite) and metabasic rocks having fine disseminations of sulphides. The third borehole PBH-2 to the west of Palpur block intersected sulphide mineralisation. Along the borehole disseminations of chalcopyrite, pyrite, pyrrhotite besides fracture-filling pyrrhotite, chalcopyrite and pyrite were observed at 42.30-46.00 m within amphibole marble,at 46.00-60.50 within biotite schist, at 60.50-68.50 m within amphibole marble, at 68.50-78.00 m within metabasic rock, at 80.50-95.50 m within amphibole marble, at 95.50-102.00 m within metabasic rock, at 102.00-113.00 m within amphibole marble, at 120.00-123.00 m, and 136.50 - 143.50 m within metabasic rock.
Bhilwara & Ajmer	Sandmata complex	Mapping, sampling and analysis	G4 stage investigation for base metal and gold was taken up in Sandmata Complex. An area of 50 sq km was mapped on 1:12500 scale) 1 sq km on 1:2000 scale and carried out pitting and trenching.Three hundred bedrock samples have been collected from all rock types.Gritty conglomerate is the host rock of copper mineralisation in the area.The surface indication of mineralisation in form of malachite staining, old mine pits and slag dump has been observed south of Hanutiya. Analytical results of 33 samples (BRS + soil) received so far have not showed any significant anomalous value of Cu.
-do-	Sandmata complex	Mapping, sampling and analysis	G4 stage investigation for base metal and gold was taken up in Sandmata Complex. An area of 50 sq km was mapped on 1:12,500 scale) 1 Sq km on 1:2000 scale and carried out pitting and trenching.Three hundred bedrock samples have been collected from all rock types.Gritty conglomerate is the host rock of copper mineralisation in the area.The surface indication of mineralisation in form of malachite staining, old mine pits and slag dump has been observed south of Hanutiya. Analytical results of 33 samples (BRS + soil) received so far have not showed any significant anomalous value of Cu.

(Contd.)

EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
<b>Base metal/Copper</b> Sikar	Nanagwas block	Drilling	G2 stage exploration for base metal was carried out, which is one of the most significant explored blocks in Neem ka Thana copper belt. The block having 2 km strike length, has contributed 14.66 MT × 0.33% Cu by cross-section method at 0.2% cut off. A total 4171.10 m has been drilled in 22 boreholes. Copper mineralisation is in the form of vein-filling, stringers and dissemination of bornite (dominantly) and chalcopyrite.
<b>Base metal and RM &amp; REE</b> Sikar	Kishanpura-Loharwas area	Mapping, sampling	G4 stage preliminary investigation in parts of Kishanpura-Loharwas area was carried out to evaluate the potential of basemetal and RM and REE mineralisation. Large-scale mapping of 56 sq km on 1: 12500 scale was carried out. The surface evidence of basemetal mineralisation is marked by the presence of malachite stains, fresh sulphides i.e. chalcopyrite, pyrite, bornite and specularite occurring along the quartz/carbonate veins. The mineralisation is hosted by calc-silicate rock and amphibole-bearing marble. A mineralised zone of 1 km long and 25-50 m wide has been delineated on surface and 71 bedrock samples on grid pattern (100 × 25 m) have been collected and analysed. Three channels have been put across a mineralised zone at spacing of 200 m. From channel RCH-1, 13 samples have been collected which analysed copper varying from 10 ppm to 4400 ppm. Eight samples from channel RCH-2 have been analysed for copper which varies between 90 ppm and 240 ppm and copper content in 5 samples collected from channel RCH-3 varies between 60 ppm and 170 ppm. A total of 135 samples have been collected from different pegmatite bodies for REE & RM mineralisation. Results of 5 samples do not show any encouraging results for REE & RM mineralisation.
<b>Base Metal</b> Sikar	SE of Kharagbijpur	Mapping, bedrock/channel sampling and analysis	G4 stage investigation for basemetal was taken up. Detailed mapping on 1: 2000 scale has been carried out to the west of Dhabala, covering an area of about 0.75 sq km. The area exposes dolomitic marble and biotite-rich dolomitic bands. The surface indication of mineralisation is manifested in the form of malachite staining and fine specks of chalcocite in the biotite dolomite lithounit. Mineralisation is in the form of chalcopyrite and bornite specks which is observed along thin veins of quartz and calcite. Several thin (few centimeters to 0.5 m wide), pink-coloured pegmatite veins are observed along foliation planes. The thicker quartz veins are mostly emplaced along S3 foliation plane which do not show any evidence of copper mineralisation. A total of 90 BRS samples from a

(Contd)

EXPLORATION & DEVELOPMENT

Table - 4 (Contd.)

State/District	Name of block	Details of exploration	Results
sikar (Contd.)			
			<p>baseline of 1000 m length,trending 080°-260°, have been collected at 100 m × 50 m grid and processed. Bedrock samples collected along the baseline for a distance of 600 m were analysed for copper which varies from 0.58% to 0.14%. On the basis of chemical analysis of BRS, a 600 m-long surface mineralised zone has been demarcated in the biotite dolomitic marble unit and four channels have been cut across it at an interval of 200 m and 100 channel samples have been collected. The exact thickness of the mineralised zone will be known after the results of chemical analysis of channel samples.</p>
<b>Base metal &amp; Molybdenum</b>			
Sikar	Pachlagi-Narsinghpuri area, etc.	Mapping & sampling	<p>G4 stage search for basemetal and associated molybdenum was taken up. A total of 82 sq km area has been mapped on 1: 12500 scale and 75 bedrock samples were gathered for geochemical analysis. Forty samples have been collected for petrographic and EPMA study. In the study area Atomic Minerals Directorate (AMD) has been carrying out extensive exploration work in north-west of Narsinghpuri area for uranium. Surface indications of mineralisation are malachite, azurite stains in hornblendite/ pyroxenite, vein-filled chalcopyrite,pyrite in calcite within calc-silicate, intense ferruginisation in brecciated quartz hornblendite, presence of magnetite-albitite breccia, where fresh chalcopyrite associated with magnetite and malachite stains is observed. On the basis of surface indications and the presence of old workings (for fluorite,Salwari area, where intense malachite/ azurite stains occur),the area holds good promise for basemetal mineralisation. Also east of Guhala the magnetite-bearing brecciated albitite which contains sulphides has been marked as a mineralised zone extending for approximately 600 m with 5 to 10 m width. In Salwari and Guhala areas ground geophysical survey has been carried out as the areas hold good potentiality. In eastern part of the study area, near Karoth Dhaniyal, NE-SW-trending iron (magnetite)-rich quartzite band is very well exposed. The approximate length of the band is 1.5 km with 5-30 m thickness at places.Analytical results of 17 BRS indicates Cu content varies from 10 ppm to 2.1%. Three disposed core samples of AMD have been analysed and one sample shows the presence of 201 ppm of molybdenite. The analytical results of 55 BRS are awaited.</p>

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EXPLORATION & DEVELOPMENT

Table - 4 (Concl.d.)

State/District	Name of block	Details of exploration	Results
Sikar	Southern extension of Nanagwas block	Mapping, drilling & sampling	G3 stage investigation for basemetal was carried out to delineate southern extension of mineralised zone from Nanagwas main block. An area of 0.55 sq km was mapped on 1:2000 scale in south of the said block. The detailed surface geochemical evaluation and mapping of the block helped in tracing the southern extension of the main mineralised zone exposed in Nanagwas main block and in delineating an additional mineralised zone in the eastern part of the block for a strike length of 1550 m. Besides, subsurface continuity and potential of the copper mineralisation was also established by putting four boreholes in the western mineralised zone (the main mineralised zone) and three bore holes were drilled in the newly delineated eastern mineralised zones. In order to have a proper surface control on the mineralised zone surface geochemical profiles were laid down along the profile of each borehole drilled. The drilling in the western zone established strike continuation up to 800 m. Similarly four boreholes drilled in the newly delineated eastern zone established subsurface continuation of mineralisation at least for 800 m, though surface extension has been established for a strike length of 1550 m. The remaining portion of the zone will be established subsequently in relation to the subsurface continuation of mineralisation. Eight boreholes of cumulative length 1050 m have been drilled. Core sampling (116) and detailed logging of the borehole cores suggests a bornite-dominated copper mineralization in association with chalcopyrite, covellite, specularite, pyrrhotite and pyrite. Mineralisation is mostly present in the form of stringers, vein- fillings, streaks, specks of above sulphides/oxides and predominantly hosted within biotite-bearing dolomite and calc-quartz-biotite schist. The mineralised zone intersected in various boreholes at a vertical depth ranging from 50-60 m and with thickness varying between 12 and 18 m along the borehole. Visual estimate of the sulphides and copper content indicates copper values ranging from 0.1% to 0.3% Cu.
<b>Copper</b> Udaipur	Devimata- Pipaldaran area	Mapping, pitting/ trenching & sampling	G4 stage investigation for copper and associated mineralisation was carried out by large-scale mapping (LSM) of 100 sq km on 1:12500 scale, 52 m <sup>3</sup> pitting and trenching; 256 bedrock samples and 52 pit-trench samples. The major lithounits observed in the area are phyllite, dolomite, quartzite, metagreywacke, calcitic marble, polymictic conglomerate, intrusive granite and mafic. Surface indication of copper mineralisation is seen in the form of old working pits, slag heaps, profuse malachite encrustation associated with azurite, zone of oxidation and gossanisation. Fresh sulphides viz. pyrite and chalcopyrite are hosted in dolomite, sheared phyllite and interface of granite. The mineralised zone comprising 6-7 old workings at the contact of dolomite and sheared phyllite has been located around village Devimata. Number of old workings reported earlier are located near Pipaldaran and Samar area in dolomite and sheared quartzite-dolomite with profuse development of malachite stain, oxidation and gossanisation in bedrock and mine dump samples. Several old workings hitherto unknown in the north of Chandni, south of Kala Magra and Kevda Kalan area were also noticed. Bedrock and mine dump samples collected from the old workings of Devimata, Pipaldaran and Babarmal have shown Cu values varying from 350 ppm to 1.53%, Pb values between 90 ppm and 510 ppm and Zn values between 150 ppm and 0.20%.

## Bauxite GSI

During 2015-16 in Chhattisgarh, a G-2 stage investigation on assessment of bauxite ore over an area of 2 sq km in Damchuan block Balrampur district was carried out. The objective of the project was to know the extension of concealed bauxite occurrence by detailed mapping in Chandadarhi block and by drilling in Damchaun block. The laterite is red, yellow and brown in colour, pisotite to massive type, porous and sparsely oritic. Aluminous laterite occurs as irregular pockets and lenses in the area. Massive and pisobitic bauxite is found at an elevation of 940-960 m and 980-1080 m. In the east of village Damchuan, in a scrap section, massive bauxite of 200 m length and 3.5 m thickness is observed. The project could not be completed due to agitation by the local villagers for carrying out any type of exploration work in the area. G1 stage exploration work was carried in Bamhantara block Kabirdham district, Chhattisgarh. A total of 120 boreholes at 50 m x 50 m grid for a cumulative length 1277.6 m were drilled in PL area of CMDC. The depth of boreholes range between 11.5 m and 15 m (up to lithomarge clay). The maximum thickness of laterite capping is 13 m above the Deccan Basaltic province. Bauxitisation has resulted in two aluminous horizon within this laterite capping; the upper one occur within the depth range of 1-3.5 m and deeper one extends from 6 m to 8.5 m. The laterite is considered as better grade with  $Al_2O_3$  content varies from 28.05% to 58.60% and mean value is 49.08%.  $SiO_2$  content varies from 0.76 to 28.18% and mean value is 5.20%.

In Meghalaya, 1.55 sq km DM and 417.65 drilling was completed in the investigation of lateritic bauxite around Rambrai area, west Khasi hills district (G-3). The lateritic bauxite in the area is buff and brick red in colour. Pisolithic structure is also observed. Three main bodies of laterite were identified in the area having the dimensions 600 m x 100-400 m, 400 m x 100-200 m and 100 m x 50-100 m. Thickness of the complete profile of lateritic bauxite is about 8-10 m. Fifteen boreholes (BR-1, 2, 4, 5 and 9 to 19) of cumulative length 417.50 m were drilled in the area, which intersected significant mineralised zones. Thickness of ore bodies in boreholes varies from a of 6.90 m (BR-17) to a maximum of 14.50 m (BR-2), the average thickness being 10.61 m. Analytical result shows that  $Al_2O_3$  content varies from 41.34 wt% to 58.99 wt%. Cr, Sc and Ga also show encouraging values with an average value of 1083 ppm, 83 ppm and 64 ppm respectively. G4 stage investigation for bauxite in SW of Nongstoin area, West Khasi Hills was carried out with LSM of an area of 50 sq km on 1:12500 scale. The investigation identified potential areas of laterite

and lateritic bauxite deposit. Lateritic bauxite capping occurs over garnetiferous sillimanite gneiss and sillimanite gneiss. Extensive bauxitisation occurs in sillimanite gneiss and the rock has become white having friable nature. Limonitization and clay pockets are also observed within the lateritic profiles.  $Al_2O_3$  varies from 51.43% to 30.10% (average 36.20%), maximum being over the sillimanite gneiss. Ga content varies from 41 ppm to 93 ppm (average 58 ppm, background value 15 ppm), which indicates potentiality of this strategic metal in lateritic bauxite capping

## State Directorates

During 2015-16, Directorate of Geology & Mining, Chhattisgarh carried out exploration for bauxite in Salgi area, Kabirdham district (Mapping on 1:50000 and 1:4000 scales in 412 & 1.030 sq km areas, respectively; Pitting : 80.40 M<sup>3</sup> in 8 pits; 1055.80m drilling in 104 boreholes; 739 sample analysis and estimation of about 371.98 thousand tonnes of bauxite in inferred category); in Daldali area Kabirdham district (Pitting: 20 m<sup>3</sup> in 2 pits; 280.20m drilling in 31 boreholes; 562 samples analysis and estimated 19.98 thousand tonnes of bauxite under indicated category and 78.01 thousand tonnes of bauxite under inferred category); in Dandkesra area, Surguja district (mapping on 1:50,000 & 1:4000 scales in 100 sq km & 2.54 sq km areas; pitting : 110 m<sup>3</sup> in 7 pits; 1530.60m drilling in 153 boreholes; 1324 samples analysis and estimated about 1.0 mt of bauxite under inferred category)

Directorate of Geology and Mining, Maharashtra carried out 40 sq km area on 1:25000 scale and analysed 50 samples for bauxite/aluminous laterite in Guhagar area, Ratnagiri district.

## GMDC

During 2015-16, GMDC carried out 1838 m exploratory drilling involving 151 boreholes in five mines i.e. Ratadia (544 m in 38 boreholes), Goniasar (330 m in 26 boreholes), Wandh-1 (316 m in 34 boreholes), Balachod (610 m in 50 boreholes) and Naredi (38 m in 3 boreholes) in Kachchh district, Gujarat.

## FERROUS MINERALS

### CHROMITE

#### GSI

In Nagaland, a G4 stage investigation for chromium and associated base metals was taken up during 2015-16 in the 'ophiolite belt' in and around Waziho, Ziphu, village in Phek district. An area of 50 sq km was covered by LSM (G4). No surface indication of presence of chromite and associated sulphide

mineralisation was recorded in mapped area. Chromite pods varying in size from 10-30 cm are scattered along the slope of peridotite in the WNW of Washelo. Limonitisation and ferruginisation containing occasional specks of pyrite hosted within basalt was observed along the Shillion Phokhungri road section.

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

During 2015-16, OMC carried out exploration for chromite in two mining leases and exploration activities include - In Jajpur district : (i) South-Kaliapani: mapping on 1:1000/1:2,000 scale in 17 ha and 109ha, respectively, chemical analysis of 224 nos of samples and 289 m drilling in six boreholes including one running boreholes and (ii) Sukrangi: mapping on 1:1000 scale in 35 ha, 249 nos sampling and 396 m drilling in seven completed and one running boreholes.

#### **IRON ORE**

##### **GSI**

In Chhattisgarh, a G-4 stage preliminary investigation was carried out in Ranidhara-Magarkund area, district Kabirdham, to delineate iron ore occurrence in the southern strike continuity of the discontinuously exposed 9.7 km long iron band in Bhalapuri-Eklam Chelikama block of M/s CMDC Ltd. Raipur. An area of 100 sq km was mapped on 1:12500 scale between Magarkund and Jhandi. During investigation, 20 petrological samples, 10 ore microscopy samples and 40 bed rock samples were collected for study. Iron ore in the area is associated with N-S to NNE-SSW trending rocks of Chilpi Group. Iron ore is steel grey to reddish brown with cherry red streak. Study of polished samples reveals that the principal ore mineral is haematite with subordinate specularite, goethite and rarely magnetite. Iron ore band is thin (maximum thickness 3 m) and out crop width is not appreciable (mostly under 10 m). Strike length of the band is not significant (average 100m, maximum -160m). Average grade of iron ore is 55.88% Fe (N=15) for samples analysing greater than 45% Fe content and 35.46% Fe(N=4) for samples analysing Fe content between 30 to 45%. The part of the area lies within protected and reserved forest.

In Madhya Pradesh, a G-4 stage investigation was carried in Sihora, Gosalpur area in distt. Jabalpur. An area of 100 sq km on 1:25000 scale was mapped around Sihora-Kurro-Gughara-Dhanwahi-Mangeli and 150 bed rock, 50 pit-trench and 10 petrochemical samples were collected for analysis. Besides, detailed mapping on 1:5000 scale was also carried out in the block near Kurro village. Various rocks like phyllite, banded jasper quartzite, banded

quartzite/brecciated quartzite/cherty quartzite, banded haematite quartzite with manganese at places, quartz veins, lateritic capping were mapped in the area. Three types of mineralisation i.e. iron ore in the form of banded haematite quartzite manganese as a secondary residual deposit and laterite as detached and isolated patches. Iron ore of primary origin reported as Banded Haematite Quartzite in reniform (Kidney) shape is located 1.5 km ESE of Marhai village; whereas, near Mansakra and Silaundi area as secondary deposit in brecciated and quartzite and banded jasper quartzite. Manganese ore is closely associated with banded iron formation (BIF). Detached patches of lateritic outcrops of yellow to brick red in colour and at places mixed with clay were also reported in the area.  $Fe_2O_3$  values of 25 BIQ, 02 BHQ and 14 laterite samples varies from 12.37 to 80.3%, 70.58% to 82.04% and 13.18% to 61.11% respectively. Two samples suspected manganese mineralisation were collected from brecciated zone (near Toala village) showed Mn values between 46% and 46.89%. Three blocks namely PB-1, PB-2 and PB-3 were identified for further exploration. A G-4 stage regional assessment of low grade iron ore was carried out in Mahakoshal belt, Jabalpur, Katni, Rewa, Sidhi, Shahdol and Singroli districts. During traverse mapping 1000 sq km area on 1:25000 scale was covered and different litho units meta basics, BIF/BHQ/BJQ, arkosic quartzite, Phyllite, dolomite, intraformational conglomerate, basic schist and orthoquartzite were identified. 450 BRS, 10 PCS and 50 PS were collected for study. Prominent bands of BIF/BHQ analysed  $Fe_2O_3$  content from 25% to 70%. Average thickness of BIF/BHQ bands ranges from 10 to 50m and haematite band ranges from 2mm to 5 cm. Iron is present in the form of haematite and goethite ores. Manganese containing BHQ bands were also reported. Besides, sulphides in the form of pyrite, chalcopyrite, bornite and malachite stains were noticed in the study area. A G-3 stage preliminary investigation was carried out in Morar subgroup of Gwalior Group of rocks in Motijhil-Akbarpur and surrounding areas in parts of Gwalior distt. An area of 1 sq km on 1:2000 scale was mapped in Akbarpur-Motijhil block. Birauli formation overlies basic sill and consist of ferruginous shale, banded iron jasper and chert. In western side of block, 2 to 5m thick succession of cherty limestone is present on the Birauli formation. Seven scout boreholes were drilled at 400m interval. Five boreholes (GA-1, GA-2, GA-5, GA-6 & GA-7) in Akbarpur area and two boreholes (PB-1 and PB-2) in Motijhil area were drilled for a cumulative depth of 200.30 m. Depth of boreholes in Akbarpur area varies from 13.25m to 35.25m and in Motijhil area it is 44.35 m and 20.25 m. Iron (Fe) content in BH No. GA-5 is 23.88% (Min.

14.3 to Max. 32.6%) in GA-6 it is 28.82% (Min 20.6 to max 36.2%) and in GA-7 it is 28.70% (Min 17.5 to max 51.8%). Apart from iron ore mineralisation there is thick band of limestone which is interbedded with thin chert and iron bands. Limestone was intersected in borehole no. GA-1, GA-2 and PB-1.

In Arunachal Pradesh, a G4 stage investigation for iron and associated sulphide mineralisation was carried out in Meta sedimentary sequences of Bomdila group in West Siang and Upper Subhanshri district. LSM was done over an area of 81 sq km. Three sulphide mineralised zone was delineated at Gadimendi and Tode. Two iron formation associated sulphide mineralised bands were also delineated at Karte and Baririjo area. Iron formation with associated sulphide mineralisation at Karte shows an average of 24.87% Fe and 71.15 ppm Cu from channel and trench samples. Channel samples from pyrite bearing talc-tremolite schist yielded an average 32.25 ppm Cu and 6.09% Fe. Channel samples from magnetite bearing chlorite-biotite-quartz schist at Lama Deke yielded average value of 9.31% Fe and 72.90 ppm Cu. Trench samples from Takam in the haematite goethite quartz band yielded average value of 6.61% Fe and 33.875 ppm Cu while samples from iron formation at Baririjo yielded average value of 28.18% Fe, 367.6ppm Cu, 74.4 ppm Pb and 123.8 ppm Zn.

In Telangana, a G-2 stage investigation for iron ore in Bayyaram area, Khammam and Warangal districts was taken up (as an MOU bound collaborative project between GSI and DMG, Telangana) with an objective to established the grade of ore body and assess the resources. An area of 100 sq km was mapped between Bayyaram Cheruvu to Motla Timmapuram on 1: 12500 scale including mapping of eight blocks with cumulative area of 4.54 Sq Km on 1: 2000 scale. A total of 1168.6 m of drilling was done (17 boreholes) and 430 core samples, 262 BRS, 67 PS, 111 PCS and 47 ORM were collected. The NNW-SSE-trending hills in the Bayyaram-Motla-Timmapuram tract hosts iron ore mostly as capping on hillocks. The mineralisation is stratabound and imostly haematite with specks of magnetite. The iron ore sandwiched between quartzite east of Irsalpuram is highly variable in Fe-content along its strike and dip. The core samples from 18.5 m to 47 m, totaling 20 samples at an interval of 1 m to 2 m analysed high Th values ranging from 43 ppm to 1992 ppm and  $\Sigma$ REE values from 239 to 8395 ppm while  $\Sigma$ HREE is 47 ppm to 286 ppm. La, Ce, Pr and Nd are the dominant REEs in the samples. The samples are also high in Zr ranging from 115 ppm to 2183 ppm. However, low U content (1 ppm to 31 ppm) is recorded. As a part of G4

stage investigation of Iron ore in the south of Manthani village, Karimnagar district, LSM of 197 sq km area on 1:12500 scale and 150 bed rock samples, 50 PT samples, 20 PS samples, 5 PCS samples and 20 samples were carried out. Two iron-enriched zones-south of Manthani and Shanthinagar were delineated. Near south of Manthani ferruginous/laterite capping of dimension of 1x 0.5 km (approx.) with an average thickness of 1 m is developed over ferruginous shale. The Shantinagar iron-enriched zone contains haematite and goethite nodules in reddish iron-rich soil which is flanked on either side by ridges capped by ferruginous sandstone. This Fe-rich zone has an approximate dimension of 0.75 x 0.3 km (approx) with thickness of about 1 m. Chemical analyses of 150 samples show that  $Fe_2O_3$  ranges from 0.74 wt% to 91.88 wt% and the calculated Fe varies from 0.51% to 64.25%. The higher Fe values are from the float iron ore present within laterite. Apart from iron ore, dolomite is extensively developed over the entire area. CaO content of the samples varies from 24.78 to 51.26 wt% and  $SiO_2$  varies from 6.12 to 11.01 wt%. This is very near to SMS-grade limestone.

In Odisha, a G-3 stage exploration was carried in Kalamang west block (northern part), Sundargarh district to search for iron ore. A total of 20 boreholes viz. SKN-1 to SKN-20 at grid interval of 200 m x 200 m were drilled for cumulative meterage of 2043.85m. Borehole SKN-1 to SKN -11 have intersected powdery and laminated iron ore with considerable cumulative thickness of 74.0 m, 67.05 m, 43.0 m, 41.0 m, 44.60 m, 92.10 m, 55.0 m, 48.70 m, 67.40 m, 107.60 m and 67.70 m. Borehole SKN -14 to SKN -19 have intersected cumulative iron ore zone of 123.30 m, 22.20 m, 13.30 m, 54.95 m, 57.35 m and 53.70 m respectively. A total 62.97 million tonnes iron ore has been assessed at >55% Fe and 11.90 million tonnes at Fe(T) is ~45% - 55%. Further an additional G2 stage exploration was carried out in the area. The boreholes were drilled at 100 m x 100 m grid interval and area mapped on 1:2000 scale. The boreholes intersected medium to high grade powdery, soft laminated, hard laminated, blue dust iron ore. Boreholes OSKIN -1 to OSKIN 4 intersected cumulative iron ore zone (including low grade ore) of 87.10 m, 82.25 m, 76.25 m and 59.9 m respectively. Bore holes OSKIN-5, OSKIN-7, OSKIN-8 and OSKIN-9 have intersected medium to high grade ore body with considerable cumulative thickness of 18.85 m, nil, 12.0 m and 6.5 m respectively. During G3 stage investigation in Ghorhaburhani south block, Sundargarh district, fifteen boreholes at a grid interval of 200m x 200m were drilled for a cumulative depth/meterage of 1556.65m. Depth of vertical boreholes varies from 80m

to 127m. The cumulative thickness of ore zone intersected in borehole SGS-12 is 77.00m, SGS-13 is 90m, SGS-20 is 55m, SGS-21 is 75m, SGS-23 is 37m, SGS-24 is 59m, SGS-25 is 77m, SGS-26 is 46m. In Mendhamaruni block (G2), Sundargarh district, ten boreholes were drilled at 100 m x 100 m grid interval with total meterage of 1937.10 m. The boreholes depth varies from 113 m to 181 m and the cumulative thickness encountered in boreholes varied from 55 m to 167.95 m with average Fe(Total) value between 47.69% -64.77%. During G-3 stage exploration of Mendhamaruni west block, Sundargarh district, an area of 0.34 km<sup>2</sup> was mapped on 1:2000 scale and 4 boreholes were drilled at 200 m x 200 m grid pattern for total depth of 511.4 m. The main lithounits intersected in boreholes were hard laminated ore(HLO), soft laminated SLO) and powdery iron ore, ferruginous shale, banded hematite chert. The cumulative thickness of ore zone intersected in boreholes varies from 35m to 40m with maximum Fe(Total) value from 42.51% to 44.04% .

### State Directorates

During 2015-16, DMG, Jharkhand carried out exploration for iron ore in the areas near Karampada and Kiriburu (Bhangaon), West Singhbhum distt. 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 sq km 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, collected 28 nos samples and analysis have shown Fe content between 47-55 percent. Occurrences of manganese ore are also located in this area.

DMG, Rajastjan carried out exploration for iron ore, red/yellow ochre, and other economic minerals near villages Shyampura, Mejorh, Raipura, Ramjikaguada, Balwas, etc, tehsil Thanagazi, Alwar district. Exploration activities include - (i) geological mapping on 1:50000/1:10000 /1:4000 scale in 100 sq km, 10 sq km and 1 sq km area, respectively ii) sampling - 42 nos. The iron ore mainly haematite in nature, dark brown in colour and fine grained.

### MECL & NMDC

The details of exploration for iron ore carried out by MECL and NMDC during 2015-16 are given in Table -5.

## MANGANESE ORE GSI

During 2015-16, in Odisha, a G4 stage investigation of Manganese was carried out in Bhagwanpur-Santipur block and in Tentalapani block in the eastern part of the Eastern Ghats Granulite Belt covering part of Angul district. Manganese ore bodies within Khondalite group of rocks shows a general trend of WNW-ESE dipping towards NNE. The ore body is hard, compact and fragmented in nature. Manganese minerals found in ore are mostly pyrolusite and psilomelane. The width of ore body varies from 0.5 m to 3 m. Four discontinuous manganese ore bands are exposed on ground and in trenches. Their width varies from 0.5 m to 3 m and their strike continuity has been established approximately as 8 m, 10 m, 15 m and 30 m, respectively. Chemical analysis of 20 trench samples shows that manganese and phosphorous concentrations vary from 5.81% to 23.11% and 0.28% to 3.23% respectively. A G-3 stage investigation was carried out in Gudighat-Barbandha area in western part of the Eastern Ghats Granulite Belt covering part of Bolangir district. The ore body is exposed on isolated mounds at an elevation of 260-270 m and traced discontinuously over 1 km with an average of 10 m around west and east of village Babejuri .The ore is frequently silicified and locally graphite occurrence is also reported. Manganese minerals found in ore are mostly pyrolusite and psilomelane. Another band has also been observed in Balikhamar area having 100 m strike length with an average width of 5 m. Chemical analysis of 15 trench samples has been received in which manganese and phosphorous concentrations vary from 3.05 to 21.90% and 0.25 to 0.72%, respectively.

### MOIL

During 2015-16, MOIL carried out 1,932 m exploratory drilling involving 13 boreholes in six mines: two mines Dongri Buxurg & Chilka mines situated in Bhandara distt and four mines situated in Gumgaon, Kandri, Mansar, Beldongri including Old Satuk and New Satuk in Nagpur distt, Maharashtra. The reported reserves / resources of manganese ore as on 01.04.2016 were in Gumgaon (5.76 million tonnes), Kandri (8.38 million tonnes), Mansar (5.74 million tonnes), Chikla (4.55 million tonnes), Dongri-Buzurg (11.12 million tonnes), Beldongri including old & new satuk (0.8 million tonnes).



## STRATEGIC METALS TUNGSTEN GSI

In Andhra Pradesh, a G-3 stage of investigation was carried in Chinagalikonda-Potaram in Rampachodavaram taluka, east Godavari district with an objective to delineate mineralised zones for tungsten and graphite in eastern ghats supergroup. The investigation was taken up based on the recommendation of previous field work. An area of 1.55 sq km on 1:2000 scale was mapped with drilling of seven bore holes (6 first level borehole and one second level borehole) for commulative length of 1143.35m. Pitting and trenching (85 m<sup>3</sup>) has been carried out and 43 pit/trench samples, 103 BRS, 108 core samples, 15 PS, 15 ORM, 19 PCS and 5 EPMA samples have been collected. Generally, the Chinnagalikonda area exposes predominantly khondalite group of rocks and quartzo-feldspathic rocks as minor amount. Old working of graphite in the area have an average length of about 20-30 m and width of 3-5m. Graphite in the area is fine grained, amorphous and flaky in nature and mainly occurs in the form of thin stringers, veins, pockets/lenses in graphite schist/gneiss and khondalite. Out of 7 boreholes drilled in the study area, six boreholes intersected the mineralisation at 1<sup>st</sup> level (60m vertical depth) and one borehole intersected the mineralisation at 2<sup>nd</sup> level. (120m vertical depth). Drilling has established graphite zone continuity for a strike length of 470 m with an average width of 2.5m with approximately fixed carbon content of about 10%. Fixed carbon values of core samples and bedrock samples ranges from 0.07 to 35.83%.

Assam, a G-4 stage investigation was taken up in 2015-16 for search of W, Sn & REE in the Kumarkuchi and Chagaligaon, Kamrup district. LSM of 50 sq km and detailed mapping of 2 sq km was completed. Analytical results show that the porphyritic granite is rich in total REE as compared to other Unit. The REE in porphyritic granite is varies from 114.97 ppm to 1672.45 ppm with average ÓREE 1005.60 ppm. The average ÓLREE in porphyritic granite is 901.54 ppm with minimum 369.70 ppm to maximum 1531.91 ppm, whereas ÓHREE varies between 277.31 and 42.37 ppm. The average concentration of tin in porphyritic granite is 3.46 ppm which varies from a maximum of 5.53 ppm to a minimum of 2.22 ppm. The tungsten value in most of the samples is less than 0.5 ppm and maximum value observed is 2.22 ppm. In another area in the Chakrasila, Nandangiri and Bhumeswar in Bongaigaon, Dhubri district a G-4 stage investigation was carried for search of W, Sn & REE by LSM & DM of 50 sq km and 2 sq

km, respectively. Analytical results revealed that the highest value (998.329 ppm) of ÓREE in quartzo-feldspathic gneiss and lowest value (31.42 ppm) in pegmatite. Quartzo-feldspathic gneiss yielded average ÓREE value of 998.329 ppm with maximum and minimum value of 258.359 and 74.11 ppm, respectively. Mica Schist yielded average ÓREE value of 974.133 ppm with maximum and minimum values of 974.133 and 254.99 ppm respectively. Pegmatite yielded average ÓREE value 133.48 ppm with maximum and minimum values of 303.829 and 31.42 ppm, respectively. The maximum and minimum concentration of tin are 11 ppm and 1 ppm reported from quartzo feldspathic gneiss and mica schist, respectively. In pegmatite average tin value is 2 ppm. The maximum tungsten value of 74 ppm has been reported from amphibolites. The geochemical concentrations of trace elements viz Rb and Y vary between 229 & 15414 ppm and 10 & 943 ppm, respectively in lepiololite bearing pegmatite exposed at hill top in NNW of Chakrasila village. From EPMA study various REE bearing minerals or carrier phases i.e. xenotime, monazite, uranothorite (?), Ta-Nb phase, zircon, apatite and sphene have been identified in the rocks with very low occurrences.

In Maharashtra a G-4 stage investigation was taken up Lawari-Amboli area, Chandrapur district with an objective to identify the zones of tungsten and associated mineralisation. The investigation involves 3 sq km detailed mapping on scale 1:5000, pitting & trenching (26 m<sup>3</sup>) and collection of bed rock samples (50), petrological samples (15) and samples for SEM-EDX, XRD, OM and EMPA studies. Geologically, the area represents the basement gneiss i.e Bengal Gneissic complex, quartz-tourmaline vein, pegmatite, etc, Beryl crystals and some peacock coloured staining are observed in the pegmatite vein near village Chichola. Some mafic enclaves of amphibolites are observed within the gneissic rock near village Amboli. Scheelite is observed in quartz tourmaline vein under UV lamp in SW of village Amboli. All the litho units in the area are mapped on 1:5000 scale. Bed rock samples and pitting & trenching samples of quartz-tourmaline veins in SE of village Amboli were studied. Towards the SW and south of village Amboli, a pit trench is made to know the depth persistence of the quartz tourmaline vein. Towards SE of village Amboli bedrock samples of quartz-tourmaline vein gives W value of 339 ppm. The highest value of W recorded is 530 ppm from BRS of quartz. Pitting and trenching samples from quartz tourmaline vein of the village Amboli gives maximum W value of 322 ppm. Towards SW of village Amboli scout drilling of 124 m is carried out. From 64.80 m to 73.40 m compact quartz-chlorite mica schist having little tourmaline is also observed. In this zone scheelite is

encountered under UV lamp. From 107.10 to 11.320 m compact quartz- mica schist having tourmaline is observed. In this zone along boundary of quartz crystal scheelite is observed under UV lamp. Borehole analytical data are awaited. A G-4 stage investigation in Navgram area, Gadchiroli district was carried out to ascertain tungsten and associated mineralisation. 50 Sq Km area delineated for large scale mapping reveals that Bengal group of gneiss is the basement that covers major part of the study area. In LSM block, two major mineralised quartz reefs are observed along shear zone within the basement gneiss near Navgram (Sitabai Dongri) and Karakapalli (Sigamodi Dongri) area. The Sitabai Dongri quartz reef is about 4.0 km in length and width varies from 5m to 25 m. The quartz reef (Sitabai Dongri) is silicified, ferruginised, fractured and breccated. Sulphide mineralisation is noticed in the form of specks and dissemination of a galena, chalcopyrite, sphalerite and bornite. Another lensoid type of quartz reef (Singamodi Dongri) is mapped near Karakapalli area for about 300 m strike length and 15-22 m width and tapering on either side. The quartz reef (Singamodi Dongri) shows intense ferruginisation, silicification, moderately gossanised and mineralisation with presence of galena specks. Chemical analysis of 6 BRS samples from quartz reef shows values of W varying from 154 to 604 ppm, 3 BRS samples depict values of Zn varying from 700 to 800 ppm and 11 BRS samples depict value of Zn varying from 300 to 590 ppm. Three BRS samples from quartz reef illustrate value of Cu ranging from 0.11 to 0.15% and eight BRS and PTS samples show value of copper ranging from 129 to 885 ppm. Four channel samples indicate value of Au ranging from 150 to 240 ppb.

#### MECL

During 2015-16, MECL carried out exploration for tungsten in Kuhi sub block (Zone-I) by involving drilling 1343.70 m in 7 boreholes; mapping 0.55 sq km on 1:1000 scale; 03 trenching admeasuring 8.0 x 1.20 x 1.30; 8 x 1.20 x 1.35 and 29.0 x 1.05 x 1.25, sampling & analysis-754 nos primary + 75 nos check samples for analysis on W and 75 nos for Cr, Nb, V, Sn, Mo & Ta and 41 nos composite samples each for W, Nb, V, Sn, Mo and Ta. Analysis of 30 nos composite samples for XRD studies, 36 nos composite samples for spectroscopy studies were carried out. Also 40 nos samples each for petrographic and mineralogical studies was carried out. Besides 63.50 m<sup>3</sup>-trenching, 91 nos primary samples, 12 nos.-check trench samples were analysed. 'Indicated' resources estimated at 2.102 mt of 1.160% WO<sub>3</sub>. Out of this, measured resources are placed at 0.931 mt with 0.158% WO<sub>3</sub>. The resources estimated by MECL include the resources earlier estimated by GSI.

## TITANIUM AND VANADIUM

### GSI

During 2015-16, a G-3 stage investigation was initiated to assess Ti, V, Ga and REE potentiality in the bauxite around Batuatoli block of Netarhat plateau, Latehar district, Jharkhand. Detailed mapping of 5 sq km area was carried out on 1:5000 scale. A total seven boreholes were drilled for cumulative length of 500.65 m. Subsurface data indicate the cumulative thickness of mineralised zone of bauxite varies from 26.80 m (NBBH-4) to 46.35m (SRBH-7) between the depth range of 1.10 m and 46.35m. Analytical results of core samples from two boreholes are: TiO<sub>2</sub>(0.47-8.55%), V<sub>2</sub>O<sub>5</sub>(0.001-0.064%), Ga(10-80 ppm), SiO<sub>2</sub>(6.56-71.74%), Al<sub>2</sub>O<sub>3</sub>(8.77-47.10%). Considering cut off grade of Al<sub>2</sub>O<sub>3</sub> at ≥ 30% and SiO<sub>2</sub> at ≤ 10% two bands of bauxite in NBBH-1 (1.50m and 1.05m) and NBBH-2(0.65m and 1.10m) are proved. During G-4 stage investigation of titaniferous vanadiferous magnetite around Myniar area, west Khasi hills district, Meghalaya, an area of 51 sq km were covered by large scale mapping. Three main types of rocks observed in the area are granitic gneisses, porphyritic granite, norite, metanorite and granite. Out of the total six magnetite bodies of different dimension delineated by LSM(1:12,500), five were developed over granite gneiss and one over porphyritic granite. First body is about 100m x70m with average Fe<sub>2</sub>O<sub>3</sub>-67.83%, TiO<sub>2</sub>-15.21%, V-6101.84 ppm, Cr-11093.8 ppm. Second magnetite body is about 80m x 50m with average Fe<sub>2</sub>O<sub>3</sub>-65.76%, TiO<sub>2</sub>-17.03%, V-6902.5 ppm, Cr-6947.25 ppm. Third magnetite body is about 15m x 12 m with average Fe<sub>2</sub>O<sub>3</sub>-65.41%, TiO<sub>2</sub>-15.23%, V-5848 ppm, Cr-9974 ppm. Fourth magnetite body is about 8m x11m with average Fe<sub>2</sub>O<sub>3</sub>-64.70%, TiO<sub>2</sub>-16.80%, V-6794.2 ppm, Cr-6440 ppm. Fifth magnetite body is about 7m x 8 m with average Fe<sub>2</sub>O<sub>3</sub>-65.53%, TiO<sub>2</sub>-17.46%, Cr-5417 ppm and Sixth magnetite body is about 350m x200m with average Fe<sub>2</sub>O<sub>3</sub>- 65.06%, TiO<sub>2</sub>-15.54%, V - 6484 ppm Cr -7479 ppm.

### NICKEL

#### GSI

During 2015-16, In Rajasthan a G-4 stage preliminary investigation was taken up in Mangliawas Makrera – Rajgarh Lachhipura Hatundi area in parts of Ajmer district for search of Ni and associated PGE mineralisation. An area of 100 sq km was covered by LSM(1:12500 scale). The ultramafic rocks of the area belong to Phulad ophiolite suite and occur within mica schist of Ajabgarh group. The ultramafites are highly altered and occurs as chain of bodies comprising mainly serpentinite with patches of chlorite schist and actinolite tremolite schist. The serpentinites are mainly massive, fine grained greenish with pitted appearance. Criss cross veins of magnesite are also reported. Out of the

total 106 BRS and 25 petrochemical samples, analytical results of 30 BRS were received; of which 14 samples show Ni value ranging from 541 ppm to 0.18% and Cr value ranging from 130 ppm to 0.21%. Analytical results of PGE are awaited. During G-4 stage investigation of Ni and associated PGE mineralisation in Rikhabdev ultramafic rocks, Udaipur district, Rajasthan, an area of 100 sq km was mapped on 1:12500 scale. A total 100 BRS and 25 streams samples were collected. The main lithounits observed are phyllite, quartzite, dolomite and ultramafic rocks. The ultramafic rocks are highly altered and comprise predominantly of serpentinites. These occurs as large irregular lensoid bodies (Kherwara-Dhelana area) and lenticular bands of more than 5 km long. A major part of the large serpentinite body extending through Rikhabdev and Masaron-Ki-Obri was covered during investigation. A total 169 samples were collected for PGE, Ni and Cr analysis. Analytical results indicate that Ni values range from 500 ppm to 0.22% and Cr values range from 450 ppm to 0.44% in serpentinite. The analysis of PGE is awaited

## **TIN**

### **GSI**

During 2015-16, in Haryana, a G-2 stage exploration of multi-metal deposit in north of Tosham Hill, district Bhiwani was carried out. Cassiterite is the main tin ore mineral along with other ore minerals of copper and tungsten. The mineralisation is hosted by altered metamorphites of Delhi super group and post Delhi intrusive i.e. rhyolite and granitoid of the Tosham hill. Mineralisation reported as thin veins and disseminations along the shears/fractures /foliation planes in metasediments and at or near granite/metasediment and granite/rhyolite contact. Microscopic study shows presence of pyrite, pyrrhotite and chalcopyrite in quartz-mica schist. Analytical results of 124 core samples indicate 11 ppm tin, 3.7 - ppm 200 ppm tungsten and 16 ppm - 433 ppm copper.

## **COBALT**

### **GSI**

During 2015-16 an area of 102 sq km was mapped on 1:12500 scale under G-4 stage of re-appraisal of cobalt incidences in southern part of North Khetri fold belt in Babai area, Jhunjhunu district, Rajasthan. Arkosic quartzite of Alwar group is exposed in Gadrata, Ghatitola and Kalota. Ajabgarh group is pelitic and consists of basal andalusite schist with bands of carbon phyllite and marble. Most of the old working and mineralised zones are confined to the interbands of carbon phyllite. There are many zones of carbon phyllite within the amphibolites. Calc silicate is fine to medium grained, grayish white to dark grey and has fine

dissemination of sulphides. Near Surari silicified schist, numerous old workings showing encrustations of malachite and azurite was seen. Albitite, the monomineralic rock is well developed east of Babai. Granite is exposed in Babai-Karmari section. It has sharp contact with phyllite/schist south of village Karmari. The surface evidences of cobalt mineralisation in the area consist of occasional bright pink leaching after erythrite ( $\text{Co}_3\text{As}_2\text{O}_8 \cdot 8\text{H}_2\text{O}$ ) known as 'Cobalt Bloom' associated with malachite and azurite encrustations in the mine debris mostly occurring within carbon phyllite. A total of 376 BRS samples, 100 pit trench samples and 60 channel samples were collected. Analytical results of 45 samples collected from quartzite, phyllite, amphibolites and carbon phyllite in Babai-Kalota area indicate Cu value ranging from 10 ppm to 0.28% and Co value ranging from 15 ppm to 800 ppm. Analytical results of 5 mine dump sulphide samples from Akwali area indicate Cu values ranging from 0.26% to 8.6%, Co values ranging from 40 ppm to 0.7%, Zn values ranging from 85 ppm to 0.81% and Ni values ranging from 50 ppm to 750 ppm. The average Co value is 0.16%. Analytical results of 68 samples from gossanised silicified quartzite/phyllite in Surari area indicate Cu values ranging from 20 ppm to 2% with an average of 0.39% and Co values ranging from 15 ppm to 950 ppm with an average 222 ppm. Co value is significant in this zone too. Analytical results of 8 samples from silicified quartzite/phyllite and granite in Gadrata-Karmari area indicate Cu values ranging from 190 ppm to 2.4% and Co values ranging from 15 ppm to 220 ppm.

## **Rare Earth Elements (REE)**

### **GSI**

During 2015-16, In Andhra Pradesh, a G4 stage of preliminary investigation of REE and other rare metals was carried out in and around Chetlamallapuram, Kurnool district. An area has been explored by mapping 105 sq km on 1:12500 scale, pitting and trenching of 50 m<sup>3</sup>, 50 PTS, 101 BRS, 51 SSS, 19 PCS, 23 PS, 10 EPMA samples. The area exposes rocks of Gadwal schist belt of Archaean age and TTG (Tonalite-Trondhjemite and Granodiorite) and tourmaline-bearing leucogranite of MS (Monzogranite-Syenogranite) suite of Archaean to Paleoproterozoic age, Gulcheru Quartzite of Cuddapah Supergroup of Mesoproterozoic age. The Gadwal lithopackages are represented by agglomerate patches of meta-andesite and quartz ± chlorite ± sericite ± actinolite schist. Archean to Paleoproterozoic quartz reefs and pegmatites, Paleoproterozoic dolerite dykes are intrusive into Gadwal schist belts and younger granites. Two types of pegmatites are identified in the area: quartz-K-feldspar pegmatite (QKFP) bodies and quartz-albite pegmatite bodies. The QKFP is highly brecciated

and silicified with multiple injections of quartz, haematite, specular haematite and rare calcite and magnetite veins. It extends discontinuously up to 2 km, the width varies from 10-70 m. Profuse malachite stains, crosscutting malachite veins and botryoidal malachite grains and two old workings mined earlier for copper are reported in the pegmatite around Chetlamallapuram area. Sulphide ores like pyrite, chalcopyrite, covellite and bornite are seen to be associated with silica, ferruginous and quartzofeldspathic groundmass. Potassic alteration is the dominant type of hydrothermal alteration seen in this pegmatite besides silicification, sulphidation, ferruginisation and rare tourmalinisation. Another type of pegmatite is quartz-albite-bearing, associated with tourmaline-bearing leucogranite, agglomerate and quartz-chlorite-sericite schist units, noticed around Bastipadu, Ulindakonda and Bommireddipalli areas. These pegmatites occur as horizontal sheets within tourmaline bearing leucogranite, as parallel bodies trending NNW-SSE to NE-SW within agglomerate and as sub-horizontal linear bodies trending NW-SE within the quartz-chlorite-schist. Sodic, calcic, tourmalinisation, silicification and ferruginisation are the types of alteration noticed in the quartz-albite-bearing pegmatite. NE of Bommireddipalli, NW-SE-trending quartz  $\pm$  K-feldspar  $\pm$  iron oxide reef is seen extending over a strike length of approx. 2.5 km having width of 20-60 m is emplaced within the chlorite-schist unit. At places specular haematite, disseminated pyrite and chalcopyrite are seen within quartz reefs SW of Gokulapadu. Ore petrographic study indicates presence of sulphide ores like pyrite, chalcopyrite, covellite, digenite and the oxides of iron like haematite, specularite and magnetite. The mineral paragenesis is as follows: chalcopyrite-digenite-covellite-magnetite-haematite. Analytical results for the samples submitted are awaited. However, EPMA and SEM studies have indicated the presence of rare metal minerals having Nb and Ta. The rare metal-bearing phases identified are columbite and tantalite seen enclosed mostly within K-feldspar followed by Na-feldspar. At places, only Ta-bearing mineral phases are seen within the feldspar veins. Some REE (Eu, Nd)-bearing grains are also seen within the feldspars. The study area shows some IOCG-like features like regional scale potassic alteration, iron-oxide breccia zones, sodic-calcic-tourmaline alteration, iron oxide + copper + REEs mineralisation, etc.

In Bihar, a G4 stage preliminary investigation was carried out to locate REE & rare metals in Bihar Mica belt around Chandan area, parts of Jamui and districts Banka. The area of investigation forms the north-eastern part of the "Chhotanagpur Gneissic Complex" exposed at the southern margin of Bihar Mica Belt. Concentration of TREE (La-Lu) in various rock types of Sector-I is as follows: i) amphibole-bearing granite: 369-657 ppm (n = 07), ii) biotite-bearing granite: 370-408 ppm (n = 02), iii) medium grained leucocratic, aplitic

granite: 57-757 ppm (n = 16), iv) coarse-grained pegmatite: 06-516 ppm (n = 44), v) medium-grained pegmatite: 08-377 ppm (n = 36), vi) coarse- to medium-grained mixed variety of pegmatite: 32-315 ppm (n = 22), vii) laterites over different gneissic group of rocks 145 ppm to 2782 ppm (n = 8). In Sector-I, the ÖREE (La-Lu) concentration of 1<sup>st</sup> order stream slope wash materials varies from 69 to 31223 ppm and that of 2<sup>nd</sup> order stream slope wash materials varies from 136 to 7254 ppm (n = 18). The ÖREE (La-Lu) concentration of top soil varies from 291 to 797 ppm (n = 12), that of kankar horizon soil varies from 283 to 637 ppm (n = 11) and that of weathered bedrock soil is 64 ppm (n = 1). The ÖREE (La-Lu) concentration of pitting/trenching samples of the top, transported soil varies from 223 to 541 ppm (n = 29), that of kankar horizon soil varies from 205 to 1144 ppm (n = 36), and that of weathered bedrock horizon varies from 66 to 701 ppm (n = 56). Two blocks *i.e.* Heth Chandan block and Belhariya block have been identified for further detailed investigation.

In Chhattisgarh, a G-4 stage ground evaluation of geochemical anomalies of REE and associated mineralization in and around baloda Bazar Latwa and Rasera area, district Balodabazar was carried out. An area of 100 sq km was covered by large-scale mapping which revealed rocks of Gunderdehi and Chandi formations of Raipur Group of Chhattisgarh Supergroup and laterites. Gunderdehi shale is fissile and calcareous. Chandi limestone occupies major part of the mapped area. The limestones are both stromatolitic and non-stromatolitic. Stromatolites are mainly 'SH-C type'. Laterite/ lateritic soil appear to have formed due to weathering and leaching of limestone. Calcrete / calcareous concretions are seen over Gunderdehi shale. A total of 104 unit cell samples pertaining to the composite samples showing anomalous REE values were analysed. The REE data of 104 unit cell samples match with the corresponding composite sample data. The REE pattern is concave with negative Europium anomaly and high Y/Nb ratio indicating a crustal source for the sediments. Analytical data of 10 BRS have been received. Total REE of stromatolitic limestone varies from 41.46 ppm to 80.19 ppm and that in shale varies from 125.87 ppm to 231.47 ppm. Total REE of laterite is 549.04 ppm.

In Gujarat, G4 stage search for REE and other rare metals in Amba Carbonatite complex Kawant Taluka Chota Udaipur distt was carried out by large scale mapping of 13 sq km in Ambadungar-Saidiwasan area was carried out and 426 samples on 100 m  $\times$  100 m grid pattern were collected. Area comprises different varieties of carbonatite (sovite, brecciated carbonatite and intrusion of ferro-carbonatite/ankerite), carbonate sandstone, phonolite, syenite (nepheline syenite), volcanic tuffs, basalt, dolerite dyke and quartz veins. In Manka-Nakhal area south of Saidiwasan village brecciated carbonatite with sovite intrusion is present. Intrusion like nepheline syenite/syenite is observed

with NNW-SSE trend within phonolite. The emplacement of sovite plugs is conspicuous in the mapped area which shows magmatic layering. The association of magnetite crystals with octahedron geometry is observed within sovite and brecciated carbonatite near Manka-Kasarwaj and Ambadungar area. Field studies have helped to identify four phases of carbonatite *i.e.* Ferro carbonatite/ ankerite Calcio carbonatite/sovite Brecciated carbonatite and brecciated carbonatite. The Ambadungar Carbonatite Complex is traversed by number of prominent ferro-carbonatite/ankeritic veins, quartz veins and fluorite veins suspected for REE mineralisation. Carbonatites occurs along fractures in basalt and sandstone. The grid samples are mainly collected from different variants of carbonatite and syenite bodies for analysis of REE. The analytical results of the grid samples show encouraging values. Association of fluorite is observed at a number of places in the vicinity of carbonatite. Pyrochlore mineralisation is suspected with magnetite along the intrusion plane/contact plane of sovite and ankerite. The  $\Sigma$ REE in brecciated carbonatite ranges from 500 ppm (0.05 %) to 11000 ppm (1.1%).

In Haryana, REE investigation of fluorite associated with magnetite and quartz biotite schist was carried out in Antri Biharipur area, district Mahendragarh REE-bearing zones are delineated in quartz-biotite schist and magnetite quartzite of the Golwa-Gangutana Formation (or Kushalgarh Formation, Ajabagarh Group, Delhi Supergroup). REE-bearing fluorite occurs in magnetite quartzite and quartzbiotite schist as inter-banded lenses and disseminated patches. The REE mineralisation follows the contact between quartzbiotite schist and magnetite quartzite and continues up to 1 km length and 5 m width (occasionally up to 50 m width). A total of 30 samples show total REE content of 2000-4500 ppm. Calcareous schist and amphibole marble have very less concentration of REE. The analysed samples are rich in LREE (La content varies from 300 ppm to 1800 ppm). Ce content varies from 400 ppm to 2000 ppm. The samples show negative Eu anomaly varying from 0.15 ppm to 40.00 ppm.

In Jharkhand, an investigation of G4 stage for rare metals and REE was carried out in Chhotanagpur Gneissic Complex in Maheshpur-Kamta-Nawatoli-Jaratoli-Guridih area, Ranchi district. An area of 100 sq km was mapped on 1: 12500 scale. Seventy-nine bedrock samples, 28 petrological samples, 50 soil samples for heavy mineral studies have been collected. Granite gneiss of the CGGC forms the country rocks of the area with older enclaves of amphibolites and quartz-sericite-mica schist. The analytical results of 60 bedrock samples received so far show concentration of Li: <5-86 ppm (17 ppm) Ga: 13-29 ppm (19 ppm), Nb: <5-31 ppm (20 ppm), Rb: 15-286 ppm (78 ppm), Sc: <5-10 ppm (22 ppm), Y: 05-198 ppm (31 ppm) and Zr: 8-559 ppm (162 ppm). The values in the brackets show crustal abundance of

the elements. The total REE value of 13 bedrock samples received so far ranges from 69-1498 ppm. The mean value of total REE is 293.7 ppm which is higher than the mean total REE concentration of the upper continental crust (179 ppm). The total REE values of 40 soil samples range from 158 to 1428 ppm. Other results are still awaited. EPMA analysis of samples shows presence of REE-bearing phases such as allanite, monazite and xenotime. Other important mineral phases identified include sphene, apatite, zircon, magnetite, ilmenite, rutile, uraninite and thorite.

In Karnataka, a reconnaissance stage investigation was continued from 2014-15 for delineating the REE bearing zones around Wanadurg, district Gulbarga. The area around Wanadurg was explored by mapping 100 sq km on 1: 12500 scale followed by trenching, bedrock sample collection and stream sediment sample collection which led to the identification of geologically favourable area near Mallibavi. The area exposed younger granites (equivalent to Closepet Granite) intruding older rocks such as gneiss and migmatites. Both acidic and basic dykes (pegmatite, quartz vein, gabbro and dolerite) intruded into these rocks. Relicts of the greenstone are also exposed at few places. Migmatite is exposed as a relict mount as well as enclaves within granite. The area hosts dominantly stromatic type of migmatites along with few outcrops of agmatic types. Stromatic migmatite is exposed in the north and NW of Narasingampet, SSW of Waginagera and agmatic migmatite is exposed in the east of Ammapur. Composition-wise these are tonalitic having biotite, hornblende and calcic plagioclase dominantly. As another older unit of this area, pink granite gneiss is present and is exposed to south of Talawaragera. The composition of these gneisses is dominantly quartz, feldspar and biotite, hornblende. Besides, some garnet crystals are also present. The rock is sheared and trending  $315^{\circ}$ - $330^{\circ}/60^{\circ}$ -SW. Younger to these rocks a few small outcrops of greenstones are also present as enclaves within the younger granites. The younger intrusive granites in the study area mineralogically dominated by alkali feldspar, plagioclase, quartz and also biotite which corresponds to monzo-granitic to quartz monzonitic variety. A small outcrop of alkali feldspar syenite is exposed in the SW of Devaragonal reserved forest. A linear orbicular granite body having spheroidal concentric rings is exposed 1.5 km NW of Bammanahalli. Near the contact of the granitic bodies, magma mixing and mingling features are preserved. Other rock types are gabbro dyke, dolerite dyke and quartz vein. Besides, a prominent shear zone is also present SE of Mallibavi trending  $345^{\circ}/65^{\circ}$ -SW. Thickness of this zone varies from 20 to 30 m. In the detailed mapping block, the lower contour regions show shear zones and are mostly occupied by pegmatite veins and dolerite dykes while the areas at higher elevations consist mostly of monzogranite. There are several pegmatite veins of varying thickness (2-25 m).

Detailed mapping is carried out along with trenching and pitting across the trend of veins. Along with mapping, 61 bedrock samples and 50 stream sediment samples were collected from suitable locales. These samples along with 62 trench samples were sent to Chemical laboratory, Hyderabad for ICPMS analysis for REE. 24 bedrock samples for thin section (PS) and 14 bedrock samples (PCS) for petrochemical analysis were sent to NCEGR Division for analysis. A G-3 stage exploration of REE bearing zone in Mincheri block, Lingasugar taluka, Raichur was carried out with an objective to delineate REE mineralisation. The amphibolites rock of Gurgunta schist belt occur as enclaves within the Penninsular Gneussic complex. The rock types like pink biotite granite are present in the adjoining area. Younger intrusive like quartz vein and quartz brecciated reef trending N-S are seen occupying the fracture planes in the area. Dolerite dyke trending E-W. Investigation was planned with systematic drilling at 100 m interval to intersect the ore zone at a vertical depth of 60 m. The main host rock of REE is quartz vein. The quartz vein has 1.3 km strike length with pinch and swells characteristics occupying the N-S-trending lineament within PGC. Detailed petrography and EPMA study show the presence of minerals like yttrioflourite, gadolinite, britholite, cerianite, barite, allanite, monazite and bastnaesite. 10 boreholes have been drilled at an interval of 100 m with cumulative length of 967.50 m. Each borehole penetrated approximately up to 100 m. In each of the boreholes the quartz vein has been intersected with REE mineralisation. The width of the zone in general varies from 0.50 m to 8 m. The zone in contact with the quartz vein is coarse-grained potash feldspar-rich rock with sulphide-rich zones observed with mafic enclaves. Alteration in the form of epidotisation and shearing of the mafic units is common within the zone. A total of 202 core samples were collected. Detailed geological mapping on 1: 2000 scale was carried out to cover the quartz reef in Mincheri. The area was selected on the basis of ÓREE varying from 0.135%/5 m to 3.202%/5 m. In Mincheri, a 1.9-km-long and 25- to 30 m wide mylonitised silicified fault gauge was mapped. The Mincheri reef was found to be highly brecciated with quartz venation. The quartz brecciated reef shows multiple intrusion of quartz vein. Generally, it is observed that there are two modes; one is parallel to the fault and another is trending N10°E. Mylonitisation is common in the reef with mineralisation in the form of malachite stains, iron leaching. Detailed geological mapping of 0.5 sq km amphibolite enclave was also carried out in the western part of the quartz vein bearing REE mineralisation. The amphibolites trends N10°E-S10°W dipping 45° westerly. The systematic collection of bedrock samples at 25 m interval covering the quartz reef was carried out. Thirteen trenches were excavated to demarcate the boundary of the quartz reef within PGC. A total of 103 BRS and 86 PTS were collected to demarcate the potentiality of REE

in the quartz reef. Analytical results of 302 samples out of 390 are still awaited. Encouraging results of ÓREE are expected from the core samples.

In Maharashtra, an area of 1 sq km was covered by detailed mapping on 1: 2000 scale for investigation of REE & RM in Nagpur district. The main litho-type exposed in the area is Tirodi biotite gneiss (TBG), amphibolite, foliated granite, pegmatite and quartz vein ± epidote vein. TBG, the host rock, occurs in patches almost weathered into soil. Beryl column of 55 cm × 20 cm near downstream of Kharkhaliya Nala is the largest column so far observed. Most of the beryl mineralisation is in quartz core zone of the zoned pegmatites. Beryl found is of varying colours i.e. pink, light green, pale green and brownish yellow. A total of 100 BRS, 40 PS and 25 PTS samples have been collected. East of village Sumartola, a ridge dominantly made of quartzite trending E-W and dipping due north has been observed with an average dip of 72°. The quartz present here is been marked for wolframite mineralisation as indicated by rock colour, weathering colour and high density. The weathering colour is typically yellow. A typical black and greyish black colour with metallic lustre is marked within both light pink-coloured as well as greyish green-coloured quartz. The width of the body is approximately 45 m and length is around 3.5 km. A granite exposure trending E-W is also recorded which is rich in muscovite and quartz and is dipping due north. Twenty-three petrological samples collected from Dhargaon for microscopic study. The main litho type exposed in the east of Bandara village, SE of Chawari, NW of Navegaon Khurd and North of Ghuksi village are Tirodi biotite gneiss (TBG), amphibolites, quartzite interbanded with quartz-mica schist, marble, granite, foliated granite, pegmatites and quartz veins. The highest concentration of ÓREE 18.91% is found in the talus sample from east of Bandara village. Both LREE and HREE are higher in this SSS. In talus sample maximum concentration of ÓREE 16.8% is found 1.5 km east of village Bandara. 18 SSS yielded ÓREE 1%. The talus sample from east of Bandara has the highest concentrations of Nb and Ta i.e. 8145 ppm and 9439 ppm respectively. Besides, other important elements based on the analysis are: i) Be: Three samples sourced from beryl have Be varying from 36800 ppm to 43000 ppm. Two samples show values in between 250 and 500 ppm contributed by beryl and mica. ii) Rb content in five samples sourced from beryl and mica varies from 1400 to 2100 ppm. Six sample show values of Rb ranging from 600 to 1000 ppm contributed by mica, beryl and tourmaline. Eleven samples from pegmatite show values ranging from 400 to 550 ppm, contributed by mica, and beryl. iii) Nb content of four samples varies from 250 to 400 ppm contributed by tourmaline and beryl. iv) Cs content of three samples sourced from beryl varies from 760 to 1276 ppm. An investigation of G4 stage in Ghuksi Granite, Parseoni, Nagpur district, Maharashtra was

carried out for locating REE and RM mineralisation. Regional traverse was carried out around northwest of Nawegaon khurd, east of Bandra, north of Ghuksi, southeast of Chawari. The area is occupied by E-W- to ESE-WNW-trending basement gneissic complex and rocks of Sausar Group. The main litho-types exposed in the area are Tirodi biotite gneiss (TBG), amphibolites, quartzite interbanded with quartz-mica schist, marble, granite, foliated granite, pegmatites and quartz veins. The rock exposed due NE of village Dolamine is rich in alkali feldspar, clinopyroxenes (aegerine augite) and amphiboles (mostly hornblende) with very little or no quartz. Five BRS samples and seven PS samples were collected for chemical analysis. Large-scale mapping was carried out over 50 sq km area on 1: 12500 scale. Dolomitic marble is exposed as discontinuous outcrops towards east of village Dolamine. It is coarse grained and at places contains thin band of silicate minerals in alternation with dolomite bands. Biotite granite is of two types, one is medium grained and well foliated and the other is coarse to very coarse grained and massive to weakly foliated. It is chiefly composed of quartz, biotite and K-feldspar. The amphibole-rich granite is coarse grained and consists of quartz, K-feldspar, plagioclase, amphiboles and pyroxenes. This granite also contains pegmatite and quartz veins containing big crystals of amphiboles. Few pegmatite veins have been marked. The pegmatite located towards north of dolamine village is intruded along the contact of amphibolites and biotite granite. It is 250 m long and 25 to 30 m wide and chiefly composed of quartz, K-feldspar and plagioclase. The pegmatite (300 m long and 15 to 20 m wide) at north of Ghuksi is blocky in appearance and zoned with pockets of quartz. This pegmatite has intruded biotite granite along the S1-parallel fracture plane. It contains big crystals of blue-green coloured amazonite (up to 8 cm × 6 cm) associated with quartz and grains of magnetite dispersed throughout the pegmatite vein. REE-bearing mineral phases like monazite, xenotime, allanite and zircon have been recorded in petro-mineralogical studies. Analytical results of 18 bedrock samples (out of 44 BRS submitted) revealed that the highest concentration of ÓREE is 6180 ppm. This sample has been collected from the contact zone of biotite granite and AP granite located NE of Ghuksi village. In this sample the concentration of HREE (HREE = 5667 ppm) is more as compared to LREE. Amongst the rare metals the concentration of niobium and tungsten is more as compared to Li, Cs, Ta, Be, Sr, Rb, Sn. The highest concentration of Nb i.e. 523 ppm has been recorded in the samples collected from the contact zone of biotite granite and AP granite. In 10 samples of biotite granite the concentration of Nb has been recorded between 200 ppm and 500 ppm. Cs (768.93 ppm) is more concentrated in the biotite-rich zone of biotite granite located 1 km NE of Dolamine.

In Meghalaya, an area of 50 sq km on LSM was covered during G-4 stage investigation of REE in the area around Bhailymbong and area between Mynsynghat-Nartiang, Jaintia hills and Ri –Bhoi districts. Analytical results show REE enrichment in megacrystalline hornblende biotite and two mica leucogranite. The REE results are awaited. An area of 50 sq km has been covered by large-scale mapping. On the basis of available analytical results, REE enrichment is shown by megacrystic hornblende biotite as well as two-mica leucogranite. The REE results of the samples are awaited.

In Odisha, a G-4 stage preliminary investigation of REE was carried in the contact zone between Eastern ghat mobile belt and Singhbhum craton around Kankadakhhol in parts of Deogarh district. The area forms the northern part of “Eastern Ghats Granulite terrain” adjacent to Singhbhum Craton. The litho-assemblages of the mapped area include granulite, amphibolites, tremolite-actinolite schist, mica schist, micaceous quartzite, sillimanite quartzite, khondalite, migmatite gneiss, granite gneiss, porphyritic granite gneiss, syenite, nepheline syenite, pegmatite, quartz vein and laterite. Total 250 nos of samples were collected from bed rock, trenches, soil and stream sediments for chemical analysis. The result shows of RM (34 samples and XRF (38 samples) Li values range from <5-61 ppm# (# Nephelene Syenite of Kankarkhol), Cs : <10 ppm and Rb: 27-271 ppm\* (\*pegmatite vein, Salebhata), 8 nepheline syenite samples show Zr values ranging from 165-591 ppm, Nb: 21-90 ppm, Rb: 73-232 ppm & Y: 9-32 ppm. Presence of trace minerals like allanite, rutile, zircon, sphene, apatite, etc. were noted in petrographic study.

In Rajasthan, a G4 stage investigation was taken up in Gothara granite of Khetri Fold Belt, district Jhunjhunu. During the study, a total of 0.6 sq km detailed mapping on 1: 2000 scale has been completed in Rajota block. The main lithologies mapped are biotite schist, phyllite, quartzite, granite, metadolerite dykes, pegmatitic quartz and quartz veins. The schist is mainly of two varieties viz. biotite schist and quartz-sericite-biotite schist. The quartzite is mainly of two types viz. ferruginous quartzite and amphibole-magnetite bearing quartzite. In the southern part of the mapped area at the contact of quartzite and schist, quartz-pebble conglomerate is present. The Gothara Granite body is inhomogeneous and shows two variations viz. fine- to medium-grained granite and porphyritic granite. In the south eastern part, the granite is silicified in nature. Three amphibolite dykes have been mapped in Rajota area crosscutting the metasedimentary units. A number of later quartz veins are also present in the area. Two fault zones trending NE-SW evidenced by brecciation, silicification and carbonatization in the metasediments are also present. Old workings and indications of

sulphide mineralisation (malachite staining, limonitic and sulphide grains) are observed in quartzites and quartz veins. In Gothara Granite central block 9 vertical boreholes of 50 to 60 m length were drilled. The entire length of the boreholes is sampled. The analytical results of core samples are awaited.

In Uttarakhand, a G4 stage search for tungsten and associated REE and rare metals was carried out in Almora-Dudhatoli crystallines around Bhararisain area, district Chamoli. The area comprises litho-sequences of Almora Group and Garhwal Group in parts of the Lesser Himalayan sequence. The rocks of Almora Group comprise Gumalikhhet, Gorakhnath and Chaura formations in younging order. Rautgara Formation constitutes the Garhwal Group in the investigated area. Few monazite crystals have been observed under thin section of the granite samples of the area. The analytical results are not encouraging.

In Uttar Pradesh, a reconnaissance investigation of tungsten and REE was carried out in the Dudhi Granitoid Complex (DGC) around Muirpur-Mahuaria area, Sonbhadra district. The litho-units of the area include biotite granite gneiss, K-feldspar granite gneiss, K-feldspar granite, biotite granite, tourmaline granite, amphibolite, quartz-sericite-muscovite schist of the Dudhi Granitoid Complex. Biotite granite gneiss at Baliari, Nawatola and Laband occur as medium- to coarse-grained, hard, compact, foliated rock with porphyroblastic texture having augen-shaped porphyroblasts of feldspar. The analytical results of 44 samples, received so far from three trenches around Laband, Nawatola, Baliari and Aurahwa areas, show very high values of total REE ranging from 964 ppm to 4538 ppm. The highest value of 4538 ppm total REE has been recorded from pegmatite vein at Laband area. Columbite crystals have been observed in pegmatite vein.

## BEACH SAND/PLACER MINERALS GSI

During 2015-16, evaluation of heavy mineral resource potential was taken up near shore area off Poompuhar, Nagapattinam along with mapping of sea bed. The area from north of Koolaiyar to south of Karaikal has been divided into four sectors: (i) northern sector from Toduvaipattanacheri to Chavadikuppam villages (ii) top middle sector from Chavadikuppam to Chidambarapakkam villages, (iii) bottom-middle sector from Chidambarapakkam to Tarangambadi villages and (iv) southern sector from arangambadi to Pattanacheri villages. In sector-II, heavy mineral concentration could be observed more in the Chavadikuppam area. Near Poompuhar due to construction of groins coastal erosion could be

observed in the northern side of groins while accretion could be observed to its southern side. Sector-III is characterised by coarse garnet grain concentrations with relatively lesser heavy mineral concentration than sector-II. In sector-IV, 3- to 4-cm-thick consolidated crust with 51.99 HM wt % could be observed across three joint dunes extending over 3000 sq m. Single beam bathymetric survey carried out near shore showed water depth variation from 3.04 m to 15.41 m. Seabed samples (177 grab samples at 500 m interval along 45 transects) showed heavy mineral-enriched fine sand off Chidambarapakkam-Talampettai area. Heavy mineral separation indicate that the heavy mineral wt.% in beach sediment varies from 5.98% to 57.72%. Sector wise distribution of heavies on the beach is 10.88 to 13.3%, 10.79 to 57.72%, 16.20 to 56.31% and 27.06% to 37.70% at sector-I, II, III and IV, respectively. The samples collected from beach front near Akkaravattam show 5.98% & 33.29% of HM wt. % within 0.00-0.50 m and 0.50-1.00 m respectively. Taking average of heavy mineral wt. % in the onshore beach sediment as 28.74%, the heavy mineral reserve in the surface sediment of the onshore area [0.00-0.50 m] is estimated to be about 2.84 million tonnes in about 9.9 million tonnes of sand.

The cruise was taken up to assess the phosphorite potential in the seabed sediments in the continental shelf and slope regions off Nellore to Chennai by systematic multibeam bathymetric survey, sub-bottom profiling, gravimetry, sediment and water sampling in an area of 6,000 sq km (RV Samudra Ratnakar). Detailed bathymetric map shows that the width of the continental shelf varies from 25 km in the northern part (off Nellore), 40 km in central (off Pulicat) and 45 km in the southern (off Chennai) sectors. Carbonate-dominated skeletal fragments, calcareous concretions and phosphatic nodules blanket the area. At water depth of 320 to 375 m, contour parallel series of discontinuous sliding/slumping features trending N-S are noticed and are believed to be the result of a major lineament. The SBP profiles indicate the presence of low strandline positions at a water depth of 90, 100 and 130 m. Some of the profile sections off Chennai-Pulicat sector show gas escape/venting indications in subsurface layers of a thickness of 10-14 m. Higher concentration of  $\text{CaCO}_3$  observed in the southern part of the area. REE concentration is high in fine-grained sediments and depleted in coarse-grained sediments. Phosphatic concretions as black to grey massive encrustations/ concretions are observed in surface and subsurface sediments. The geochemical analysis based on major elemental concentration shows concentration of  $\text{P}_2\text{O}_5$  in the range of 0.15 to 19.72% and EPMA analysis reveals upto 34%  $\text{P}_2\text{O}_5$  in some phosphatic concretions.



During the cruise, geological and geophysical surveys were carried out to search for phosphorite-bearing sediments over and around Karwar Mounts Arabian Sea and also to delineate the geomorphology/subsurface features. Multibeam echo-sounders (MBES), sub-bottom profiling (SBP), magnetic and gravity survey were conducted over and around Karwar mounts. An area of 7,465 sq km was covered over and around the Karwar Central and South Mounts by traversing 2,995 lkm along run lines with varying line spacing. Depth in the survey area varies from 2,000 m in the western part to 200 m in the southeastern part. Multi-beam echo-sounding data delineated Karwar Central Mount (KCM) in the northern part, Karwar South Mount (KSM) towards south and a small mount in the south-western corner of the area. Sub-bottom profile data depict almost flat mount in the central part, steep slopes along western margin and a V-shaped valley at eastern part of KCM. It also reflects different sediment layers with varying thickness. Dome/ conical- shaped features are observed at different places below, above and within the sediment layers at a depth of 600 m to 1000 m with a height of 13 to 15 m and a width of 60 to 80 m. Gas-venting features are observed at few places. The general trend of gravity contours is NW–SE associated with five prominent highs namely GH1, GH2, GH3, GH4 and GH5. These gravity highs are associated with strong relief on bathymetry/ seamounts. FAG anomaly shows isolated high-frequency, high-amplitude and semi-circular anomalies over the isolated Karwar seamounts. Two NE–SW-trending faults are mapped in the FAG map in the study area similar to magnetic map as deep seated faults extended from the coast in between the Karwar mounts. Part of the leftover seabed sampling operations was carried out during SR-017 cruise and phosphatic materials were recovered from KSM.

Placer mineral resource evaluation was taken up in the territorial waters off Chilka, Odisha. An area of 48 sq km off Harchandi and Puri, south-east of Chilka Lake was covered during the cruise to identify and quantify the surface and subsurface heavy mineral distribution zones by close grid vibro core sampling (1 km × 1 km grid) and also to understand the depositional history of the sediments. A total of 72 vibro core (VC) samples were collected. The length of retrieved cores varied from 0.11 m to 3.47 m. A total of 91 subsamples were generated for heavy mineral separation, 105 subsamples for grain size analysis and 52 subsamples for micropaleontological investigations.

The cruise was taken up to evaluate placer mineral resources in an area of 50 sq km within the territorial waters off Santapalle, northeast of Bhimunipatnam, Andhra Pradesh. Sixty-six vibro core samples, with core

length varying from 0.16 to 3.25 m were collected on a grid pattern of 1 km x 1 km within water depths of 12.98 to 21.5 m. Besides, 55 LKM of bathymetric survey was carried out. Increase in grain size towards bottom is recorded in the area. Heavy minerals are observed in grey fine sand. The vibro core sediments were subsampled at half-a-metre interval for evaluation of heavy mineral resources. Heavy mineral analyses indicate weight percentage variation of 0.61 to 6.3% with an average of 2.5%. Detailed studies are in progress. Preliminary investigation of placer mineral resources was carried out in the shelf area off Kollidam and Uppanar River mouths. An area of 220 sq km lying in the middle to outer shelf within 7.8 m and 84.9 m water depths and 1 km to 15 km away from the coast off Kollidam and Uppanar River mouths has been covered with close-spaced bathymetric survey and simultaneous systematic seabed sediment sampling in 2 km × 2 km grid pattern and seawater sampling at selected places. A total of 69 vibrocores, 6 gravity cores and 2 grab samples have been collected. The physical parameters of seawater determined onboard like pH, conductivity, salinity and dissolved oxygen vary from 8.016 to 8.17, 49.5 mS/cm to 52.4 mS/cm, 32.5 g/l to 34.7 g/l and 4.33 mg/l to 4.79 mg/l respectively. Down the water column the dissolved oxygen content is observed to decrease while the conductivity increases with salinity. On the seabed off coastal stretch between Kollidam and Uppanar River mouths, fine to medium sand enriched with heavy mineral occurs beyond 15 m water depth, Beyond 45 m water depth, pebbly coarse sand enriched with HM, shell and shell fragments (some coral fragments could be seen) could be observed. The processing of the samples for heavy mineral studies is under progress. As per the result of Cruise ST-195 (FS 2007-2008), the expected heavy mineral concentration on seabed in this area may give an average of 4.76% which may yield an average HM reserve of 8.37 million tonnes (approximately) in 176 million tonnes of sand (approximately) on seabed i.e., 0 m to 0.50 m level. The zones of heavy mineral concentration on seabed and at different levels below seafloor i.e., at levels of 0–0.5 m, 0.5–1.0 m, 1.0–1.5 m, 1.5–2.0 m, 2.5–3.0 m, 3.0–3.5 m, 3.5–4.0 m will be evaluated comprehensively and the potential area of heavy mineral concentration may be demarcated and proposed for survey at 1 km × 1 km grid sampling.

### **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.

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

In Kerala, a G4 stage Preliminary investigation was taken up for platinum group of minerals in Vellamari block, Attapadi Valley, Palakkad district. A total of 50 sq km area on 1: 12500 scale and 1.5 sq km area on 1: 2000 scale have been mapped. Three to seven-metre-wide chromite-bearing zone could be delineated in metapyroxenite with magnesite veins exposed in Mulli area. In LSM area, metapyroxenite/talc-tremolite actinolite rocks, amphibolite and pyroxene granulites of the Attapadi Group occur as linear bands in hornblende-biotite gneiss and granite gneiss of the Bhavani Gneissic Complex. These bands are mainly exposed in and around Mukkali, Pakulam, Kalkandi, Mulli, Elaichivazhi, and Chalayur area and are mostly massive and medium- to coarse-grained. Banded magnetite quartzite is mainly associated with amphibolite. A 3 to 7 m-wide chromite-bearing zone could be demarcated in metapyroxenite with magnesite veins exposed in Mulli area. During detailed mapping in Vellamari area, the mafic and ultramafic rocks were mapped along with the gneissic country rock. The ultramafics are represented by metapyroxenite and mafics are represented by gabbro and amphibolites. Other rock types include BMQ and sheared granite. The gneisses include hornblende-biotite gneiss, quartzo-feldspathic gneiss and granite gneiss. BMQ occurs as nearly a discontinuous band mainly associated with mafics. General trend of these lithounits are NE-SW to ENE-WSW. Chromite-bearing metapyroxenites are sampled from one of the trenches. Some of the metapyroxenites are sulphide bearing. The chromites in the area are known to be PGE-bearing. Bed rock sampling was done from chromite±sulphide-bearing ultramafics. A total of 202 BRS/groove samples have been collected for PGE and trace element analysis. Three trenches were made near Vellamari area to expose the chromite-bearing ultramafics, sulphide-bearing metapyroxenite and the contact zone between metapyroxenite and gabbro. A total of 10.5 cubic m of pitting/ trenching has been completed and 25 trench samples have been collected for chemical analysis in search of PGE. The strike extension of the chromite zone in metapyroxenite exposed in the quarry section at Kalkandi mapped during previous field session has been traced discontinuously towards SW for a length of 400 m with a width of 3-6 m. The available PGE values in this zone range from 11 to 543 ppb. A sulphide bearing pyroxenite analysed 618 ppb in previous year has been resampled in FS 2015-16. Samples from mafics and ultramafics were collected for different types of study including petrography, ore-petrography, petrochemical, REE, XRD and EPMA. Analytical data of 201 BRS/groove samples collected during previous field session were received and the PGE values vary from 9 ppb-726 ppb. The sample with 726 ppb is from magnesite mine dump near the quarry at Kalkandi. The higher values

are 618 ppb, 541 ppb, 490 ppb, 266 ppb, 213 ppb and 205 ppb. Four PGE grains were found during EPMA analysis in four samples. They are associated with chromitite and sulphide minerals. A total of four PGE-bearing minerals could be identified in 11 thin-polished sections during EPMA study. The sulphides found in chromitite are mainly pentlandite and chalcopyrite and in ultramafic rocks they are mainly chalcopyrite, pyrrhotite and pyrites.

In Madhya Pradesh, a G4 stage investigation was taken up in search of PGE mineralisation in Mordongri mafic/ultramafic complex, Chhindwara district. Large-scale mapping (1:12500) of 50 sq km has been carried out in Mordongri area. The lithology is represented by foliated granite, quartz syenite, different variants of rhyolites (tuffaceous, agglomerates, massive and altered), pillowed and non-pillowed metabasalt, cumulus, non-cumulus amphibolite, gabbro, anorthositic gabbro, basaltic and gabbroic intrusive bands, porphyritic granite and few quartz/pegmatites veins. Main Mordongri mafic-ultramafic body which is an E-W-trending 8 km long, with an average width of 750 m shows intrusive contact with tuffaceous rhyolite and has been observed in and around south of Mordongri, Jamtara, Piparia and Jilharighat area. Different zones of cumulus, non-cumulus, altered and serpentinised ultramafics have been observed. Further, the quartz/granitic veins intruded within gabbro and at the contact considerable amount of sulphide (pyrite, chalcopyrite etc) has been developed. Besides, sulphides of Ni, Cu, Fe and oxides of Ti and Mn, two grains of gold have also been identified by petrography and SEM-EDX studies. Geochemical results are awaited.

In Odisha, a G4 stage Search for PGE was carried out in the mafic-ultramafic plutonic bodies in Patakhal-Balijori and Ghuturigaon-Mundasahi areas, Kendujhar and Dhenkanal districts. The rocks exposed in the area are mainly quartzite, fuchsite quartzite, ferruginous shale, conglomerate, chromiferous quartzite/conglomerate and mafic-ultramafic suite of rocks like dunite-peridotite, pyroxenite, gabbro and granophyre. Cumulus textures and primary magmatic layers preserved in peridotite and pyroxenite are noticed at the south of Ajayapur, at Baiganapal and at the west of Balangisahi. Layered ortho-pyroxenite associated with peridotite, is noticed to the west of Jhumbasahi and at Baiganapal. Three isolated bodies of chromiferous quartzite along with a patch of chromiferous conglomerate were delineated in and around Ghuturigan village. Chromite occurs as laminae, layers and bands ranging in thickness upto 10 cm. Enclaves of quartzite within chromiferous quartzite are seen at places. Source of chromite in chromiferous quartzite/conglomerate may be peridotite. Four NW-SE-trending local shear zones were delineated, south of Ajayapur, west of Balangisahi and Baiganapal which are manifested by shear banding

in quartzite, mylonitisation in ultramafites and/or intense silicification in both the units. Fine disseminations of chromite and/or sulphides are common in peridotite and pyroxenite. Alteration zones with significant Fe- Cu sulphide mineralisation were noticed west of Jhumbasahi, south of Ajayapur, west of Balangisahi and Baiganapal. Bed rock samples were collected from lithological contact zones and sulphide-bearing zones which are supposed to be the favourable loci for PGE  $\pm$  gold mineralisation. A total of 104 BRS and 52 PTS were collected. Analytical results of twenty eight BRS from serpentinized dunite-peridotite, 27 BRS of pyroxenite/sulphide-bearing pyroxenite, 29 BRS of gabbro/sulphide-bearing gabbro and 10 BRS of chromiferous quartzite indicated Cr & Ni values upto 0.35% & 0.20%, 0.35% & 894 ppm, 640 ppm & 391 ppm and 0.22% & 284 ppm respectively. One laterite sample (over peridotite) located in the west of Baiganapal shows anomalous Cr (0.60%), Ni (0.35%), Co (0.16%) and Cu (140 ppm). High values of Cr and Ni were recorded from trenches in Baiganapal and Ghuturigan area.

In Tamil Nadu, a G-2 stage exploration was carried out to assess resources of Platinum group of Elements (PGE) in T-2 sector of Tasampalaiyam block in Sittampundi Anorthosite complex (SAC), Namakkal district. The PGE mineralisation, as thin bands and lenses within anorthosite, is mainly confined to chromitite /chromiferous metapyroxenite. The SAC is divided into three blocks namely Karungalpatti, chettiyampalaiyam and Tasampalaiyam blocks. The SAC has a cumulative strike length of 8.5 km. It is further divided into T1, T2, T3 and T4 sectors. During FS 2012-14, G-3 stage exploration in sector T1 and T2 sector resulted in delineation of significant PGE mineralised zone stage for effective strike length of 750 m in T2 sector of Tasampalaiyaam block. During FS 2015-16 a G-2 stage investigation in T-2 sector was taken up to assess the resources of PGE. Drilling quantum of 1790.80 m and 301 m<sup>3</sup> trenching was carried out. Besides, a total of 457 core samples, 94 trench samples were generated for PGE analysis, 15 petrochemical samples were collected for whole-rock and trace-element analysis. Further, 25 and 15 samples have been collected for petrographic and ore microscope/ EPMA/SEM studies respectively. The T2 sector exposes eight bands of chromitite/ chromiferous metapyroxenite with the width of the individual bands varying from 0.10 m to 2.40 m. The PGE-mineralised band-IV (zone-IV) is represented by chromitite/ chromiferous metapyroxenite/mixed zone of chromiferous metapyroxenite with anorthosite partings. The exploration work involving close-spaced trenching

at 25 m interval, first and second level drilling at 50 m spacing indicated pinch, swell and anastomosing nature of the chromitite/chromiferous metapyroxenite bands both along the strike and in dip direction. The width and grade of PGE-mineralised zone also show drastic variation from profile to profile. In the trench sections, the width of the zone-IV varies from 0.30 m to 2.40 m and the PGE (Pt + Pd) values vary from 30 ppb (Pt + Pd) to 3458 ppb (Pt + Pd). A total of 20 boreholes, including eight first-level (30 m vertical depth) and nine second level (60 m vertical depth) boreholes with 50 m borehole spacing and three third-level (90 m vertical depth) boreholes were drilled to ascertain the depth continuity of PGE mineralisation in zone-IV. The PGE- mineralised band-IV (zone-IV) has been intersected in all the first and second-level boreholes and there is a general reduction of width of zone-IV at third-level. The width of the PGE-mineralised zone-IV intersected in the first- and second-level boreholes varies from 1.41 m to 4.25 m. Based on the available analytical results, PGE values range from 0.235 ppm (0.10 ppm of Pt + 0.13 ppm of Pd) to 2.114 ppm (0.908 ppm of Pt + 1.205 ppm of Pd) in borehole samples. Detailed petrographic and EPMA studies indicate that the PGM phases occur as submicroscopic inclusions of sulphides, arsenides and tellurides within the chrome-spinel and their size varies from 1  $\mu$ m to 5  $\mu$ m. In T3 sector, Tasampalaiyam block, a G3 stage drilling was continued from previous field season to intersect the PGE mineralised Chromitite/ Chromiferous meta- pyroxenite bands at second level with the objective to know depth persistence and estimation of resources. Close-spaced trenching and sampling was also carried out to correlate the strike continuity of the PGE-mineralised bands/zones. Drilling quantum of 1046.65 m and 100 m<sup>3</sup> of trenching was achieved. Large-scale mapping on 1: 12500 scale was carried out to delineate the lithounits favourable for PGE mineralisation. A total of 199 core samples and 29 trench samples for PGE analysis, 25 petrochemical samples for whole rock and trace element analysis, 100 samples for petrographic (25), EPMA (25), SEM (25) and ore microscope studies (25) were collected. The T3 sector of Tasampalaiyam block exposes anorthosite with bands and lenses of chromitite / chromiferous metapyroxenite / mixed zone of chromiferous metapyroxenite with anorthosite partings. The T3 sector extending for a strike length of 2.5 km in E-W, WNE-WSW, WNW-ESE directions, exposes two zones of chromitite, viz. the Northern Zone and the Southern Zone in six segments viz. A, B, C, D, E and F. The Northern Zone is traceable for a cumulative strike length of about 700 m in four segments (A, B, C & D) with width of the individual chromitite band varying from

0.30 to 2.00 m. The Southern Zone was traced discontinuously for a strike length of about 200 m only in segments B & E and the thickness of the chromitite bands/layers in this zone varies from 0.20 m to 4.63 m. The PGE values of the chromitite bands exposed in these sectors range from 10 ppb to 11,215 ppb of Pt and 45 ppb to 7035 ppb of Pd. To prove the depth persistence of PGE-mineralised zones and to estimate the resource potential, systematic drilling was carried out in T3 sector of Tasampalaiyam block to intersect the PGE mineralised zones at two levels; first level (30 m vertical depth) and second level (60 m vertical depth) with borehole spacing of 100 m during FS 2014-16. In totality, eleven second-level boreholes with spacing varying from 75 to 120 m were drilled in T3 sector. The boreholes have intersected number of chromitite/chromiferous metapyroxenite bands with width of the individual bands varying from 0.20 m to 2.39 m. The grade and width of the chromitite/ chromiferous metapyroxenite bands show drastic variation from profile to profile. Trench work covering 100 cu m was carried out to trace the strike extension of chromitite/ chromiferous metapyroxenite bands which has indicated the discontinuous and lensoidal nature of these chromitite/chromiferous metapyroxenite bands. Large-scale mapping on 1: 12500 scale was carried out in to trace the continuation of anorthosite and the associated chromitite/chromiferous metapyroxenite bands, to study the contact relationship between anorthosite complex and the gneisses and also to delineate the other ultramafic/mafic bodies adjoining the Sittampundi Anorthosite Complex for identifying the potentiality of PGE mineralisation.

## DIAMOND

### GSI

During 2015-16, in Andhra Pradesh, a G-4 stage investigation of secondary diamonds was taken up in the Pennar River basin Chennur –Kanuparthi in Cuddapah district. The alluvial diamond deposits along the Pennar River, between Jammalamadugu and the Chennur-Kanuparthi-Kondapeta belt, have been known from ancient times. The known primary source rocks in the catchment of Pennar River are the kimberlites of the Wajrakarur Kimberlite Field (WKF) occurring either as pipes or dyke-like bodies are found emplaced into the granite-greenstone terrain to the west of the Cuddapah Basin. A reconnaissance survey was taken up through detailed PGRS studies, geophysical line traverse, sedimentological studies and detailed drainage morphometric analysis of the area with a view to map the distribution of surface gravels and buried /paleo – channels of Pennar River and prove its diamond

potential between Pushpagiri and Siddavatam area. This resulted in identification of hidden gravel bed 50 cm beneath the soil cover in Obulampally village. Test pitting was carried by utilising ground geophysical data. A 2.5- to 4-m-thick gravel bed extending up to 1 km in length in E-W direction was identified for bulk sample collection. A total of 260 cu cm was excavated and bulk sample weighing 318 tonnes was transported and processed at Wajrakarur Diamond Processing Plant. Two 'Gem Quality' diamonds of 0.45 carat and 0.15 carat were recovered from +2.5 mm and +1.25 mm fraction of the material processed, thereby proving the diamondiferous nature of the Pennar River gravel. Associated Kimberlite Indicator Minerals (KIMs) like garnet, ilmenite, spinel, etc. from the gravel material were also separated and its mantle origin was confirmed by EPMA studies, this will help in narrowing down the provenance for the diamonds of Pennar River. This study has conclusively proven the diamondiferous nature of Pennar River gravel. A G-4 stage search for Kimberlite/lamproit was carried out in Kolhapur and Srirangpur blocks in Mahabubnagar and Kurnool districts with a multidisciplinary approach by study of LISS-III satellite images, aerial photographs, aerial geophysical maps and topographic/tonal lineaments from Google images. The lineaments and their intersections were identified for ground evaluation to find kimberlite/lamproite bodies along with traditional orientation stream-sediment survey. The area exposes rocks of Peninsular Gneissic Complex-II, Cuddapah Supergroup, Kurnool Group, and Quaternary sediments with basic dykes and quartz reefs. A total of 178 stream-sediment samples were collected from appropriate trap sites and processed for recovering heavy mineral concentrates. A numbers of suspected kimberlite indicator minerals were separated from heavy-mineral concentrates and their kimberlitic affinity was confirmed by EPMA as picro ilmenites, Cr spinels and pyrope garnets. During field traverse, four lamprophyres were located around Kettepalli-Telralapalli area, two at village Ankiraopalli and one near village Sheikhpalli. Based on the petrological and bulk chemistry, most of the dykes are classified as alkaline lamprophyres. A G-4 level study of Kimberlites and diamonds from Wairakarur and Narayanpet area Anantpur and Mahabubnagar districts, Andhra Pradesh and Gulbarga, Raichur districts, Karnataka was taken up as memorandum of understanding between GSI and De Beers India Pvt. Ltd (DIPL). Based on mineralogy, four ultramafic dykes around Kettepalli-Telralapalli area and two bodies around Ankiraopalli locality are classified as alkali lamprophyres. One lamprophyre dyke identified in Sekhpalli locality is mica- and pyroxene-rich variant.

In Chhattisgarh, a G-4 stage search for Kimberlite clan rocks was taken up in Mahasamund, Balodabazar and Janjgir-Champa districts. The area is located at the northern part of the already established Mainpur Kimberlite Field. Aerial reconnaissance of 700 sq km area was completed using IGRF-corrected aeromagnetic maps, LISS-III image and PAN data shows that the lithology comprises quartz-mica schist, metabasalt, metarhyolite, metaconglomerate, phyllite, granite, mafic dyke, shale, sandstone and limestone. A total of 14 aeromagnetic anomaly zones and 7 intersecting lineament zones were identified and ground checked. Large-scale mapping of 50 sq km area on 1: 12500 scale was carried out in Banglapali-Sarasdol-Mahkam area. The stream sediment samples yielded good number of spinels, ilmenite, garnets, pyroxenes and gold flakes. The spinels were typical of KCR type and have been selected for further SEMEDX and EPMA analysis. Detailed sampling and 1.18 cu.m pitting was also carried out in the upslope direction of gold incidences to expose the concealed body. Trace element data and REE data of 5 petrochemical samples were received. The compatible trace-elements in these samples are Cu: <10 to 51 ppm, Pb: 10 to 70 ppm, Zn: 34 to 114 ppm, Ni: <10 to 131 ppm, Co: 10 to 98 ppm, Cr: 23 to 173 ppm. Results of REE analysis include Sc: 10.14 to 12.93 ppm, Nb: 2.55 to 16.89 ppm, La: 3.59 to 48.04 ppm, Ce: 8.17 to 92.92 ppm, Pr: 1.27 to 10.86 ppm, Nd: 6.3 to 39.04 ppm, Eu: 0.56 to 1.89 ppm, Sm: 1.58 to 6.58 ppm, Tb: 0.31 to .88 ppm, Gd: 1.78 to 5.72 ppm, Dy: 2.2 to 5.34 ppm, Ho: 0.45 to .99 ppm, Er: 1.38 to 2.99 ppm, Tm: 0.2 to 0.46 ppm, Yb: 1.27 to 3.03 ppm, Lu: 0.2 to 0.47 ppm and Ta: 0.11 to 1.04 ppm. Close-spaced traverse was carried out in Kesharpur area and stream sediment samples were collected from where magnesian-chromite was reported earlier. These stream sediment samples yielded spinels, which were selected for SEM-EDX and EPMA analysis. Aeromagnetic maps, LISSIII image and PAN data were consulted and the anomalous zones were ground checked. A total of 17 stream sediment samples were collected from these target zones. A total of 145 polished mounted grains were submitted to SEM Lab for further analysis. A G-4 stage exploration was carried for search of Kimberlite clan rocks (KCR) in Mahasamund district. The study involves integrating PGRS and aeromagnetic data of 1400 sq km area. Ten target blocks were identified. Ground checks were carried out in the target blocks on priority basis. Reconnaissance mapping of 700 sq km was carried out.

A total of 29 petrological samples and 25 PCS samples were collected for further petrographic and petrochemical studies. The area under investigation fall in the northern parts of the already established Mainpur Kimberlite Field. Five zones are demarcated for ground check based on PGRS maps and aeromagnetic data. Reconnaissance mapping of 495 sq km on 1: 50000 scale and stream sediment sampling were carried out. Eight petrographic samples and six petrochemical samples were collected for studies. A total of 140 stream sediment samples were collected for heavy mineral separation. At place pedogeochemical samples were collected and processed for heavy mineral separation. Analytical results of trace elements and REE data are as follows: Cu: 87 ppm to 101 ppm, Pb: 10 ppm to 20 ppm, Zn: 92 to 93 ppm, Ni: 171 ppm to 174 ppm, Co: 63 ppm, Cr: 449 to 552 ppm, Sc: 10.31 to 10.39 ppm, Nb: 7.24 ppm to 9.91 ppm, La: 31.88 ppm to 812.01 ppm, Ce: 46.41 ppm to 110.06 ppm, Pr: 7.42 ppm to 94.88 ppm, Nd: 27.48 ppm to 299.20 ppm, Eu: 1.37 ppm to 6.89 ppm, Sm: 4.86 ppm to 43.30 ppm, Tb: 0.64 ppm to 4.64 ppm, Gd: 4.31 ppm to 32.81 ppm, Dy: 3.82 ppm to 22.63 ppm, Ho: 0.69 ppm to 3.32 ppm, Er: 1.85 ppm to 8.43 ppm, Tm: 0.26 to 1.15 ppm, Yb: 1.58 ppm to 6.61 ppm, Lu: 0.24 ppm to 0.85 ppm and Ta: 0.60 to 0.61 ppm. Eighteen thin sections were prepared for petrographic studies. A total of 216 stream-sediment samples were collected for heavy mineral separation and heavy minerals were studied under binocular microscope and 525 grains (including 200 garnet, 150 spinel, 150 ilmenite and 25 pyroxenes) were selected and epoxy mounted for further studies under SEM-EDX and EPMA.

In Jharkhand, G4 stage investigation of Kimberlite/Lamproite was continued from 2014-15 in parts of Simdega district. About 700 sq km was covered and 150 stream-sediment samples (SSS), 25 PS, 20 PCS and 20 CA samples were collected. The SSS were processed to get heavy mineral concentrates (coarser between 1.25 and 0.5 mm and finer between 0.5 and 0.17 mm). Scanning of heavy mineral samples (HMS) was carried out under trinocular stereo-zoom microscope. The heavy-mineral concentrates mostly consist of garnet, ilmenite, tourmaline, amphiboles, spinels, epidote, zircon, rutile and a few suspected microdiamonds. An

inclusion of forsterite (olivine) within garnet, confirms their derivation from mantle. Raman spectrometry will be carried out to confirm the microdiamonds. Traverses were taken and a few ultramafic bodies including two lamprophyre dykes were reported in this area.

In Karnataka, G4 stage regional survey was carried out to locate kimberlites in Kudligi block, Bellary and Chitradurga districts. Major part of the area is occupied by granite gneiss and migmatite gneiss of PG-1. The younger intrusives in the form of quartz and pegmatite veins are observed traversing the gneisses and migmatites of Peninsular Gneissic Complex. Clusters of dolerite dykes occur throughout the area along E-W, NWSE and NE-SW directions. Shears were noted in granite southwest of H. K. Halli, east of Kodihalli, north east of Bandri and south east of Suravvanahalli. The shear located south west of H. K. Halli has a strike length of 200-300 m with width of 50-100 m. The trend of shear is N20°W-S20°E. The shear observed east of Kodihalli trending N30°W-S30°E extends up to northeast of Bandri. The strike length is about 2 km and width is 200-300 m. In the north-east of Govanahalu a shear zone was recorded with a trend of N30°W-S30°E. This shear may be continuation of the shear located to the east of Kodihalli and northeast of Bandri. Another shear zone was found to the south-east of Suravvanahalli trending N20°W-S20°E. The width of the zone is 300-400 m and strike length could be traced up to 700 m. Downloaded ETM+ data were used for digital image processing to prepare lineament map on a regional scale so as to cover the known Wajrakarur Kimberlite Field and the area under investigation. The lineaments are mainly basic dykes, major joints and shears. In search for indicator minerals/heavy minerals, a total of 162 stream-sediment samples were collected from lower order stream. To recover indicator minerals, stream sediment samples were sieved through screens of 4 mm, 2 mm, 1 mm, 0.5 mm and 0.3 mm aperture. The -4 mm to +2 mm size fractions were scanned for kimberlite fragments, if any. The heavy minerals were picked up from size fraction -2 mm to +1 mm, -1 mm to +0.3 mm size were concentrated through hand-operated jig. The study revealed that the area contains heavy minerals namely amphiboles, epidote, garnet, ilmenite, magnetite,

pyroxenes, zircon, tourmaline, spinel and sphene. 25 grains suspected to be KIMs have been sent for EPMA analysis. During field traverse to characterize lineaments corundum mineralisation was observed NE of Suldahalli and south of Haravadi and on the slope of a granite hill at Gedlagatte. Old workings for corundum crystals were noted 1 km NE of Suldahalli. These were observed on the top and valley portions of a granite hill. The granite contains many enclaves of amphibolites. In most of the places these enclaves have been excavated and only depressions are present. Many pits were also observed along the valley. Agricultural land along the slope of the hill yielded a few corundum crystals. In the south of Haravadi, mineralisation of good-quality corundum grading into ruby (visual observation) was observed at the western contact of older metamorphic enclave with leucocratic granite. Corundum mineralisation was also observed in highly weathered and micaceous rock exposed on the slope of a granite hill at Gedlagatte. The general trend of this weathered zone is NW-SE. The corundum crystals are found embedded within ellipsoidal micaceous nodules varying in size from 1 cm to 6 cm and have a coating of greenish and grey mica. G4 level regional survey was carried to locate KCR in Molakalmuru block, Bellary and Chitradurga districts. The Eastern Block of the Dharwar craton is underlain by a thick and cool stable subcontinental lithosphere which is a prerequisite for the formation and stability of diamonds. This part of the craton hosts the well-known Wajrakarur Kimberlite Field (WKF). Many of the kimberlite pipes in this field are proved to be diamond-bearing. In the WKF it is found that the emplacement of kimberlites is primarily controlled by major ENE-WSW- and NW-SE-trending basement faults and their intersections. The study area comprises rocks belonging to Sargur Group, Peninsular Gneissic Complex, Bababudan Group, Chitradurga Group and Javagondanahalli belt of Dharwar Supergroup and intrusive granite. The entire area is traversed by quartz veins and dolerite dykes. Lineament map was prepared by studying IRS ID LISS III imagery. The drainage map with stream sediment locations has been prepared with the help of Arc GIS. Reconnaissance mapping of 720 sq km was carried out with special attention to the zones of intersecting lineaments and mafic dyke swarms as they form probable

loci for emplacement of kimberlites. A majority of lineaments, controlling the straight course of the streams, are only master joints. In general, the lineaments are NW-SE, NNW-SSE and ENEWSW trending. The major NNW-SSE trending lineaments in SW corner of the study area represent the Chitradurga schist belt. 172 stream sediment samples, one in situ spoil sample, 5 petrochemical and 5 petrographic samples were collected from the area. Processing of samples involved recovery and study of the heavy minerals in the size range of 2 mm to 0.3 mm. The 1 mm to 0.3 mm size fraction was taken up for concentration with the help of Garytz type jig and sent for iso-dynamic/bromofrom separation. Less than 0.3 mm fraction was not taken into consideration, as the percentage of heavy minerals in this size was much less and also difficult for proper identification of the minerals. Heavy minerals thus recovered were further studied at camp under binocular microscope to recover the kimberlite indicator minerals. The heavy minerals namely garnet, ilmenite, spinel, magnetite, zircon, amphiboles, pyroxenes, epidote and sphene were recovered. Most of the minerals are of crustal origin as per their morphological characteristics. A total of 28 suspected grains were submitted for EPMA study including 13 ilmenites, 7 diopsides, 3 spinels, and 5 zircons.

In Telengana and Andhra Pradesh, G-4 stage investigation was carried out for secondary diamond in Munneru- Paleru River basin in Khammam district. An area of 800 sq km has been mapped for the distribution of surface gravels and buried/paleo-channels of Munneru and Paleru rivers, tributaries of Krishna. Terrace mapping has been done and a total of 11 gravel patches have been identified on the basis of clast morphometry and difference in elevation of the terrace. Cross-profile traverse along both the Munneru and Paleru rivers in an E-W direction has been taken up at different locations. T2 surfaces have been distinguished from the T3 surfaces on the basis of clast size, composition and elevation differences. Dominantly quartzite, dolerite, haematite float ores and quartz are the composition of gravels. T2 patches have been identified near Lakkavaram, Gondrala, Nallabandagudem, Balasupadu and Budavada for Paleru River and near Wallapuram and Lingala for Munneru River. A probable T3 patch has been identified near Gandrayi. Lamprophyre dyke has been suspected near Lakkavaram. Length and width of the dykes varies from approximately 15-20 m and 0.30 cm to 0.5 m,

respectively. A total of 103 SSS (stream sediment samples) have been collected and scanned for heavy minerals and KIMs (Kimberlite Indicator Minerals). Nine trial pits were dug for buried gravel bed. The heavy minerals identified under the binocular microscope are garnet, ilmenite, amphiboles/diopside, spinel, epidote and zircon and they were also separated and sent for EPMA analysis to study the provenance of these minerals.

## **PRECIOUS MINERALS**

### **GOLD**

The GSI, MECL and HGML were engaged in the exploration for gold during 2015-16. 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.

### **MECL**

During 2015-16, in Jharkhand, MECL carried out exploration for gold ore in Parasi(West block) Ranchi district involving : mapping – 5 sq km area on 1:1000 scale ; drilling-1564 m in 10 boreholes ; sampling and chemical analysis -1242 nos of primary, 62 numbers check samples for fire assay of Au %, 50 nos for As, Sb, W, Co, Ni, Mo and 8 nos composite samples each for Au, Ag and six radicals, XRD and spectroscopy; Petrological studies - 30 nos minerographic studies - 30 nos specific gravity determination - 40 nos Estimated 0.365 million tones of gold ore with 1.644 g/t Au at 0.50 g/t Au cut off and 0.181 m.t. of gold ore with 2.644 g/t Au at 1.0 g/t Au cut off under UNFC code 331 & 332. Total in situ gold metal content is 608.446 kg.

## **INDUSTRIAL MINERALS**

The details of exploration work carried out for industrial minerals by GSI, State Governments and Central/State Undertakings during 2015-16 are given in Table - 9.

## **DECORATIVE DIMENSION STONES**

The details of exploration work carried out for granite, sandstone and decorative dimension stones by GSI and State DGMs during 2015-16 are furnished in Table -10.

EXPLORATION & DEVELOPMENT

**Table - 5 : Exploration for iron ore by NMDC & MECL, 2015-16**

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (Ha)	Boreholes	Meterage		
<b>NMDC</b>							
<b>Iron Ore</b>							
<b>Chhatisgarh</b>							
South Bastar (Dantewada)	Deposit -14 and Deposit 11 C Bailadila Iron Ore mine Kirandul Dep. ML Dep. 14	1:2000	Lease Area	13	1070	-	Exploratory drilling and reserves estimation are under process.
	Dep.14 NMZ	1:2000	-do-	11	1080.3	-	
	Dep. 11 ML 11C	1:2000	-do-	03	190	-	
Dantewada	Bailadila Iron ore mines Bachel	-	-	10	1522.6		
do-	Dilli A	-	-	35	2295.5		
<b>Karnataka</b>							
Ballari	Donimalai iron ore mine DIOM-BMMX 3E & 2E Deposit	-	-	35	2621.6	1187	Proved reserves enhanced by 18.36 million tonnes i.e. 8.3 million tonnes in BMMX deposit, 7.45 million tonnes in 3E deposit & 2.61 million tonnes in 2E deposit and probable reserve by 7.53 million tonnes i.e. 2.05 million tonnes in BMMX deposit & 5.48 million tonnes in 3E deposit.
<b>MECL</b>							
<b>Karnataka</b>							
Chitradurga	Chennakesava Reddy mine ML 2566, Hosadurga Taluka	1:1000	7.57	06	273.0	340	The average depth of the mineralised zone proved by exploration in the lease area is 8.6 m. over 340 m strike length. Estimated 3.179 million tonnes of iron ore resources with average grade of 51.73% Fe .
Ballari	MMT mine lease area(ML 2185A) Sandur Taluka	1:1000	44.42	15	904.5	-	The mine lease area/deposit extend over a strike length of 397.50 m with a width of about 450 m. The average depth of the mineralised zone is 58.75 m and ore body continues even beyond this depth. Estimated 9.224 million tonnes of iron ore with average grade of 53.26% Fe.

(Contd)



EXPLORATION & DEVELOPMENT

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (Ha)	Boreholes	Meterage		
Ballari	Nidhi Mining Co.,M.L.2433 Sandur Taluka	1:1000	29.49	15	899.0	863	The mine lease area/deposit is located in Donimalai range and extend for a strike length of 750m with width varying from 250 to 300m. Estimated 10.024 million tonnes of iron ore of 58.67% Fe.
	Rama Rao Paol Mine(ML-2621) Sandur Taluka	1:1000	33.80	23	1438.5	1424	The mine lease area is located on the southern part of Kumaraswamy range and has about 117m strike length and width varies from 180 to 200 m with an average depth of 34.47 m. Estimated 31.53 million tonnes of iron ore with an average 56.60% Fe
	Ramgad Mineral & Mining Pvt.Ltd ML-2451 Sandur Taluka	1:1000	24.04	11	719	680	The mine lease area extends about 474 m in strike length with an average width of 102m. The depth of ore body in lease areas ranges from 5.98 to 26.51 m. Estimated 2.137 million tonnes of iron ore with an average of 50.39% Fe.
	S.B. Minerals ML-2393 Sandur Taluka	1:1000	40.38	26	1640	1613	The mine lease area is located on Ramgad range. The deposit extends for a strike length of 1300 m with width varying from 320m to 380.00m. The average depth range of the mineralised zone inthe area is 1.49m to 19.80 m. Estimated 4.296 million tonnes of average grade of 48.51% Fe.
	Tungabhadra Minerals Pvt.Ltd ML-2365 Sandur Taluka	1:1000	125.58	40	2588.50	5056	The deposit extends over the strike length of 1700 m within 200 to 300 m wide area in Part - I and it extend over 710 m in strike length in Part II within 250 to 300 wide area.The average depth of of mineralised zone in the lease area of PartI is 28.01m and Part II 15.07m. The ore body continues even beyond the explored depth. Estimated 33.89 million tonnesof iron ore with an average grade of 57.87% Fe.
	Tungabhadra Minerals Pvt.Ltd ML-2366 Sandur Taluka	1:1000	33.97	08	374.0	353	The deposit extends about 355 strike length. The average depth of mineralised zone in the lease area is 64.309 m. Estimated 6.933 million tonnes of iron ore with average grade of 59.52% Fe.
Chitradurga	Srinivasalu mine ML-2631 Hosadurga Taluka	1:1000	75.14	31	1221.5	1174	The average depth of the mineralised zone in the mine lease area is 26.56 m over 1.8 km strike length. Estimated 9.880 million tonnes of iron ore with average grade of 55.08% Fe.

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**Table - 6: Exploration for Gold by GSI, 2015-16**

State/District	Location	Details of work done	Results obtained/Remarks
<b>Andhra Pradesh</b> Kurnool	Gani-Kalava area	Trenching, sampling and analysis	G-3 stage investigation was carried out for gold . Detailed geological mapping on 1:2000 scale was carried out over an area of 1 Sq. Km in the Gani block. Collected a total of 177 grid bedrock samples along with 103 m <sup>3</sup> of trenching and sampling. Also collected 20 samples for PS, 5 samples for PCS 20 samples for fluid inclusion and sulphur isotope studies. Drilling of 472.7 m has been completed in Kalava east , south and Gani block. In Kalava south block three boreholes (320.10m) intersected sulphite quartz veins but chemical analysis of core samples are not encouraging. Borehole AGK2 analysed 42 ppb to 100 ppb Au in 3 samples; rest of the samples analysed < 25 ppb Au. Analytical results for Au from 15 core samples of AGK-3 showed 34 ppb from just one samples and 3 samples from quartz veinlots analysed 0.21 to 0.3 Cu. Analytical results of all core samples from AGK-4 are also not encouraging and Au value recorded < 25 ppb.
<b>Arunachal Pradesh</b> Papumpare & Lower Subansiri	Posa-Potin Road section	Mapping	G4 stage search for gold and associated mineralization was carried out in metasedimentary sequence of Bondila group. An area of 75 Sq. Km was mapped on large scale. Three limonised, ferruginised and gossanised zones of approximate thickness of 10 m are noticed in the garnet mica schist near Posa Potin road section. One zone is exposed in the trench dug about 140 m in the southern extension of this section. One band is noticed in the northern banks of the river in the northern extension. The bands have a general trend of NE-SW with steep NW dip. Boudinagd quartz veins having width of 2 to 50 cm have not yielded any significant gold value.
<b>Jharkhand</b> Ranchi	Birgon block	Mapping, IP, SP Survey, sampling and analysis.	G-4 stage investigation was carried out with an objective to assess gold potentiality and to establish the geological and structural control of mineralisation in Babaikundi-Birgaon sector. An area of 1.013 sq km was mapped on 1:1000 scale along with IP and SP surveys covering 31.51 km. Mica schist occupies the plains while cherty quartzite and reef quartz are exposed on mounds and hillocks. The general strike direction of foliation is N75°E – S 75°W to E-W with steep dip towards south. Three sets of joints are observed trending N30°W–S30°E, N43°E-S43°W and N70°E-S70°W with steep to sub vertical dips on either directions. Collected 100 samples each of BRS & PTS, 25 PS, 10 OM and 5 SSS. The value of gold ranges from 0.07 ppm to 0.29 ppm in 3 PTS and 0.07 ppm in one BRS sample in quartzite. Also the IP results show one 1200 x 200 m anomalous zone of IP value ranging from 10mV/V to 25m V/V indicating possible mineralisation.

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Table - 6 : (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
<b>Jharkhand</b> Ranchi	Nauhri-Rasuri Sereng area	-	G4 stage investigation was taken up in the northern contact of volcano-sedimentary sequence of Singhbhum Group with Chhotanagpur Gneissic (Tamar- Porapahar Shear Zone). These rocks are by and large of low metamorphic grade and have suffered three phases of deformation and are intensely sheared. Sporadic sulphide mineralisation of copper & lead and gold mineralisation are found along these shear zones. The study area is represented by mica schist, quartz-sericite schist, phyllite, granites, mafic rocks, quartz veins, pegmatite veins and subordinate chert bands which exhibit the presence of pronounced shearing zones. The surface evidence of mineralisation in the area is indicated by ferruginisation, limonitic stains, leached out pyrite crystals and silicification. Sulphide mineralisation in quartz vein is observed near village Barudih . Also, near Gitilbera, Berapara, Bansban and Rasurisereng villages leached out pyrite crystal scars are present in quartz veins and quartz-tourmaline veins which intruded concordantly within metasedimentary unit.
	Sindauri East block	Geophysical survey, drilling, trenching, samples	General exploration was carried out to demarcate gold mineralisation. The work involves collection of 250 trench samples through 12 trenches for establishing the correlation between surface and subsurface mineralised zones. A total of 100 petrological samples were collected from surface and subsurface core samples for the study of petrography including ore petrography. A total of 20 quartz vein samples were collected from subsurface core samples for the study of fluid inclusion. Surface geophysical survey and bore-hole geophysical logging (both IP & SP) have been carried out in Sindauri East block. A total of 1519.35 m drilling through 10 boreholes and collection of 650 samples have been achieved. The geological setting of Sindauri East block consists of volcano sedimentary sequence. To the north of Dalma Group, acid volcanics-chert-quartzite lithopackge of Chandil Formation has been observed. The major rock types are fine-grained biotite-magnetite-quartz- sericite schist and tuffaceous phyllite intercalated with cherty quartzite. The general trend of most dominant foliation is N70°E-S70°W, dipping 70° to 80° towards south.

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Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
West Singhbhum	Bisrampur-Jaikani	-	G4 satge investigation of gold was taken up. Detailed mapping of an area of 0.5 sq km has been carried out on 1: 1000 along with a collection of 101 bedrock samples on grid pattern, 25 petrological samples from representative stratigraphic units and 100 pitting and trenching samples from 100 cu m pitting/trenching. Analytical results of 20 bedrock samples and 20 trench samples have been received from chemical laboratory. Bedrock samples do not show any gold value, however, one trench sample from tuffaceous phyllite with quartz vein shows 100 ppb of Au. The area is occupied by Iron Ore Group of rocks namely phyllite, tuffaceous phyllite, slaty phyllite, cherty quartzite, chlorite schist, quartz, quartzite, and chert. At places, the tuffaceous phyllite is intruded by numerous quartz veins along the foliation, which show boxwork and limonitisation at places. The quartz vein varies in thickness from a few centimeters to five metres. Three distinct phases of deformation are noted in the area apart from shearing. Evidences of shearing are manifested in the form of stretched quartz boudins within the phyllite/tuffaceous phyllite unit and interfolial silicification. Phyllitic unit shows broad open fold.
<b>Karnataka</b> Mapping, Drilling,	Dharwar Block	Bangaragatti trenching and sampling.	G-3 stage investigation was carried out in south western and northern blocks of Bangaratti block. In south western block detailed geological mapping of 1 sq km on 1:1000 scale and sampling was carried out to delineate auriferous zones in the BIF bands. The area is represented by argillite greywacke suit of rocks interbedded with banded magnetite quartzite and traversed by younger quartz/carbonate veins. The BMQ bands are made of alternate layers of magnetite/haematite and chert/ quartzite with thickness varying from 1.0 to 4.0 m. Gold mineralisation is confined to sulphidic facies in sheared and intensely silicified BMQ bands which are criss-crossed by quartz veins. Pyrite and pyrrhotite are the main sulphide minerals reported in fresh and oxidized forms. Systematic trenching in BIF at every 50m interval was carried. Ninety four samples from 13 trenches, 59 bedrock samples, 25 petrographic samples and 22 ore microscopic studies samples were collected. Detailed mapping has brought out one major band which is highly oxidized and folded isoclinally. Oxidised and fresh sulphides with boxwork all along the strike are present and bedrock contains 0.70 g/t/2m ~ 1.64g/t/3m gold. Earlier exploration (FS 2006-07) in northern block was taken up to assess gold mineralisation. A total of 10 boreholes at 100m interval was drilled for a cumulative length of 1006.45m. The auriferous zone in borehole BGT -14 (0.41 g/t/2m), BG-18(0.79g/t/1m), BG-15(0.62g/t/2m), BG-16 (0.33 g/t/1.5m) was proved.

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Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
Haveri	Budigudda Block	Mapping, trenching, & geochemical sampling	<p>A G4 stage investigation of gold was taken up with the objective to assess the auriferous potentiality of the sulphidic BIFs. A total area of 1.5 sq km was mapped on 1:1000 scale and 102 trench samples and 154 bedrock samples were collected. Besides, samples (5 nos each) for petrographic, petrochemical, ore microscopic and trace elements studies have also been collected. The NW-SE-trending Budigudda block comprises thick pile of argillite/ greywacke sequences with intercalations of BIF. At places, a thin film of highly carbonated, friable, whitish coloured tuffaceous rock is also seen at the contact of BIF. Intrusives like basic dykes and quartz are also noticed at several places. Pyrite is the major sulphide observed throughout the area mainly in the form of disseminations and chunks within BIF. The major trend of BIF and regional foliation (<i>i.e.</i> NW-SE) is controlled by D2 deformation. The BIF which have been targeted for auriferous potentiality are restricted mainly to the ridges and confined within 70-80 m width. However, their strike continuities are not traced for long. The southeastern side (950 m long and 90 m wide) hosts three main BIF bands along with several unmappable thin bands all confined over a width of about 30-40 m. Band-1 is seen over a strike length of 700 m with average width of 1.5 m. Analytical results of trench samples and bedrock samples from this band contain 60 ppb to 1.3 ppm Au. Band-2 is 80 m east of Band-1 and is established over a strike length of 1000 m with average width of 0.97 m. Trench samples and bedrock samples from this band contain 45 ppb to 1.35 ppm Au. Band-3, which is 40 m east of Band-2, has a strike length of 700 m with average width of 1 m. Trench samples and bedrock samples from this band contain 40 ppb to 0.70 ppm Au. Compared to south-eastern side, the north-western side comprises only two bands. A total of 128 cubic metre has been excavated in 23 trenches at regular intervals. Analytical results of bedrock samples indicate Au mineralisation ranging from 30 ppb to 21.25 ppm. Ore microscopic study shows the presence of euhedral pyrites in disseminated forms within argillite and in BIF. Panning of sediments from the mapped area also shows presence of gold grains. However, consistency in Au mineralisation is better in the south-eastern part compared to northwestern part.</p>

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Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
Haveri	North of Maruthipura-Attigere block	Mapping, drilling, trenching, & sampling	G-3 stage preliminary exploration was carried out to assess gold mineralisation which includes different components such as 928.40 m drilling (9 boreholes) in Maruthipura – Attigere blocks, detailed mapping on 1:2000 scale of 1.5 sq km area in the southern part of the block to check continuity of BIF bands and LSM of 100 sq km in the western part of the block. LSM in western part of the block exposes BIF bands hosted in predominantly argillite-greywacke suite of Ranibennur Formation of Dharwar Supergroup. A northerly-plunging regional fold was observed within BIF bands to the north of Jekkinakatti village. This fold shows axial culmination as it plunges in both directions. Complementary regional synclinal fold was marked to northeast of Basavna village based on change in dip direction of BIF and other associated rocks. Shear zones resulting protomylonite, mylonite and ultramylonite were identified as these zones are favourable loci for gold mineralisation. A green-coloured, soft and highly carbonated suspected ultramafic rock unit was delineated within two BIF bands. An acid volcanic rock unit was also identified near village Montrodi which shows sheared contact with chlorite phyllite. Detailed mapping was carried out in the southern continuity of Maruthipura-Attigere block. This block contains several BIF bands within argillite-wacke rocks. Width of these bands varies from 2 m to 4 m in the limb portion and 6-7 m in hinge portion. A total of 13 trenches measuring 216 Sq m have been put forth across the strike continuity of several BIF bands and 111 samples were generated. A total of 928.40 m was completed by May 2016 in 9 bore holes. The major lithology intersected along the borehole is argillite, greywacke, quartz wacke, chlorite phyllite and BIF. A total of 239 samples have been generated from 9 boreholes. A total of 575 samples have been generated and sent for chemical analysis. Analytical results of 3 boreholes have indicated gold values in borehole KDA-1 and KDA-3. KDA-1 intersected a zone of 2 m/0.876 ppm gold while borehole KDA-3 intersected a zone of 2 m/0.37 ppm gold.
Shimoga & Davangere	Around Yekatte & Siddapura area	Mapping pitting, trenching, sampling	G-4 stage preliminary investigation of gold in and around this area was taken up with the objective of assessment of gold and associated minerals and to study the structure and control of mineralisation. The rocks belongs to Shimoga group of Dharwar super group. Four major reserved forests namely Gangavanasara, Yekatte, Markande and Kudreonda fall in the study area. The granite gneiss of Pennisular Gneissic complex (PGC) forms the basement for overlaying rocks of Dharwar super (Contd.)

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Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
			group i.e. quartzite, quartz-chlorite schist, metabasalt, ferruginous phyllite, banded magnetite quartzite, magniferous iron quartzite, argillite, quartz veins and basic dykes. Near Hosakoppakere a small band of fuchsite bearing quartzite is seen having length and width of 150 m and 40 m respectively. It is observed within chlorite schist. At places rock with tuffaceous nature is also found at the contact of quartzite. These rocks are composed of chlorite-actinolite-sericite and minor amount of carbonates and host rock for disseminated pyrite. This unit is overlain by ferruginous phyllite which carries banded magnetite quartzite and magniferous iron quartzite. Near Tarlaghatta road section magniferous iron quartzite is seen parallel to BMQ. This unit is composed of haematite and goethite. Again argillite overlies the ferruginous phyllite and is exposed in the northern part. Gabro and dolerite dykes are reported in the area. 150 sq km area was covered on LSM (1:12500). One hundred trench samples and 79 bed rock samples have been collected and analysed. 20 petrological samples, 14 petrochemical samples and 20 ore samples have also been collected for lab study. Out of 79 BRS samples analysed, five samples have > 550 ppm Zn. Only one out of 100 trench samples contains 81 ppb gold. This trenching is carried out in magniferous banded quartzite. Rest of the samples have Au < 25 ppb.
Tumkur	Basavanagudda block	Mapping, trenching, sampling	G-4 stage investigation of gold was taken up to assess the gold potential of the area. An area of 1.5 sq km has been mapped on 1:2000 scale and 130 bedrock samples and 103 trench samples (from 120 cu m trenching) have been collected for study. Twenty petrological samples, 8 petrochemical samples and 10 REE samples were also sent to the labs for detailed study. The investigated area forms a part of Chitradurga schist belt. The major rock types mapped during investigation are metabasalt, Banded Haematite Quartzite/Chert, meta-argillite and dolomite along with number of quartz veins. The entire area shows a synformal fold defined by three major BIF bands. BIF occurs mainly as layered haematite chert and haematite quartzite. Thin layers of magnetite are also seen at places. Pyrites are reported along the bedding planes of BIF at the northern part of the area. The quartz veins in the area are white and grey in colour, massive to sheared and have short length. The veins in contact with BIF are slightly deformed and show wall-rock alterations. Thin intercalations of dolomite are seen along with BIF bands. Basavanagudda block forms an integral part of Ajjanahalli Gold Field and gold has been reported from BIF. The fold closures and

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Table - 7 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
			structural complexities form possible loci of mineralisation. The major fold hinges formed by the BIF bands, show evidences of hydrothermal alteration. The BIF bands at hinges are limonitised, slightly silicified and intruded by thin quartz veinlets in all directions. Boxworks formed by sulphides are also seen at the fold hinges and the major sulphides are pyrite and chalcopyrite. BIF is slightly brecciated at places and shows recrystallised haematite layers. Ore microscopic studies indicate presence of disseminated pyrite and chalcopyrite grains within BIF. Fragmentation and intergrowth of sulphides are noted within a few BIF samples. The analytical results of 179 samples show the Au values vary from 25 ppb to 700 ppb. The samples collected from the hinge zones detected with Au values 0.025g/t/2 m, 0.0236g/t/6 m and 0.616g/t/4 m, respectively. The results obtained from the rest of the BIF samples are not encouraging. The area between the peripheral fold hinge and innermost hinge can be considered as a mineralised zone with moderate Au values (25 ppb to 700 ppb).
Tumkur	Ajjanahalli Block -C	Drilling, sampling	G-3 stage of investigation of gold was continued from previous FS 2014-15 in BIF –hosted Ajjanahalli Gold Prospect (block G). This is well known deposit is situated in meta-turbidite-dominated Chitradurga greenstone belt of Dharwar craton. 5 boreholes for a cumulative length of 1023.95 m have been drilled. Boreholes were planned to intersect the mineralised zone hosted in the western most BIF band. Five boreholes (from AGG-10 to 14) of 1094.25 m cumulative length were drilled at an interval of 100 m along strike targeting mineralised zones at 120 m vertical depth (2nd level). In borehole AGG-10 average gold content is 0.893g/t/1.0 m whereas in borehole AGG-11 mineralised zones were intersected with 0.823g/t/4.5 m, 1.5g/t/0.5 m, 1.275g/t/0.5 m, 1.4g/t/0.5 m, and 0.680g/t/1.5 m of gold. In AGG-12 gold content is 0.31g/t/0.5 m. The length of mineralised zone yet to be calculated after receiving all the chemical analysis data. Sulphide mineralisation such as pyrite, pyrrhotite and arsenopyrite occurs as disseminated specks, veins and stringers along foliation/fracture planes in BIF band as well as in carbon phyllite unit. The wall-rock alteration has been noted in the form of chloritization, sericitization, carbonitization, epidotization and biotitization. Gold mineralisation is confined to sulphide facies of BIF, sheared and silicified in nature hosting thin quartz-carbonate veins and veinlets. Gold mineralization is epigenetic in nature in this area.

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Table - 6 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
Tumkur	Ajjanahalli Block -C	Drilling	<p>G-2 stage exploration for assessment of gold resources has been carried. The rocks are of Chitradurga greenstone belt of Dharwar craton. The main rocks of the area are metabasalt, pyroclastic, pillowed and carbonated metabasalt with ferro-dolomite bands and veins, banded iron formation and argillite greywacke suit. Out of the three phases of deformation noted in the area second generation deformation (F2) is most prominent and related to gold mineralisation. During FS 2008 -09, 10 boreholes were drilled in the northern part of Ajjanahalli block C. A tentative resource of 99,460 tonnes of gold ore with an average grade of 2.17 g/t over 2.95 m true width has been estimated at 1.0 g/t cut-off grade. For 0.5 g/t cut off grade, a tentative resource of 2,13,524 tonnes of ore with an average grade of 1.45 g/t over 4.18 m true width has been estimated. In the southern part of Ajjanahalli Block-C, G-3 stage of exploration was carried out involving drilling of 6 boreholes (ACG-11 to 16). An inferred resource of 0.21 mt of gold ore (approx. 186.9 Kg of Au metal) has been estimated with an average grade of 0.90 g/t over an average thickness of 2.60 m (UNFC-333). Out of the proposed drilling of 1000 m., a total of 323.80 m has been drilled in mineralised zone within the BIF bands. Since the commencement of drilling, a total of 3 boreholes (KTAC-1 to 3) have been completed in this block and remaining 700 m will be drilled as spill over drilling during FS 2016-17. Sulphide mineralisation such as pyrite, pyrrhotite and arsenopyrite occurring as disseminated specks, vein and stringers along foliation/fracture planes in BIF band as well as carbon phyllite unit has been observed in drill cores. Chalcopyrite occurs occasionally along with other sulphide minerals. Sulphide mineralisation is mostly confined to sheared, silicified BIF hosted within quartz-carbonate veins and veinlets.</p>
<b>Rajasthan</b> Banswara	Makanpura area	Mapping, Drilling, Sampling	<p>G-4 stage investigation was carried out for assessment of gold and associated mineralisation . An area of 1 sq km was mapped on 1:2000 scale and collected 202 channel samples &amp; 50 bed rock samples. Four boreholes were drilled for a cumulative length of 500.40 m. Surface indications of mineralisation are noted in the form of old workings, gossan/ferruginisation, malachite staining and silicification. Four mineralised zones (MZ-I to MZ-IV) vary in length from 100 m to 280 m and in width from 4 m to 20 m. have been delineated on the basis of surface evidences. Eleven channels are laid across these mineralised zones. Mineralisation in the area is confined to grey carbon phyllite,</p>

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Table - 7 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
			massive marble, metabasic rock and chlorite phyllite. The sulphide minerals present in the area are pyrrhotite, pyrite and chalcopyrite in order of decreasing abundance and occur as dissemination, vein, stringers and veinlets. The width of sulphide zones along boreholes varies from 3.00 m to 22.20 m and visual estimate of sulphides ranges from 5 to 10%. Analytical results of basemetals pertaining to borehole MPH-1 indicate 0.20% cut off grade of copper zone (6.65 m thick) with 1.14% Cu (average). Analytical results of some of the channel samples also indicate anomalous values of copper and zinc.
Banswara	Area between Bhukia West block in the west and Bhukia east-central block in the east.	Drilling, , sampling	Drilling of 350.25 m was carried out and all boreholes intersected 1.10 m to 9.45 m thick zones containing 5 to 8% sulphides. Mineralisation is mainly associated with alteration zones in the form of dissemination, stringers, veinlets and massive zones of pyrrhotite, arsenopyrite and chalcopyrite. Analytical results of core and channel samples indicate anomalous values of gold and copper.
Banswara	Area between Dungaripara and Nawa Khera	Mapping, pitting, trenching	G-4 stage investigation of gold and associated mineralisation was carried out by mapping 106 sq km area, 225 bedrock samples, 112 petrochemical samples, 57 petrological samples, 11 ore samples and 6 samples for XRD analysis. A total of 27 m <sup>3</sup> of pitting/trenching has also been carried out. The rocks in the study area show a general NW-SE trend dipping towards NE as well as SW. Surface indications of mineralisation include presence of gossan zones, old workings, malachite stains, epidotisation, feldspathisation and silicification. Five gossan zones have demarcated in the mapped area: 1. Gossan at the contact of phyllite and grey dolomitic marble near Undwala village, approximately 600 m long and 20 m wide. 2. Gossan/ferruginised-silicified zone in phyllite/dolomitic marble intercalations near Doliapada village, which is about 500 m long and 25 m wide. 3. Gossan developed at the contact of amphibole marble and bluish grey phyllite, south of Padi-ka-Khera village, which is approximately 250 m long and 25-30 m wide. 4. Ferruginization/gossanization at the contact of grey banded marble and bluish grey phyllite near Sadri village, which is approximately 200 m in length and 20 m in width. 5. Gossan in bluish grey banded phyllite near Padi-ka-Khera village approximately 150 m in length and 20 m in width. Mineralisation has been recorded near Kundli village in ferruginised quartz vein having specks of chalcopyrite and pyrite. A small zone of mineralisation (chalcopyrite along with malachite

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Table - 7 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
			stain) and alteration in the form of epidotisation and feldspathisation has been seen in the banded quartz amphibole rock near village Dharma over a strike length of 10 m and width of 2 m. Anomalous values of REE varying from 829 to 1979 ppm (TREE including Y) have been recorded in 6 samples from granites exposed near Miyasa, Murasel and Goj areas. Analysis of pyrite-bearing grey quartzite to the west of Doliapada recorded Zn content of about 784 ppm. Analyses of two channel samples and five grab samples collected from a 500-m-long and 25-m-wide gossan zone exposed near Doliapada village recorded zinc and lead with concentrations range from 210 ppm to 0.75% and 100 ppm to 0.19% respectively.
Pratapgarh	Mahuri Khera block	Drilling	G-3 stage exploration of gold and associated basemetal mineralisation was carried out by drilling 4 boreholes to a cumulative length of 516.80 m to test the depth continuity of 800m long mineralised (MZ-1) zone. The study was taken up based on encouraging value of gold and copper obtained during previous field work. Surface indications of mineralisation are in the form of gossan, ferruginisation, silicification, wall-rock alteration, old workings and malachite/azurite staining. Fresh sulphides in the form of pyrite and chalcopyrite are recorded in dolomitic marble and tourmalinite bands. Based on these surface indications, seven mineralised zones have been identified. Drilling proved subsurface continuity of the surface mineralisation zones. The sulphide zones (1.10 m to 9.00 m thick) are recorded mainly in the altered dolomitic marble and massive dolomitic marble with sparsely spaced alteration veins. The main sulphide minerals are pyrite, pyrrhotite, chalcopyrite and arsenopyrite in decreasing order of abundance. The sulphide minerals are medium- to fine-grained and occur as fine dissemination, veins, veinlets, stringers and smears. Analytical results of core samples received so far have indicated the presence of 4.25 m thick zone with 0.26% average copper content.
<b>Uttar Pradesh</b> Sonbhadra	East & South East of Bihwaadesh	Sampling	A G4 stage investigation was carried out for assessment of gold and associated mineralisation. Generally foliation-parallel quartz veins host sulphide mineralisation in disseminated form in quartz veins and quartz-carbonate veins intruded phyllite. Sulphide mineralisation is also observed in BIF. Drill core samples of quartz veins contain pyrite, arsenopyrite at various levels in disseminated form. The BIF as banded magnetite chert contains pyrite and arsenopyrite at various

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Table - 7 (Contd.)

State/District	Location	Details of work done	Results obtained/Remarks
<b>Madhya Pradesh</b> Tikamgarh	Gotet area	Mapping & sampling	<p>levels. The analytical results of bed rock samples show gold values ranging from &lt;0.05 ppm to 0.23 ppm in quartz veins, BIF and quartzite. Analytical results of samples of quartz vein exposed in a trench show Au value of 0.23 ppm. The sporadic high values of Cu (<i>i.e.</i> 173 ppm and 195 ppm); sporadic high values of Pb (1355 ppm and 982 ppm); Zn (207 ppm and 147 ppm) and As (3364 ppm, 2122 ppm and 1859 ppm from quartz vein, quartzite and BIF) are obtained.</p> <p>G-4 stage investigation for of gold and associated mineralisation was taken up with an objective of detailed study of shear zone and its environment for Au and sulphite mineralisation. The mapped area exposes rocks of Bundelkhand Granitic Complex (BGC). Hornblende-bearing granite comprises plagioclase feldspar, orthoclase, microcline, hornblende, biotite and quartz. Its composition ranges from monzogranite to granodiorite. The shearing in the area is manifested by development of S-C plane, mylonite and ultra- mylonite. The general trends of shear planes are NW-SE, E-W, NE-SW, and N-S with vertical to subvertical dips. Mineralisation is represented either by vein or disseminated type, which includes minerals like pyrite, chalcopyrite, malachite, bornite, covellite, and sphalerite. Pronounced sulphide mineralisation is confined within the hornblende-bearing granite, which is controlled by NW-SE and E-W-trending shear zone associated with alteration zones. Besides this, quartz veins intruded along the weak planes also contain specks of pyrite, chalcopyrite and malachite. Occurrence of pyrophyllite is also seen along shear zone within granite and quartz vein/ reef. The analysis of bed rock samples shows Au: &lt;25 ppb; Ag: 1 to 5 ppm (12 samples); Pb: 15 to 400 ppm (29 samples); Cu: 25 to 1800 ppm (31 samples); Zn: 25 to 605 ppm (28 samples); Ni: 15 to 265 ppm (22 samples) ; Co: 10 to 165 ppm (30 samples); As: 1 to 11 ppm (29 samples); Bi: 0.1 to 11.5 ppm (40 samples); Mo: 12 to 1086 ppm (5 samples). Investigation is continued.</p>
<b>Maharashtra</b> Gondia	Ghatitola area	Aerial survey, mapping, pitting, trenching, sampling, EPMA & SEM-EDX study	<p>G-4 stage investigation for search of gold and basemetal mineralisation was carried out around Ghatitola, Bothli, Mendki, Ghatbori Teli and Ghatbori Kheri villages . Initially LISS-III (1 RS 1D) Satellite imagery of 150 sq km was studied to delineate structural, geomorphology and drainage pattern of the area followed 50 km<sup>2</sup> of LSM on 1:12500 scale, 1 sq km of DM on 1:2000 scale, 55 soil samples on 50m x 100m grid and 28 m<sup>3</sup> of pitting and trenching. The basement gneisses are intruded by brecciated quartz veins. In the study area, towards 1 km SW of Ghotitola village a metapyroxenite body of 500 m x 300 m dimension is exposed and shows minor sulphide mineralisation. Primary sulphides such as chalcopyrite and pyrite are observed in fresh outcrop. Secondary sulphides like bornite(?) and covellite are found, whereas, malachite is present as surface smears. Amphibolite also shows malachite stains at certain places. In some relict pyroxenes of metapyroxenite, sulphide minerals are found deposited along these cleavages and fractures. Ore microscopic studies of metapyroxenite reveal that</p>

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EXPLORATION & DEVELOPMENT

Table - 6 (Concl.)

State/District	Location	Details of work done	Results obtained/Remarks
Sindhudurg	Kudal-Kasal Kunkavle-Vagde area	Mapping, sampling, SEM-DEX study	<p>sulphides <i>viz.</i> (descending order of abundance) chalcopyrite, pyrite, sphalerite, covellite and pentlandite; occur as fine disseminations. Ilmenite surrounded by sphene is also observed. SEM-EDX studies of metapyroxenite show lautite and telluride grain occurring within the chalcopyrite. Chalcopyrite, pyrite, sphalerite, galena, pentlandite and iron oxides phases have been identified under EPMA. Out of 23 bedrock samples analysed, only 08 samples (metapyroxenite) show presence of Au; its concentration varies from 30 ppb to 130 ppb. Cu concentration varies from 1000 ppm to 0.15%. The Au value in all the soil samples and trench samples analysed, is below detection limit. The analytical results show that metapyroxenite of Ghotitola does not carry any significant anomaly of Au. Overall nature of mineralisation is very sporadic and it is restricted to a few patches within the metapyroxenite. Investigation has been completed.</p> <p>G-4 stage reconnaissance survey for Au, PGE, Ni and Cr in Precambrian terrain of Kudal-Kasal-Kunkavale-Vagde area was carried with the objective to target causative bodies for Au, PGE, Ni and Cr anomalies reported in FS 2001 to 2003. This was a two FS programme initiated in FS 2014-15. Large-scale mapping (1: 12500) of 70 sq km area has been carried out along with collection of 75 BRS, 84 SSS and 20 PGE samples for geochemical analysis. Besides, 10 samples each for PS, PCS, ORM, SEM and EPMA studies were also collected. The area is located in 4 blocks namely i) Kudal ii) Kunkavale-A iii) Kunkavale-B and iv) Kunkavale-C and it exposes a variety of rocks belonging to older supracrustals (talc-tremolite schist, amphibolite), TTG suite of gneisses, younger supracrustals (BIF, quartzite), gabbro, quartz vein and pegmatites; Kaladgi Supergroup of rocks (sandstone and shale) and Deccan lava flows. TTG suite of gneisses, granitoids, migmatites carrying enclaves of BIF, amphibolites and ultramafites forms the basement for a suite of supracrustals. All the rocks have discontinuous capping of laterite over them. Significant results for Au, Ni &amp; Cr are reported only from Kudal block and PGE from Kunkavale-A block. In Kudal block, Au value varies from &lt; 25 to 62 ppb. The maximum value of gold (62 ppb) was recorded in a sample (BRS) from Banded Iron Formation. The other higher values of 43 ppb and 36 ppb of Au are from laterite and BIF respectively in the same block. Twelve BRS from Kudal block have Cr values &gt;500 ppm and 3 BRS have Ni &gt;300 ppm in them. The highest value of Ni is 988 ppm in BRS and 996 ppm in SSS whereas the highest value of Cr is 3070 ppm in BRS and 3292 ppm in SSS in Kudal block. The maximum values of platinum (Pt) 114 ppb, palladium (Pd) 212 ppb, iridium (Ir) 14 ppb, ruthenium (Ru) 34 ppb and rhodium (Rh) 22 ppb are recorded in the BRS from laterite in Kunkavale-A block. The causative body for higher values of Cr and Ni in Kudal block is curvilinear mafic-ultramafic body. In Kunkavale-A block, the causative body for higher values of PGE is laterite which may be underlain by ultramafic rocks. Based on the analytical results of BRS and SSS, the outline of the causative mafic ultramafic body has been demarcated. In SEM-EDX studies, native Au, pyrite, arsenopyrite, Ni-phases have been identified.</p>

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**Table -7: Exploration for Gold by HGML, 2015-16**

State / District	Location	Agency	Details of work done	Results obtained
<b>Karnataka</b>				
Raichur	Hutti	HGML	Underground mapping - 1954 m on 1:400 scale; trenching 02 nos- 62 cu m; surface drilling - 1543 m (09 boreholes); underground drilling - 2700 m (25 boreholes) collection of samples 13732 nos; and exploratory mining - 4854.90m.	As on 31-03-2016, reserves of gold ore were estimated at 9.39 million tonnes with 5.34 g/t Au
-do-	Hira-Buddini Manavi Taluka	HGML	Exploratory mining - 78.80 m and samples analysed - 900	About 0.475 million tonnes of proved reserves of gold ore with 3.94 g/t Au were computed.
-do-	Uti, Deodurg Taluka	HGML	Exploratory mining - 443.00 m and samples analysed - 1,403	Total minable reserves are estimated at 2.17 million tonnes ore with 2.59 g/t Au.

**Table - 8: Exploration for Industrial Minerals by GSI, DGMs and Central/State Undertakings, 2015-16**

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Geological Survey of India</b>							
<b>ANDALUSITE</b>							
<b>Uttar Pradesh</b>							
Sonbhadra	Salaidih- Harwariya area	-	-	33	-	32	A G2 stage detailed exploration was carried out. The rocks comprised of andalusite-bearing phyllite and quartzite of Parsoi formation, Mahakoshal group. Andalusite occurs as porphyroblasts crystals of length > 2 cm and width around 0.7 cm. All boreholes drilled indicate andalusite mineralisation from surface to 60 m depth. Length of crystal noted up to even 27 cm within phyllite and schist. As per visual estimate, andalusite content may vary from 2% to 20%. The chemical analysis of andalusite bearing phyllite show high alkali (Avg. 6.2%), high iron (avg. 6.6%) and low alumina (average 26%).

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Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling	Sampling	Remarks	
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Geological Survey of India</b>							
<b>LIMESTONE</b>							
<b>Chhattisgarh</b>							
Raigarh	Kharri-Parsadih block	1:4000	8.5	50	-	-	G2 stage exploration was carried out for assessment of limestone. The limestone is grey to dark grey in colour, finegrained in nature, and compact, bedded and at places massive. The area is mostly covered by soil. Few exposures of limestone and shale are observed. Boreholes drilled in grid pattern at an interval of 400 m, each with 30 m average depth. Out of 50 boreholes, 29 boreholes are positive, 06 boreholes are economically significant in which limestone has been intersected from 2 to 12 m bgl and continued up to 30 m bgl. The thickness of limestone varies from 18 to 28 m. CaO content of bedrock samples of limestone varies from 39% - 46.31%, SiO <sub>2</sub> content varies from 13.31% to 19.28% and MgO varies from 1.15% - 1.57%. The project is completed.
<b>Gujarat</b>							
Junagarh	Khodada, Khambaliya block	-	-	-	63	2057	G2 stage investigation was carried out to assess SMS/ Cement-grade limestone in the area. Chaya limestone is the only exposed litho unit. The limestone is white to dirty white, porous, and highly fossiliferous. During the course of investigation, 2057 m was drilled in 63 boreholes. Chemical, SMS and Cement-grade limestone has been intersected.
<b>Himachal Pradesh</b>							
Solan	Upper Karol Formation	-	-	-	-	-	A G4 stage investigation of limestone/ dolomite was carried out. Geochemical samples were collected to assess the quality of limestone/ dolomite bands of Krol 'C' and Krol 'D' Members of the Krol Group exposed around Pachmunda, Krol, Khanog and Rajgarh synforms. Analytical results, indicate CaO content varies from 28.78% to 39.7%, MgO content varies from 12.78% to 19.9% and SiO <sub>2</sub> varies from 0.05% to 4.71%. On the basis of CaO/MgO ratio, most of the samples fall in 'slightly calcitic-dolomite' to 'calcitic-dolomite' categories.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling	Sampling	Remarks	
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Jammu &amp; Kashmir</b>							
Udhampur	Batot-Sudh Mahadev- Latti area	-	-	-	-	-	A G4 stage survey for Baila Limestone was carried out. The limestone bands of the Baila Formation delineated from Sudh Mahadev to Jakhed for a strike length of 15 km shows 15 to 120 m thick greyish, thinly to very thinly bedded limestone with argillite intercalations or partings. The analytical results of the limestone samples, indicate average value of CaO 38.91%, MgO 1.8%, Al <sub>2</sub> O <sub>3</sub> 3.3%, Fe <sub>2</sub> O <sub>3</sub> 1.8% and SiO <sub>2</sub> 11.56 %.
<b>Madhya Pradesh</b>							
Morena & Shivpuri	Sabalgarh & Garhi area	1:50000 1:12500	200 50	-	-	-	Mapping was carried out to assess cement grade limestone. The area exposes sediments comprising of ferruginous shale, limestone, blue shale, stromatolitic limestone, variegated shale at lower part; sandstone of Lower Bhandar Group of Vindhya on the top. It was noticed that limestone occurs throughout the area, quality wise cement-grade limestone occurs in Garhi-Upcha area where CaO content of 6 BRS/channel samples collected from massive limestone is 38.38%, 39.51%, 40.64%, 40.95%, 45.84%, 47.29% with average of 42.10%. CaO content of 8 channel samples from Badretha area is 34.65%, 34.71%, 42.61%, 42.67%, 42.95%, 42.98%, 46.03% and 46.02% respectively. The first two above mentioned samples with low CaO content are from Bakaspur area which lies in NW corner of the Badretha Block. Two bedrock samples of stromatolitic limestone area yielded 42.95% and 42.98% CaO content. Dolomitisation of brecciated limestone exposed in Upcha - Garhi area was noticed. Heavy minerals including zircon, epidote, pyrite and rutile were also observed. Limestone exposed in north-western part of Sabalgarh town is impure, however towards south-western part the thickness of limestone in Garhi- Upcha area varies from 8 m to 20 m. In eastern part of Sabalgarh area the thickness of limestone varied from 20 to 40 m in Garpera-Jalalgarh area. A total of four potential blocks. I. Garhi-Upcha block, II. Gulali block, III.

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Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
							Badretha block and IV. Hirawale block. Out of these blocks. Garhi-Upcha block has maximum resource of 159.45 million tonnes of limestone with 38.38%-47.29%CaO; Badretha Block has 129.5 million tonnes of limestone with 34.65%-46.03% CaO; whereas Hirawale Block has minimum resource of 20.57 million tonnes of low-grade limestone with 37.68%-38.99% CaO. However, Gulali block exposes stromatolitic limestone, which is cherty and siliceous in nature with 33% CaO.
<b>Meghalaya</b>							
Jaintia Hills	Um-Maju block, West of Litang river	- 1:12500	1.5 50	10	918	-	G2 stage exploration was carried out by detailed mapping and drilling. The Upper Sylhet Limestone (Prang Limestone) which is the most important limestone horizon varies in thickness from 52 to 69.70 m with an average thickness of 58.64 m as intersected in ten boreholes. Additionally, Middle Sylhet Limestone (Umlatdoh Limestone) underlying Upper Sylhet Limestone (Prang Limestone) varies in thickness from 11.65 m to 15.55 m with an average thickness of 13.74 m. The Upper Sylhet Limestone (Prang Limestone) is classified into Cement (Portland), SMS (OH & LD), Chemical grades and the Middle Sylhet Limestone (Umlatdoh Limestone) is classified into Cement (Portland), and SMS (OH) grades.
Jaintia Hills	Jalaphet block Litang valley	-	1.5	-	902	-	G2 stage detailed investigation was carried out. The thickness of Prang Limestone varies from 23.70 m to 111.50 m with an average thickness of 70.57 m. the limestone was classified as Cement (Portland) grade, Cement (Blendable) grade & SMS (OH) grade.
East Jaintia Hills	Shyrwang block Litang valley	-	3	-	1816.75	-	G2 stage detailed investigation was carried out by detailed mapping and drilling. Prang limestone of cement grade of huge thickness is exposed in the area. The upper sylhet limestone which is the most important horizon varies in thickness from 14.45 to 120.40 m (Average thickness 94.57 m).

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Rajasthan</b>							
Jaisalmer	Jiraj ka Toba- Asu Tar (southeast) block	1:5000	7	25	1200	-	A G3 stage investigation for SMS/ Cement grade limestone was taken up by detailed mapping & drilling. The main lithounits recorded are hard foraminiferal limestone, fragmentary ironstone and gritty sandstone. The borehole drilled in grid pattern of 500 m × 500 m, depth varies from 40 m to 60 m below ground level (bgl) depending upon intersection of limestone. Rocks intersected in boreholes are sub-bentonitic clays, impure clayey limestone, gritty limestone, hard and compact limestone, fragmentary ironstone. Visually it is interpreted that about 40% - 50% of limestone intersected will be of SMS (LD) grade. Two to 4 bands of hard and compact limestone and impure clayey limestone have been intersected in different boreholes. Thickness of limestone band intersected in different boreholes varies from 15 m to 29 m and limestone is intersected from 0.50 m to a depth of 58.73 m below ground level.
Jaisalmer	Minyun ki Dhani(North) area	1:5000	4	16	800	792	G3 stage investigation for SMS/ Cement grade limestone was carried out. The area forms flat topography with isolated exposures of bioclastic limestone, clayey foraminiferal limestone, fuller's earth and ironstone fragments. Selenite variety of gypsum is also observed at a few places on the surface as well as in borehole intersection. Boreholes were drilled in a grid of 500 m × 500 m down to a depth of 50 m. Visually it is interpreted that about 20% of limestone intersected will be of SMS (LD) grade. 1 to 2 bands of hard and compact limestone and impure clayey limestone and chalky limestone have been intersected in different boreholes. Thickness of limestone band varies from 25 to 40 m and limestone was intersected from 2 m to a depth of 50 m bgl.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
Jaisalmer	Minyun ki Dhani(Main block)	-	-	50	2500	2203	G2 stage exploration was carried out for evaluation of SMS/ Cement grade limestone deposit. Tertiary limestone, known as Khuiala Limestone occurs in the form of a sickle shaped exposure covering more than 900 sq km area and assessed largely as chemical/SMS grade. The fragmentary ironstone is developed in the north-eastern part of the area. Small exposures of light pink to pinkish white, hard and massive nodular limestone were reported in the southern part of the area. Drilling was carried on 330 m × 330 m grid pattern. All the boreholes have intersected both hard and compact limestone which is expected to be of SMS grade and impure limestone which is expected to be of cement grade. Hard and compact limestone has been encountered in the form of bands in the impure limestone, whose thickness varies from 1 m to 16 m along borehole. Thin bands of gypseous clay also have been recorded in the boreholes located in the northern parts of the area.
<b>DUNITE</b> <b>Tamil Nadu</b> Namakkal & Thirchirapalli	Valasiramani West blocks	1:5000 1:12500	5 50	13	757.75		G3 stage investigation was carried out with an objective to demarcate all the dunite bodies to bring about their disposition and assess dunite resources. The dunite bands occurs as a linear band between Ichchavari in the west and Kalingappatti in the east over a strike length of about 20 km with an average width of 60 m. The western continuity of the dunite band was traced from Valasiramani to Ichavari for a strike length of 10 km, in which three potential dunite bands with width of more than 50 m were identified. These bands were named as segments "A", "B" and "C". "Segment A" starts from west of Valasiramani village and extends to south of Okkarakuttai, and the dunite band was traced for a strike length of 1.75 km. A total of 8 vertical boreholes were drilled. The dunite band width of and the rig was shifted to segment "B" where 5 boreholes viz. VIR-1 to 5 were drilled. The 0/0 pillar was

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		

Namakkal &  
Thirchirapalli (Contd.)

made on Viralipatti outcrop where the outcrop width of dunite band is 145 m. The baseline for 4 km was made in E/W direction and the dunite band was traced for 1 km with outcrop width varying between 40 m and 125 m. Further westerly in Kavakarapatti area (Segment C), the dunite band was traced for 2 km with outcrop width ranging between 20 m and 100 m. Detailed mapping carried out in Segment "C" has identified three prominent dunite bands. The southern band traced from Viralipatti (Segment B) has thinned to a thickness of <40 m westerly and swells to a maximum thickness of 100 m in Kavakarapatti (Segment C) and continues further westerly up to south of Ichavari where it thins to <20 m. The northern band (occurring 40-50 m north of the southern band) at Viralipatti (Segment B) thins out westerly to <20 m and swells to a maximum thickness of 125 m in Kavakarapatti area (Segment C) and thins to <20 m further west and continues up to Ichavari. Apart from these two dunite bands an additional band was delineated from Ichavari in the west to Kavakarapatti in the east with an average thickness of 50 m. Serpentinised/altered dunite occurs between 18 m and 23 m, followed by occurrence of fresh/unaltered dunite. Analytical data of boreholes VMW-1 and VMW-3 indicate that all the samples show  $MgO/SiO_2 \geq 1$ , which is suitable for flux in iron and steel industry. In borehole VIR-1, 4 bands of dunite with  $MgO/SiO_2 \geq 1$  and width varying from 1 m to 7 m are found with intermittent pyroxenite bands. Based on  $MgO/SiO_2$  ratio, the Segment "A" is enriched with high-magnesium minerals compared to dunite band of Segment "B". Resource estimation of dunite in the Valasiramani West Block will be done after receipt of complete analytical data.

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Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>GLAUCONITE</b>							
<b>Bihar</b>							
Kaimur	South of Adhaura	1:12500	-	-	-	-	G4 satge investigation was taken up to delineate the Potash bearing zone with estimation of glauconitic sand stone resources. The lithounits of the area are brecciated banded haematite chert (BHC) of Agori Formation of Mahakoshal Group, olive shale and khakhi splintery shale of Kheinjua Formation, Cherty stromatolitic limestone of Fawn Limestone Formation and fine to medium grained glauconitic sandstone and siltstone intercalated with green shale of Glauconitic Sandstone Formation. Acid volcanics/ volcanoclastic horizons sandwiched between clastic sedimentary horizons were seen within the beds of Glauconitic Sandstone Formation. Glauconitic mineralised zone of strike length of 500 m with an average width of 50-60 m has been identified in glauconitic sandstone in Chutia area. Glauconite is seen in grain form, pelletal form as well as filling material in void spaces. The mineralized zone was also observed near village Ghamaria in strike continuity of the above mentioned zone. The cumulative strike length of the mineralised zone is approx 3 to 3.5 km. The analytical result of 117 samples have been analysed with highly encouraging results showing K <sub>2</sub> O concentration upto 13.79% (28 samples yielded K <sub>2</sub> O content more than 5% and 62 samples yielded more than 4% of K <sub>2</sub> O. Two samples collected from different depths of a dug well at Tiura exposing more than 5 m thick glauconitic siltstone yielded K <sub>2</sub> O concentrations of 13.71% and 13.79%. The glauconitic siltstone further continues along the depth of dug well. At Banahi at the contact of Fawn Limestone, glauconitic siltstone yielded 13.02% of K <sub>2</sub> O. This is a prospective block for further exploration.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Madhya Pradesh</b>							
Sidhi	Vindhyan Super group of rocks	1:12500	58	-	-	36	G4 stage preliminary investigation was continued from earlier field session to delineate glauconite bearing strata in vindhyan super group of rocks. The various rock types of the mapped area are sandstone, limestone and glauconitic shale of Semri Group of Vindhyan Supergroup and a transition zone between Kaimur and Semri groups of Vindhyan Supergroup, represented by an interbanded sequence of sandstone and carbonate rocks. Rocks exposed near village Khunteli are welded tuff and few bands of volcanic rocks with phenocrysts within them. The glauconite-bearing shale was noticed all along the southern portions of the area in intercalation with limestone of Bargawan Formation. The maximum thickness of bands was up to 5 m and minimum varied from 15 to 16 cm. Three major bands were traced along with minor intercalations in between. Glauconitic sandstone was also traced in intercalation with the above package of Bargawan Formation. An experiment about direct application of glauconitic shale as fertilizer was initiated by cultivating potatoes. Earlier in FS 2014-15, a tentative resource of glauconitic shale in and around Barsatiya-Bichhiya-Digghar village section was estimated at 1.8 million tonnes (average 7% K <sub>2</sub> O) for 1200 m x 400 m spatial domain. Investigation has been completed.
<b>Rajasthan</b>							
Madhopur & Karauli	Madhopur & Karauli	12500	150	-	300	403	As a part of G4 stage exploration, 403 bed rock samples including 80 pitting/trenching samples, 225 core samples for chemical analysis, 37 rock samples from different lithounits for petrographic study and 5 rock/mineral samples for XRD analysis were collected. The study area lies in Sapotra-Gunushri syncline and the general strike of the rocks is NE-SW with moderate dip towards NW and SE. The detached band of glauconitic sand stone is noted near Mahauli for a strike length of 2 km with thickness varying

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
Madhopur & Karauli (Contd.)							<p>from 1 to 2 m. The maximum content of <math>K_2O</math> in olive-green Panna shale is 5.65% near Bapoti and 4.95% near village Kanotipura. Two scout boreholes were drilled in Panna shale near Bapoti and Kanotipur, respectively. Olive-green shale continues up to a depth of 30 m bgl. Olive-green shale is the most potential rock for potash content. Analytical results of 17 BRS show <math>K_2O</math> content in the range of 5.81 to 2.39 % with average value of 4.63%. A total 5 scout boreholes were drilled in Jhiri Shale, with maximum depth of 45 m near village Gothra where olive-green shale continues up to a depth of 45 m. Glauconitic sandstone extends for a strike length of 4 km from Grain to Saimarda. Two scout boreholes were drilled. Glauconitic sandstone is encountered in RKS-7, between 5 and 6.50 m bgl. In sandstone glauconite occurs in the form of alternate lenses, which vary in thickness from 1 to 5 mm. The maximum value of <math>K_2O</math> analysed in Targarh sandstone is 3%. Petrological study indicates that glauconite mineralisation in Panna Shale and Jhiri Shale is of disseminated type and is very fine in nature. The analytical result of 33 bedrock samples indicates that maximum concentration of potash in olive-green shale of Panna and Jhiri formations is 5.65% and 5.81% respectively. Four potential zones have been demarcated: (i) olive-green shale of Jhiri Formation having strike continuity of about 12 km from Adadungar to Ramapura Ghati, (ii) olive-green shale of Jhiri Formation having strike continuity of about 4 km from Gothra to Grain, (iii) olive-green shale of Panna Formation having strike continuity of about 1.5 km near Bapoti, (iv) olive-green shale of Panna Formation having strike continuity of about 1.5 km near Sapotra. The chemical analytical results are awaited.</p>

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## EXPLORATION &amp; DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Glauconite</b> Uttar Pradesh Sonbhadra	Barwadih Kurchha area	-	-	29	1015	-	A G2 stage exploration was carried out to delineate glauconite-bearing mineralised zones in glauconitic sandstone/shale of Vindhyan Supergroup. Twenty-one drill holes with total 735 m drilling in Barwadih Block and 8 drill holes with total 280 m drilling in Kurchha Block were drilled in 100 m × 100 m grid pattern, each with 35 m average depth. Glauconite mineralisation was noticed in coarse- to medium-grained glauconitic sandstone. The volume percentage of glauconite decreases 15-25 m below the surface. On the basis of available data, K <sub>2</sub> O content of bedrock samples collected from Patwadh area varies from 1.28% to 6.52% with average 4.35% in glauconitic sandstone.
<b>Graphite</b> Arunachal Pradesh West Siang	Khetabari and Ragidoke	1:12500 1:2000	55 0.76	02	400	-	G3 stage investigation of graphite was carried out by large-scale mapping and detailed mapping. Graphite is of amorphous nature, schistose and mixed with carbonaceous phyllite. The schistose bands of graphite are 1-3 cm thick as partings within carbonaceous phyllite. Flakes of graphite are 2-5 mm in length. Three discontinuously exposed lenses of carbonaceous phyllite hosted graphite schist were delineated over a cumulative strike extension of 5.5 km with an average width of 30 m in the Tai-Tachidoni area. Analytical results of the samples are awaited.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Madhya Pradesh</b> Betul	Tikar-Chiklar- Gauthana area	-	-	12	-	-	A G-2 stage exploration was taken up to establish the main geological features of graphite occurrence and to provide an estimate of size, shape, structure and grade. A total of 12 boreholes were drilled in the parts of southern and central graphite band, covering 1.25 km strike length. The graphite resources in both the southern graphite band (in parts) and central graphite band have been estimated by longitudinal vertical section method and cross checked by cross section method. Resources under UNFC category 332 as 6.25 million tonnes with an average of 8.79% FC and 6.21 million tonnes with an average of 8.79% FC respectively have been indicated for southern band. Similarly in the central graphite band, under resource UNFC category 333, as 4.69 million tonnes with an average of 11.15% FC and 4.69 million tonnes with an average of 11.15% FC has been inferred, respectively. Besides a reasonable quantity of graphite ore is expected from remaining 2.25 km strike length falling within the forest boundaries. Magnetic separation of non-conductor fraction yielded a concentrate assaying 0.88% La with 69.1% La recovery, 0.89% Ce with 73% Ce recovery, 0.65% Nd with 85.3% Nd recovery, 0.18% Gd with 52% Gd recovery, 0.15% Yb with 66.2% Yb recovery, and 1.35% Y with 64.9% Y recovery (wt.%)

(Contd.)

EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
Betul (Contd.)							yield: 0.13). The enrichment ratio of rare earth elements from the original sample to the concentrate is 530 for La, 559 for Ce, 714 for Nd, 400 for Gd, 517 for Yb, and 500 for Y. Froth flotation of graphite flotation tails using 1.33 kg/t sodium oleate as collector yielded a calcite concentrate assaying 43.23% CaO, 3.7% Al <sub>2</sub> O <sub>3</sub> , 15.02% SiO <sub>2</sub> , 0.048% P <sub>2</sub> O <sub>5</sub> , with 31.4% CaO recovery (wt. %). yield: 12.6). The calcite concentrate obtained may find application in cement industry. Thus recovery of graphite and recovery of rare earth minerals and calcite as by-products from graphite surface sample may step towards achieving zero waste mining. The investigation has been completed.
<b>Tamil Nadu graphite</b> Sivaganga	Arasanur (village) block	-	-	12	1181.25	765	A G3 stage reappraisal of graphite by drilling was taken up to investigate the depth persistence of graphite mineralisation proved during earlier FS 2004-08 and to evaluate the graphite resource potential of this block. Pitting and trenching work (100 m <sup>3</sup> ) was also carried out and 49 pit-trench samples were collected. A total of 779.70 m of geophysical logging of all the 12 boreholes except AGB-5, 8, 10, 11 has been carried out. All the boreholes (both first and second level) except AGB-1 proved depth persistence of graphite mineralisation at 60 m & 30 m below ground level.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling	Sampling	Remarks	
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>GSI</b> <b>GYPSUM</b> <b>Chhattisgarh</b> Bemetara	Akola-Patora- Bhusandi- Karesara area	1:12500	100	09	309.5	95	G3 stage preliminary investigation was taken up in this area. Ferruginous shale is the only lithounit observed in the mapped area. Repeated occurrence of ferruginous shale and calcareous shale is considered as primary depositional plane/surface. Strike of ferruginous shale is NNW-SSE with low dip of 2°-8° towards SW. Both massive and bedded type gypsum are observed in all the boreholes. A total of 30 BRS, 15 PCS and 45 core samples have been submitted for chemical analysis and 5 XRD samples for mineral phase identification of gypsum. As per the chemical analysis, 68.32% to 79.31% gypsum has been intersected in 10 zones between 121.3 m and 201.2 m depth in BH 1 at village Khati. Gypsum horizon of 72% to 77.82% has been intersected in 2 zones between 135.25 m and 169.4 m depth in BH No. 2 at village Ghiwri. Gypsum horizon of 73.41% to 82.76% has been intersected in 5 zones between 219.1 m and 242.15 m depth in BH 4 near Khursbod. Gypsum horizon of 81.86% to 83.61% is intersected in 2 zones between 82.8 m and 96 m depth in BH- 5 near Bemetara.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Uttar Pradesh</b>							
Jhansi & Hamirpur	Banda alluvium- Kotra & Puraini block	-	-	-	-	-	G4 stage preliminary investigation was taken up into Kotra block and Puraini block. Near Puraini, calcrete-rich clay horizon occurs at 1-2 m depth. Target areas for gypsum investigation had been identified in the clay beds along the Betwa River near Kotra Ghat. Gypsum crystals (selenite) had been collected from south and SSW of Puraini village. Within Kotra Block, homophanous granite and porphyritic granite are exposed along Betwa river bed. About 10 cm exposed length of clay beds was observed along the river section near Kotra Ghat at two places. These bands contain massive variety of gypsum (alabaster). The Puraini Block consists of mostly flat agricultural land. Gypsum crystals (selenite) were collected from about 800 m south of Puraini and 200 m SSW of Puraini. Few mm to 6- to 8-cm-long selenite crystals occur at barren paddy field in scattered manner.
<b>PYROPHYLLITE</b>							
<b>Madhya Pradesh</b>							
Chhatarpur	Sarkana- Banpura- Nandgaon area	1:12500	100	-	-	214	G4 stage investigation for pyrophyllite- diaspore in quartz reef in BGC was taken up with objectives to demarcate various rock types hosting pyrophyllite and diaspore mineralisation in BGC and to study mineralogy, geochemistry & mode of occurrence and to attempt classification of pyrophyllite. Pyrophyllite mineralisation observed in the area was closely associated with N20°-35°E plane. In Banpura area an altered zone 15 m × 3 m was noticed which could possibly host pyrophyllite mineralisation and in village Imaliya an old working was seen where well-developed crystals of quartz were observed in veins. In Nandgaon area, a long shear zone of dimension about 5

(Contd.)

EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling	Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age	
Chhatarpur (Contd.)						<p>km × 1 km of dextral sense was delineated from NE of Nandgaon to the north of Gora Tal. Although epidotisation was seen in granite as well as in quartz reef but pyrophyllite development was seen within granites only. Another altered zone, of dimension about 250 m × 15 m along south-western part of the same shear, was delineated around 2 km SSE of Nandgaon. Development of pyrophyllite as well as sulphide mineralisation seen in the area is related to shearing. Pyrophyllite mineralisation was also observed in association with NE-SW-trending quartz reef around village Maqbara. Close to the above major shear zone, sulphide mineralisation in the form of pyrite, pyrrhotite and chalcopyrite disseminations was also noticed in hornblende-rich porphyritic granite. Another rich sulphide mineralisation was also seen in a well section where it occurs as vein-type deposit in older metamorphic rocks (calc-silicate gneiss) south of Pipariya. Three different shear zones trending N30°E (major shear), NS and N20°W have been delineated west of Mahewa and SE of Maqbara. Out of 112 BRS, 50 PTS and 15 PCS samples, analyses of 38 BRS, 8 PTS and 6 PCS samples have been received so far. Out of 38 BRS only 4 BRS indicated encouraging value of Al<sub>2</sub>O<sub>3</sub> which varies from 44.04% to 57.21% and rest of the values are not encouraging.</p>

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>State Directorates of Geology and Mining</b>							
<b>LIMESTONE</b>							
<b>Chhattisgarh</b>							
Raipur	Kesla area	1:50000 1:4000	80.00 1.74	38	1178.10	1260	Estimated 5.37 million tonnes of cement grade limestone indicated mineral resources and 69.91 million tonnes of limestone under inferred mineral resources.
Rajnandgaon	Tekapar- Kalkasa area	1:50000 1:4000	100.00 1.00	41	1272.59	1340	Estimated 7.09 million tonnes of cement grade limestone indicated mineral resources and 44.027 million tonnes of limestone under inferred mineral resources.
Janjgir-Champa	Dhabadih-II	1:50000 1:4000	405.00 3.00	41	1276.60	1121	Estimated 74 million tonnes of cement grade limestone under inferred mineral resources.
Bastar	Chitapur area	1:50000 1:4000	215.00 1.20	39	772.55	459	Estimated approximately 10 million tonnes of limestone under inferred mineral resources.
<b>Rajasthan</b>							
Ajmer & Nagaur	Pilwa, Chinwali, Dhandota, etc Villages	1:50000 1:10000 1:2000	200 15 2	-	-	31	Geologically rocks of the area belong to Ajabgarh. Group of Delhi Supergroup. General trend of rock formation is NE-SW with 50° to 70° dips due west. Two dolomitic limestone bands measuring 780 x 80-100 m and 500 x 90-100 m (highly ferruginous) were mapped near village Mehgaon.
Ajmer (Limestone & Dolomite)	Shyamgarh Pakriyawas, Kanakheda, Kesarpura etc. Beawar Tehsil	1:1000 1:2000	10 3	-	-	91	General strike of rock formation in NNE-SSW with 70° to 80° due westerly dips. 12 parallel limestone bands measuring about 780x55-60m, 900x45-65 m, 1250 x 40 - 50 m, 1000 x110 -120 m, 550x75-80 m, 780x90-220 m, 800 x 45 - 60 m,1900 x 25 - 60 m, 1150 x 55 - 60 m,1900 x 130 - 450 m, 2100 x 400 - 800 m were mapped from village Kesarpura in the north to village Karwai in the south.
Alwar	N/v Dangarwada, Dhamrer, Thonsra, Digawada, Todagyansingh,	1:50000 1:10000 1:4000	100 10 3	-	-	44	Limestone trending NE-SW exposed N/v Shimbhukabas, Fatepura, Kharkhari Chavand Singh, Doroli, etc. Limestone worked extensively in old pits with an average depth of 25 m.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling Bore- holes	Sampling Meter- age	Remarks	
		Scale	Area (sq km)				
Jaisalmer	N/V Sam	1:50000	50	26	1200	763	Objective of exploration was to assess the quality & quantities of SMS & cement grade limestone. The limestone is horizontally disposed. It is cremish, pinkish + whitish in colour, hard & compact; chalky fossiliferous in nature. About 257.88 million tonnes limestone resources have been estimated out of which 55.49 million tonnes of SMS grade limestone and 202.39 million tonnes of cement grade limestone.
		1:10000	15				
		1:2000	04				
Jaipur & Alwar	N/v Bithoda, Mandha, Karoi, Bhankri, Nayabas, etc	1:4000	1.25	9	672.5	119	Estimated tentatively about 51 million tonnes indicated and 23 million tonnes inferred categories resources in Bhaisalana & Kujota blocks.
Bundi (Limestone, Clay, Silica sand, etc)	N/v Kathoda, Mani, Mishan Pura, Sodanpura, Kalyani, Karwar, Ariali, Antarda, etc. Tehsil Nainwa	1:50000	150	-	-	-	-
		1:10000	15				
		1:4000	1.5				
Tonk (Limestone & Dolomite)	Near village Khalilpura, Dodwari, Davri, Jabriya etc. Tonk Tehsil	1:10000	10	-	-	25	Limestone band interacted with calcsilicate, calc-schist/ calc-gneiss and mapped alternatively N/v Khalilpura and Dodwari measuring about 400 x 45 -50 m, 600 x 52-55 m, 100 x 40-42 m , 320 x 35-40 m, 100 x 30-35 m, 140 x 60-62 m, 60 x80-82 m, 68 x 25-30 m, 82 x 55-60 m.
		1:2000	3				
Dungarpur	Rama,Dad, Munger Sabla, Bhatoli, Teh Aspur & Sabla	1:5000	150	8	807	250	-
		1:10000	10				
		1:4000	2.5				
Chittorgarh	Rasulpura-	-	-	15	611	203	-
Sawai Madhopur	N/v Pali Dharampuri, Bohna, Sonkachh & Narola, Khandar Tehsil	1:50000	100	-	-	4	Limestone was seen along Chambal river bed in about 3000x250-850 m area N/v Pali; in about 2000 x 50-400 m area N/v Bohana; in about 800 x 300-500 m area in Dharampuri; 1800 x 10-80 m area N/v Sonakachh & about 150 x 15-20 m area N/v Narola, Tehsil Khandar.
		1:1000	10				

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Maharashtra</b>							
Chandrapur	Kondala	1:50000	5	18	1701.15	112	Analytical results awaited.
	Teh - Warora	1:5000	4				
	Jewara Tulsi	1:50000	10.42	10	1647.25	32	Analytical results awaited.
	Teh - Korpana	1:5000	2.80				
Yavatmal	Welabai Kurai	1:25000	26.15	54	4975.45	81	The limestone bands are observed alternately with Dolomite, Magnesium Limestone & argillaceous limestone bands. The limestone band range in length from 600 m to a kilometre and have a width range of 10 metre to 40 metre. The thickness of limestone beds in these bands ranges from 1 to 15 metre.
	Kurli block	1:5000	2.8				
<b>BENTONITE</b>							
<b>Rajasthan</b>							
Barmer	Pusad, Junejo ki Dhani	1:50000	200	-	-	16	N/v Junejo ki Dhani, the thickness of bentonite varies from 1.5 m to 2.2 m and extending up to 600 m length. Near village Pusad with thickness up to 8 m and occurring in 2200 m x 900 m area. Physical test result shows Gel value 12 ml to 31 ml, swelling index value 10 ml to 20 ml, apparent viscosity value 9 cp to 65 cp, plastic viscosity value 3 cp to 10 cp and ph value - 7.5.
		1:10000	12				
		1:2000	3				
<b>SILICEOUS EARTH</b>							
Barmer	Bhoja Bhakri	-	-	-	-	-	Siliceous earth is exposed in nala section and excavated pits near Ratta Kumharo ki Dhani & east of Bhojha Bhakhari. East of Bhojha Bhakhari, it is occurring up to 150 m in length and 10 m to 40 m in width below thin layer of soil. It is white in colour, fine grained in texture and light weight.
<b>CLAY</b>							
<b>Rajasthan</b>							
Bhilwara	Undwa- Ojhara	1:10000	5	-	-	24	-
		1:4000	2.25				
	Bhakliya- Chandgarh	<b>1:10000</b>	10	-	-	-	-
	Jeewakhera Nahargarh	<b>1:10000</b>	5	-	-	-	-

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling	Sampling	Remarks	
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>Red ochre and Laterite Rajasthan</b>							
Banswara	Near village	1:50000	100	-	-	-	Laterite within cover of red ochre are exposed east of village Dhamliya having dimension 300 x 100 m and SE of village Rathajna having dimension 300 x 70 m. Thickness of formation varies from 3 to 5m. The laterite covering have been mapped west of Thana in the area having length up to 1 km with width varying from 200 - 400m. Thickness varies from 0.5 m in down slope to 3 m on upper levels.
	Rathajna Gadola	1:10000	10	-	-	-	
	Khariya,	1:2000	1.5	-	-	-	
	Bhuwasly						
	Panmori, Thara,						
	Hemirapu						
	ka Khera, Ranjana						
	Gharawal						
	Umarkher,						
	Bamboori,						
	Padampur,						
	Triyakheri,						
	Paithan Magrora,						
	Deri Toophkhera,						
	Chhayan, etc.						
	Pratapgarh distt.						
<b>Rajasthan State Mines &amp; Minerals Ltd</b>							
<b>ROCK PHOSPHATE</b>							
<b>Rajasthan</b>							
Udaipur	A Ext, F block & E block Jhamarkotra mine	-	-	27	3168	1138	As on 1.4.2016, total resources estimated at 46.727 million tonnes including 26.093 million tonnes of reserves.
<b>State Directorates of Geology and Mining</b>							
<b>Kerala</b>							
<b>ALUMINOUS LATERITE/CHINA CLAY</b>							
Kannur	Kannadipoyil area, Perinthatta village Taliparamba Taluka	-	48	08	168	67	Estimated tentative inferred category resources of 9.6 million tonnes of low grade china clay and 3 million tonnes of aluminous laterite .
-do-	Kannadipoyil area, Peringome village, Perinthatta-Vaikara panchayat, Taliparamba Taluk	-	72	18	397.5	149	Estimated tentative inferred category resources of 21 million tonnes of low grade china clay and 11 million tonnes of aluminous laterite .
Kasaragod	Narayanamangalam area Kumbla	-	20	05	30	30	-
<b>CHINA CLAY</b>							
<b>Kollam</b>							
	Periyam village Kundara Panchayat, Kumbalam- Kottapuram area	-	-	08	327.5	220	The tentative resources of 2.7 million tonnes of dull white to greyish sandy clay estimated in Kumbalam- Kottapuram over an area of 9.2 ha. The average thickness of overburden and dull white to greyish sandy clay is 15 m each.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>DOLOMITE</b>							
<b>DGM, Chhattisgarh</b>							
Bastar	Kurundi-Jiragaon area	1:50000 1:4000	- -	15	170.75	159	Total 10 lakh tonnes of dolomite was estimated.
<b>DMG, RAJASTHAN</b>							
Rajsamand	Lal Madri, Karauli, Semail Nathdwara Teh.	1:10000 1:4000	20 03	-	-	35	About 8 km strike length of dolomite outcrops with an average width of 850 m were mapped. Estimated about 170 million tonnes of dolomite resources.
<b>SANDSTONE</b>							
<b>GSI</b>							
<b>HIMACHAL PRADESH</b>							
Solan	Around Kasuali, Dharampur Area	-	-	-	-	-	In Himachal Pradesh, on request of DGM Himachal Pradesh, a G4-stage investigation for assessment of sandstone as building stone was carried out. The rocks exposed in the area comprise Paleogene rocks of Sirmur Group (Late Paleocene to Early Miocene) divisible into Subathu, Dagshai and Kasauli formations in younging order. The reddish-tinted sandstone of the Dagshai Formation and the greenish grey, hard sandstone of the Kasauli Formation can be used as building stone, concrete material and for other construction purpose. Sandstones of Dagshai and Kasauli formations show higher density, lower apparent porosity and water absorption capacity. The specific gravity of sandstone varies from 2.55 to 2.77 which suggests its suitability for building stone. Results of Slake Durability test indicate higher values (98.79% to 99.48%) having negative relation with water absorption and apparent porosity parameters. The different geo-technical parameters suggest suitability of the sandstones of Dagshai and Kasauli formations for multipurpose building and decorative stones.

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EXPLORATION & DEVELOPMENT

Table - 8 (Contd.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>GSI</b>							
<b>PHOSPHORITE</b>							
<b>Rajasthan</b>							
<b>Banswara</b>	Sallopat	1:12500	100	09	334.50	433	G4 stage investigation was carried out for evaluation of phosphorite potential. The important litho units are stromatolitic dolomite (phosphatic)/ dolomite, chert, quartzite and calcareous sandstone (slightly phosphatic). Stromatolites of columnar, bedded, laminated, fragmentary and brecciated types are noticed. Stromatolite bearing dolomite occurs as lensoidal bodies of varying dimensions (50 m to 350 m). Mainly two generations of dolomite have been noticed in the Sallopat area - the older grey to bluish grey dolomite is mainly stromatolite-bearing (phosphatic) and it is capped by younger generations of barren dolomite. A fresh zone of stromatolite-bearing dolomite of about 10 to 15 m is exposed in Khunda Galla. About 1.5 km long stromatolite bearing dolomite has been traced in Sallopat area with a width of about 50 to 600 m, which is noticed on either side of Pat nala. Stromatolitic zones are also noticed in Shivpura, Jher Moti, Ram Ka Munna and Rola areas. The important lithounits encountered in boreholes are bluish grey stromatolitic dolomite (phosphatic), grey to greyish white dolomite (slightly phosphatic), pinkish dolomite, chert/ cherty quartzite and quartz veins. In general, the stromatolite-bearing dolomite is intersected at a depth of 0.00 -20.00 m. Mostly bluish grey stromatolitic dolomite is phosphatic in nature.
	extension area	1:2000	1				

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EXPLORATION & DEVELOPMENT

Table - 8 (Concl.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Bore- holes	Meter- age		
<b>China Clay DMG Rajasthan Chittorgarh</b>	Ragasपुरiya	1:10000	4	-	-	-	The ferruginous cherty brecciated quartzite exposed for about 1500 m in strike length and width varying from 200m to 500 m, the china clay found at places along contact of cherty brecciated rock n/v Ragasपुरiya, Thresta, etc.
Shambhupura	1:10000	5	-	-	-	-	China clay pocket deposit of dimension varying from 5m x 3 m x 1 m to 15m x10m x2-3m was reported n/v Shambhupura, Dadiya & Dhuwaliya, Tehsil - Gangrari.
Rajsamand	Darwal, Marka, Chikhalwas Tehsil Nathdwara	1:10000 1:4000	20 1	-	-	-	Sandstone is exposed around Harvecha, Rajral, Junejo ki Dhani and Bhoja Bhakhar, etc. is of brownish colour, fine to medium grained in texture. Area of sandstone measured in Harvecha is 1800 m x 100 to 600 m, Musalmano Ki Dhani 2000 m x 75 m, Pausariya Tala-Sita-Ram ki Dhani 1800 m x 50 m to 350 m and 3400 m x 10 to 350 m, NE of Bisu 1200 m x 150 m to 500.

EXPLORATION & DEVELOPMENT

**Table - 9: Exploration for Granite and Other Dimension Stones  
State Directorates of Geology & Mining in 2015-16**

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>BUILDING STONE</b>							
<b>YELLOW LIMESTONE SUITABLE FOR DIMENSIONAL STONE</b>							
<b>DMG</b>							
<b>Rajasthan</b>							
Jaisalmer	N/v Jajiya Tehsil	1:50000	100	-	-	-	About 1 Sq km potential area of yellow fossiliferous limestone suitable for dimensional stone having thickness from 0.50 - 2.0 m have been located N/V Mayajal.
		1:10000	10				
		1:2000	3				
<b>SANDSTONE(SPLITTABLE)</b>							
<b>Rajasthan</b>							
Karauli	N/v Mundeli- Mauakhera- Ratiapura & Chhawar of Masalpur Tehsil	1:50000	100	-	-	4	Total reserves of 3.55 million tonnes of splittable sandstone was estimated. Sandstone was observed in 600 m x 200-400 m & 1000 m x 100-400 m area n/v Mundeli-Mauakhera, 700 m x 100-400 m area n/v Mauakhera-Ratiyapura and in 1000 m x 300-400 m area n/v Chhawar of Masalpur tehsil below 0.5 to 3 m overburden with thickness varies from 1 to 3 m.
		1:10000	10				
		1:4000	3				
<b>SANDSTONE</b>							
Barmer	Bhoja Bhakri	1:50000	200	-	-	16	-
		1:10000	12				
		1:2000	3				
<b>MARBLE &amp; CALCITE</b>							
<b>Rajasthan</b>							
Sirohi	Tehsil Aburoad Oda-bassi	1:50000	55	-	-	13	Rajasthan Recrystallised limestone bands were mapped for strike length of more than 800 m with 300 m width in NW of Dhanbor village, more than 500m strike length with width upto 50 m n/v Taleti and more than 400 m strike length width upto 45 m in NW of Ranora village. A calcite vein deposit of 60 m length and 1m width is exposed between village Bhamriya and Jambudi. Another recrystallised limestone band extending for a strike length of more than 1.5 km with width upto 30-100 m was reported NW and SW of Govt. Primary school village Paba Nadia Fali in tehsil Abu Road.
		1:10000	5				
		1:4000	1				

(Contd.)

EXPLORATION & DEVELOPMENT

Table - 10 (Concl.)

Agency/ Mineral/ State/District	Location	Geological mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	Boreholes	Meterage		
<b>MARBLE</b>							
Banaswara	N/v Asoda, Oda-Bassi, Bhingarh, Karana Chota, Tehsil Garhi	1:10000 1:2000	10 1.5	-	-	7	A marble band have been mapped in NE of Bhingarh village having strike length of about 2.5 km with width varyinmg from 30 to 150 m. The rock is medium to coarsed grained, compact & having light grey, greyish, white impure to pinkish shade in colour.
<b>RHYOLITE/BASALT</b>							
<b>Rajasthan</b>							
Jaisalmer	N/v Didania Kerawa, Lawan Teh. Pokaran	1:50000 1:10000 1:2000	100 10 1	-	-	-	About 0.25 sq km potential area have been noticed and mapped.
<b>GRANITE</b>							
<b>Rajasthan</b>							
Sirohi	Tehsil Reodar	1:10000 1:4000	5 1	-	-	3	The granite of the area is greyish white in colour, jointed, fractured in nature. Suitable for block mining at places n/v Nagani, Idarla, Jirawal, Amarpura, Dantrai, Nivaj, etc.. South east of village Warka q is occupied by Skarn rocks which consist of quartz, calcite, garnet, calcitic marble and wollastonite.
Jalore	N/V Korana	1:2000	2	-	-	6	The granite of this area is porphyritic, pinkish, buffed cremish to variegated in colours & blackish in nature. A total 15 plots of 3 Ha each have been delineated.
Barmer	Nand, Shiv ki Magri, etc.	1:50000 1:10000 1:4000	300 23 3.0	-	-	19	-
Chittorgarh	Rajiyas	1:10000	12	-	-	-	In the south of village Rajiyas, pinkish grey coloured perphyritic granite and in the west of village Chawandiya, Mohan Ka Khera greenish grey coloured blockable granite exposed in 2000 m x 1200 m area. The granite may take good minor polish.