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STATE REVIEWS
(Offshore Regions)

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OFFSHORE REGIONS

The Government of India notified the Offshore Areas Minerals (Development & Regulation) Act, 2002 (OAMDR Act), No. 17 of 2003 in the Gazette of India, Extraordinary, Part-II, Section-1, dated 31.1.2003. The purpose of the Act is to provide for development and regulation of mineral resources in the territorial waters, continental shelf, exclusive economic zone and other maritime zones of India and to provide for matters connected therewith or incidental thereto. The Act is applicable to all minerals in offshore areas including minerals prescribed under Atomic Energy Act, 1962, but excludes oils and related hydrocarbons as there is separate legislation in force. The Act came into effect from 15.1.2010 vide S.O.338(E), dated 11.2.2010 notified by the Central Government.

The Act makes it mandatory to undertake reconnaissance, exploration or production operation in the offshore areas in accordance with the prescribed terms and conditions for reconnaissance permit (RP), exploration licence (EL) or production lease (PL) granted under the Act and the rules made thereunder. The availability of the areas for grant of RP, EL or PL shall be notified within six months from the commencement of the Act, and subsequently at such times as considered necessary. The Act empowers the Central Government to make rules for the purpose of the Act including terms and conditions under the RP, EL, PL, etc. The Rules, namely, the Offshore Areas Mineral Concession Rules, 2006 have been framed and notified on 3.11.2006 by G.S.R.691(E) published in the Gazette of India, Extraordinary, Part II, Section 3 (i), No. 539, dated 4.11.2006. The Rules have come into effect on the date on which the Offshore Areas Mineral (Development and Regulation) Act, 2002 came into force, i.e, 15.1.2010.

As a sequel, the Controller General, Indian Bureau of Mines has been notified as the ''administering authority'' and ''authorised officer'' under Section 4 and Clause (i) of Section 22 of the Act vide S.O.339(E) and 340(E) dated 11.2.2010. The Secretary, Ministry of Mines has been notified as ''authorised officer'' to hear and decide cases relating to Clauses (a) and (b) of Section 28(1) vide S.O.341(E) dated 11.2.2010.

As per S.O.1341(E) dated 7.6.2010, The Controller General, Indian Bureau of Mines has notified the mineral-bearing offshore blocks available for grant of Exploration Licence. As per the attached Schedule to the said Notification, there are 26 offshore areas available in offshore waters of Bay of Bengal and 37 offshore areas in the offshore waters of Arabian Sea for grant of Exploration Licence.

The orders for grant of exploration licences were issued by the Administering Authority on 05.04.2011 for the 62 exploration blocks (the bounding latitude and longitude of Block Nos. 3 & 32 falling in the Arabian Sea were same and therefore these were considered as a single block and granted as Block No. 3. Before execution of deed granting such licence, the grant of exploration licences in 62 blocks was challenged through the writ petition in the judicature of various High Courts. Due to interim orders passed by various Hon'ble High Courts on the writ petition and non disposal of the said petition, the offshore exploration licences granted have not been executed. Besides, it has come to the notice of the administering authority that some of the exploration blocks notified for grant of offshore exploration licences vide notification dated 07.06.2010 overlap with areas other than offshore area, to which the OAMDR Act does not apply.

The Central Government vide S.O.19 (E) dated 06.01.2011, published in the Official Gazette, has declared the extent of the Coastal Regulation Zone (CRZ) and has also imposed certain restrictions on the setting up and expansion of industries, operations or processes and the like in the CRZ. The said statutory order states that CRZ shall also apply to the water and the bed area between the Low Tide Line to the territorial water limit (12 Nm) in case of seas and has prohibited in the area so identified as CRZ, inter alia, the mining of sand, rocks and other sub-strata materials except those rare minerals not available outside the CRZ area. In context of said notification, all the 62 offshore blocks lie within the area identified as CRZ which attracts the prohibition of mining (operation undertaken for the purpose of winning any mineral).

The OAMDR Act provides that the holder of an exploration license for offshore area shall have the exclusive right to a production lease for winning of a mineral. In view of the effect of the CRZ Notification dated 06.01.2011 the purpose of executing the 62 offshore exploration licences gets defeated as the applicants cannot undertake operations for winning of minerals subsequent to the grant of production lease after the successful completion of exploration operations.

Therefore, taking into consideration all the above stated facts, the Controller General, IBM and administering authority Offshore Areas Minerals (Development & Regulation) vide S.O.19 (E) dated 6th January, 2011, published in the Official Gazette, annulled the Notification issued vide S.O.1341(E) dated 7th June 2010 with effect that all subsequent actions undertaken for grant of the 62 exploration licences hereby stand rescinded.

National Oil Companies (NOCs), viz, ONGC and OIL have been carrying out exploration and production (E&P) activities for hydrocarbon in the sedimentary basins, both inland and offshore, of the country since inception. Till the end of 1970s, Indian E&P industry was dominated by NOCs to whom Petroleum Exploration Licence (PELs) were granted on nomination basis. Exploration was primarily confined to inland and shallow offshore. In 1979, Government of India (GOI) took the strategic initiative to attract foreign investment, technology and capital to deal with future commitment and challenges of Indian Oil economy by offering block systematically through bidding. These rounds were also known as Pre-NELP Exploration rounds.

In 1991, Government of India adopted liberalised economic policy that led to de-licensing of core group including Petroleum Sector and partial disinvestment of government share including other measures. In view of this, an independent upstream regulatory body called the Directorate General of Hydrocarbons (DGH) was established in 1993 with the objective to promote sound management of the Indian oil and natural gas resources having a balanced regard for environment, safety, technological and economic aspects of petroleum activity. In addition, DGH has been entrusted with certain responsibilities concerning the Production Sharing Contracts for Discovered fields/ Exploration blocks, promotion of investment and monitoring of E&P activities.

After the Nomination era till late 1970s, Pre-NELP Exploration era (1980-95) and Pre-NELP Field rounds (1992-93), GoI formulated a policy called as New Exploration Licensing Policy (NELP) in 1997 to attract significant risk capital from Indian and Foreign companies, state-of-the-art technologies, new geological concepts and best management practices to explore oil and gas resources in the country. This NELP policy was approved in 1997 and it became effective in February, 1999. Since then licences for exploration have been awarded only through a competitive bidding system and NOCs were compelled to compete on an equal footing with Indian and Foreign companies to secure Petroleum Exploration Licences (PELs). The NELP provides an international class fiscal and contract framework for E & P of hydrocarbons.

A total of 282 blocks (including 151 blocks in offshore) have been awarded so far in Pre NELP and IX rounds of NELP. Exploration under NELP has shown positive results, in both inland and offshore areas. The details of the active exploration blocks awarded in offshore area, both deep-water and shallow-water, under Pre-NELP and NELP regimes and those that are currently in operation are provided in Table-1.

Table 1: Details of Offshore Exploration Block (as on 01.04.2015)

Round	No. of blocks awarded	No. of blocks in operation	Awarded Area (sq km)	Present Area* (sq km)
Pre NELP	11	2	6605	60
NELP-I	23	4	41942#	17221
NELP-II	16	2	17171	4661
NELP-III	15	2	16195.5	7390.5
NELP-IV	10	-	-	-
NELP-V	8	2	15504	14905.5
NELP-VI	27	4	19773	18106
NELP-VII	18	3	6812	5687
NELP-VIII	19	12	29824	29824
NELP-IX	4	3	6397	6397

**After relinquished or proposed for relinquishment.*
 # Part of awarded area converted in PML.
Source: *Hydrocarbon Exploration & Production Activities, India 2014-15.*

In order to explore and produce new sources of natural gas from coal-bearing areas, the Government had formulated a CBM Policy in 1997, wherein CBM being Natural Gas is explored and exploited under the provisions of OIL Fields (Regulation & Development) Act 1948 (ORD Act 1948) and Petroleum & Natural Gas Rules 1959 (P&NG Rules 1959) administered by Ministry of Petroleum & Natural Gas (MoP&NG). CBM policy was aimed to provide attractive fiscal and contractual framework for exploration and production of CBM which is an environment-friendly clean gas fuel similar to conventional natural gas. In order to harness CBM (Coal Bed Methane) potential in the country, CBM blocks were offered through international competitive bidding for exploration and production for the first time in year 2001. Under the CBM policy, till date, four rounds of CBM bidding rounds have been implemented by MoP&NG, resulting in award of 33 CBM blocks [including 2 blocks on Nomination and 1 block through Foreign Investment Promotion Board (FIPB) route]. Till date, most CBM exploration and production activities in India are pursued by domestic Indian companies. These CBM blocks are in the States of Andhra Pradesh, Assam, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu and West Bengal.

Resources

Deposits of hydrocarbon are located in the offshore areas in the Mumbai offshore, Cambay basin on the west coast and Cauvery and Krishna-Godavari (KG) basins on the east coast. The balance recoverable reserves of hydrocarbon in offshore areas are furnished in Table-2.

The balance recoverable reserves of crude oil and natural gas in offshore areas accounted for 51% and 66% of total reserves, respectively. As on 1.4.2015, proved and indicated balanced recoverable reserves of crude oil and natural gas in offshore areas have been placed at 389.86 million tonnes and 988.88 billion cu m, respectively.

EXPLORATION ACTIVITIES

Conventional Hydrocarbon

ONGC, GSI and other Public & Private Sector companies continued their efforts in respect of exploration for hydrocarbon in offshore region, both shallow and deep water, during 2014-15.

Table – 2 : Balance Recoverable Reserves of Crude Oil & Natural Gas in India Including Offshore Areas (As on 1.4.2015)

(Crude oil in million metric tonnes)
(Natural Gas in billion cu m)

Area	Crude oil*	Natural gas*
India	**763.47**	**1488.48**
Onshore : Total	**373.61**	**499.59**
Offshore : Total	**389.86**	**988.89**
Western Offshore	333.44	436.65
Eastern offshore	56.42	552.24

Source: *Indian Petroleum & Natural Gas Statistics 2014-15, Ministry of Petroleum & Natural Gas.*

** Proved and indicated balance recoverable reserves*

Note: In case of Natural Gas, reserves includes Coal Bed Methane in Jharkhand, Madhya Pradesh and West Bengal.

ONGC

ONGC continued its operations for exploration of oil and gas. During 2014-15, in nomination and production sharing (PSC) regime, ONGC acquired a total of 463.98 GLKM of 2D seismic data from inland areas. During the same period, 8,615.04 SKM of 3D seismic data was also acquired which included 859.33 SKM inland and 7,755.71 SKM offshore areas. ONGC also drilled 75 exploratory wells comprising 45 wells to a depth of 109.02 km in inland areas and 30 wells to a depth of 74.43 km in offshore areas.

During the year 2014-15, ONGC has made 22 Oil and gas discoveries in domestic acreages (operated by ONGC). Out of 22, 10 discoveries are in offshore and 12 in onshore. In offshore, 4 discoveries were made in the new prospects whereas 6 were new pool discoveries. Two discoveries were made in NELP blocks and 8 in nomination blocks. The efforts are on to commene production from these recoveries as early as possible. In addition to these discoveries, exploratory wells conclusively tested and proved to be hydrocarbon-bearing will help in field growth of existing fields. Details of the discoveries are in Table-3.

Table – 3 : Detail of Oil and Gas Discovery by ONGC in Offshore Areas During 2014-15

S.N.	Well No.	Basin/Sub-basin	Type of Hydro-carbon
1.	YS-9-1 (Shift)	KG (Shallow Water)	Gas
2.	GD-11 / GD-11-1	KG (Deep Water)	Gas
3.	GKS092NAA-1*	Kutch offshore	Gas
4.	GKS091NDA-1*	Kutch offshore	Gas
5.	C-1-7	Mumbai offshore	Oil & Gas
6.	C-1-8	Mumbai offshore	Oil & Gas
7.	GS-29-10 (AJ)	KG (Shallow Water)	Oil & Gas
8.	G-1-NE-1	KG (Shallow Water)	Oil & Gas
9.	G-1-NE-2	KG (Shallow Water)	Gas &Cond.
10.	WO-5 / WO-5-11	Mumbai offshore	Oil & Gas

* In NELP blocks

Source: *Hydrocarbon Exploration & Production Activities, India 2014-15.*

Continuing exploration in challenging and frontier areas, ONGC has accreted 215.65 million tonnes of oil equivalent (Mtoe) of in-place volume of hydrocarbon in the domestic basins (operated by ONGC). As on 01.04.2015, in-place hydrocarbon volume of ONGC as a group stands at 9,283.84 Mtoe; up 4.2% from FY'2013-14 figure of 8,912.81 Mtoe.

The ultimate reserves (3P) accretion in domestic area (ONGC operated) during FY'2014-15 has been 70.98 Mtoe and 2P reserve accretion has been 61.06 Mtoe. The total reserve accretion during 2014-15 in domestic basins including ONGC's share in PSC JVs stands at 60.03 Mtoe.

Reliance Industries Ltd (RIL)

RIL along with JV partners made two significant hydrocarbon discoveries in 2013-14, i.e. Discovery (D-55) in Well MJ1 drilled in the Block KG-D6 situated in the Krishna-Godavari basin and Discovery (D-56) in exploration Block CY-D5 situated in the Cauvery basin.

As a part of the appraisal programme of Well MJ1 discovery, three appraisal wells have been drilled to date, of which two appraisal wells were drilled in FY 2014-15. All the appraisal wells have provided vital information on the extent and potential of the reservoir. In addition, enhanced imaging for reservoir characterisation is underway and the first phase of conceptual engineering has been completed.

Gas production from the KG-D6 field declined by 12% in FY 2014-15. Efforts by RIL and its JV partners resulted in augmentation of production from the field through interventions like side-track wells.

Private Companies/Joint Ventures

During 2014-15, in nomination and production sharing (PSC) regime, Private companies/JVs acquired a total of 5,495.00 GLKM of 2D seismic data comprising 609.00 SKM inland and 4,886.00 SKM offshore areas. During the same period, 4,731.00 SKM of 3D seismic data was also acquired which included 1,538.00 SKM inland and 3,193.00 SKM offshore areas. Private companies/JVs also drilled 90 exploratory wells comprising 70 wells to a depth of 156.41 km in inland areas and 20 wells to a depth of 67.06 km in offshore areas.

Geological Survey of India (GSI)

Airborne Geophysical Surveys

During the FS 2014-15, the approved FSP items on aerogeophysical surveys by engaging Twin Otter Airborne Survey System (TOASS) and Heliborne Geophysical Survey System (HGSS) could not be taken up owing to a number of technical problems and related issues. However, interpretation of multisensor aerogeophysical data acquired during TOASS surveys during FS 2013-14 was taken up for Daman-Jamnagar area covering both land and offshore regions (Gulf of Kachchh, Arab Sagar & Khambat). The interpretation of this data has brought out several features of importance for drawing regional geotectonic and structural inferences and also confirms the presence of active faults/ bodies and lineaments. A total of 14 deep-seated features were identified and were integrated with regional geological maps and structural features reported from image data. The magnetic anomalies were evaluated through Euler 3D solutions, radiometric data and ground gravity data. The integrated studies confirm the extension of active faults/ lineaments buried under sedimentary cover and sea at depth. The IGRF corrected total intensity map has brought out multiple interfaces, estimated from radially averaged power spectrum at depth of 19.61 km, 9.66 km, 4.5 km, 1.75 km and 0.8 km approx., from plane of observation.

The aerial extent of high amplitude aeromagnetic zones could be attributed to (a) Presence of dense mafic lower crust at much

shallower depth at the coastal region of Saurashtra or (b) dominance of large mafic intrusive beneath the felsic alkaline volcanic –sub-volcanic rocks.

The study of radio-elemental concentration maps over shallow water in both Gulf of Kachchh & Khambat has exhibited the presence of pockets of uranium and thorium in alluvial and fluvial sediments. The exposure rate study of these anomalous zones has also brought out the probable health hazard that the people living there could get exposed to. Aeromagnetic Data of Saurashtra- Khambat area (NW I & NW II blocks), under NASM (FS 1995-96) and TOASS data (FS 2013-14) flown over the Gujarat and Arab Sagar area is presented for preparation of regional aeromagnetic map of western part of India. It covers land and offshore regions (Gulf of Kachchh, Arab Sagar & Khambat). The multi-sensor TOASS data (FS 2013-14) has been upward continued up to 1.7 km altitude to combine with NASM data. It has brought out several new features that are of importance for drawing regional geotectonic and structural inference and confirms the presence of active faults/ bodies and lineaments. A total of 26 deep-seated aeromagnetic features were identified and were integrated with regional geological maps and structural features reported from Landsat image data. Deeper structures were evaluated through Euler 3D solutions and integrated with ground gravity data. These integrated studies confirm the presence of regional active faults/lineaments buried under thick basaltic and sedimentary cover at depth. This study has also identified large areas of high susceptibility-high density and low susceptibility-high density suggesting the possibility of deep seated basic bodies on regional scale. The IGRF corrected total intensity map has brought out different interfaces, estimated from radially averaged power spectrum at depth of 28.41 km, 9.03 km, 4.57 km and 2.7 km approx., from plane of observation.

The combined integrated and interpreted aeromagnetic data has brought out three zones of contrasting aeromagnetic features over both land and marine region. The large extent of such high aeromagnetic zones could be attributed to (a) Presence of dense mafic lower crust at much shallower depth at the other regions of Saurashtra or (b) dominance of large-scale mafic intrusive beneath the felsic alkaline volcanic -sub-volcanic rocks. In view of high REE-bearing minerals recorded in the alkaline rocks of this region, a few of the aeromagnetic and ground gravity features closely associated with such rocks need to be evaluated further for the exploration of REE and high-density minerals. The magnetic contour and image map along with inferred linear features are seen in interpreted aeromagnetic map.

Marine & Coastal Survey

During 2014-15, Marine and Coastal Survey Division (M&CSD), GSI carried out offshore geoscientific studies both in the Exclusive Economic Zone (EEZ) and Territorial Waters (TW) along the East and West Coasts of India and around Andaman Islands. Surveys in the near shore zone (0 to 10 m isobaths) were carried out using hired mechanised boats. The Marine and Coastal Survey Division of Geological Survey of India aimed not only to discover the under sea economic minerals, but also to unravel the evolutionary history of formation of the seabed developed under the influence of various dynamic processes operative on different scales in different parts of the globe.

Marine and Coastal Survey Division with its Headquarters at Mangaluru functions through its operational offices at Kolkata, Visakhapatnam, Mangaluru, Kochi, Bhubaneswar, Chennai and Gandhinagar to undertake seabed survey in the EEZ and beyond with its ocean going research vessel, R.V. Samudra Ratnakar, and twin coastal launches R.V. Samudra Kaustubh and R.V. Samudra Shaudhikama. R.V. Samudra Manthan was decommissioned in Dec. 2013 on acquisition of R.V. Samudra Ratnakar. Vast resources of economic placer minerals and relict sands have been delineated besides identifying encouraging occurrence of lime mud, phosphate-bearing sediments and Fe-Mn encrustations within the EEZ of India.

As on March 2015, M&CSD has completed seabed mapping of 1,32,585 sq km out of 1,50,000 sq km in 5 km × 2 km grid within Territorial Waters (TW) and 18,54,534 sq km out of 18,64,900 sq km in the Exclusive Economic Zone (EEZ) beyond Territorial Waters on reconnaissance scale. The total EEZ coverage including TW is 19,87,119 sq km out of a total EEZ area of 20,14,900 sq km.

During the cruises of R. V. Samudra Ratnakar in FS:2014-15, baseline geoscience data collection of 82,988 sq km of multibeam bathymetry was carried out. Seabed survey of an area of 2,541 sq km utilising coastal launch RV Samudra Kaustubh was also done besides other parametric surveys. A total of 2,400 lkm of multichannel seismic survey has also been completed.

Marine geoscientific programme taken up during the period under review comprises 7 cruises onboard R. V. Samudra Ratnakar. In the shallow water domain, six cruises onboard R. V. Samudra Kaustubh and four cruises onboard R. V. Samudra Shaudhikama were taken up. It is for the first time that seismic cruise onboard R.V. S. Ratnakar was taken up. In a collaborative programme with NIO, gas hydrate occurrences in Mannar basin have been investigated. Besides these, thirteen coastal items and two laboratory based items were also taken up during the period.

During 2014-15, a total of seventeen cruises were undertaken using three vessels. The highlights of cruises and coastal programmes taken up by M&CSD are summarised below-

R.V. Samudra Ratnakar

Nine cruises were planned onboard R. V. Samudra Ratnakar within EEZ of India. Due to repair works and various unexpected reasons only 7 cruises could be taken up.

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

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

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

4. SR-005: Multibeam Bathymetric survey and exploration for manganese micronodules in EEZ of India and beyond, west of Lakshadweep Islands.

5. SR-006: Geological and Geophysical investigations in Cauvery-Mannar offshore basin and Krishna-Godavari offshore basin, eastern continental margin of India for gas hydrates studies.

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

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

R. V. Samudra Kaustubh

Seven cruises were planned onboard R.V. Samudra Kaustubh within TW of the East Coast of India. But due to the minor repairs caused by Hud Hud Cyclone out of seven cruises planned, the following six were taken up.

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

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

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

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

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

6. ST-242: Parametric (Magnetic and Seismic) survey Vainateyam River Godavari and Vasishta River Godavari mouths, Andhra Pradesh Coast.

R. V. Samudra Shaudhikama

Seven cruises were planned onboard R. V. Samudra Shaudhikama within TW of the West Coast of India. But due to issues of major repairs in the Vessel, out of the seven cruises planned, the following four were only taken up.

1. SD- 255: Evaluation of sand resources beyond TW off Kodungallur, Kerala.

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

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

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

Other Coastal Programmes

1. Item No-079: Study of changes in the nature and morphology of east and west facing beaches of South Andaman Islands in response to tectonic disturbances and beach processes.

2. Item No-080: Coastal survey between Nileswaram and Ezhimala, Kasaragod & Kannur districts Kerala for identification of heavy mineral occurrences.

3. Item No-083: Mapping of nearshore gap areas and assessment of Heavy Mineral potential off Anjengo, Kerala.

4. Item No-087: Study of coastal processes in Gopalpur–Sonapurapeta Sector in Ganjam district, Odisha with emphasis on heavy mineral concentration in the beach sand and nearshore region.

5. Item No-089: Coastal survey between Apsarakonda and Swarnagadde near Honavar, Uttara Kannada district, Karnataka for identification of heavy mineral occurrences.

6. Item No-090: Coastal survey near Ullal, Dhakshina Kannada district, Karnataka.

7. Item-091: Seabed Mapping and Study of Shoreline changes and evaluation of Geomorphological parameters in the inner shelf (0-10 m WD).

Research Project Items

1. Item-074: Study of environment and neo-tectonic aspects of the coastal area and study of beach and seabed sediments off River Setrunji Delta, South of Bhavnagar district, Gujarat.

2. Item-077: Planktonic foraminifer productivity changes in the northern tropical equatorial Indian Ocean during Last Glacial-Interglacial Transition-The role of Paleomonsoon.

3. Item-081: Geoenvironmental appraisal of coastal and inshore zone along Kakinada-Bangarampeta coast.

4. Item-082: Preliminary evaluation of REE in the marine sediments from West Coast of India.

5. Item-084: Morphometry and geochemistry of volcanic glass shards from Carlsberg Ridge, Indian Ocean: insights into the magma genesis, fragmentation and phreatomagmatic activity in the mid-oceanic ridge system

6. Item-085: Geological and sedimentological aspects along the Mandvi and Mundra Coast, near Gulf of Kachchh, Kachchh district, Gujarat.

7. Item-086: Study of creek systems, shoreline changes and evaluation of geoenvironmental parameters in relation to projected landuse in parts of Western Sundarbans.

8. Item-087 (WR-040): Study of marine geological and geoenvironmental aspects along the Vishwamitry and Mahi Estuary, Gulf of Khambhat, Anand and Bharuch districts, Gujarat.

OFFSHORE RESOURCE SURVEY BY GSI

1. Preliminary Assessment of Lime Mud in the Continental Margin off Gujarat (R.V. Samudra Ratnakar)

The objective of the survey was to determine the distribution of lime mud, its nature and quality in the selected area in the continental margin off Gujarat.An area of 16,000 sq km to the WSW of Dwarka off Gujarat was surveyed by 2,214 l-km sub-bottom and Gravity profiling against a target of 1,800 lkm each and 850 sq km multi-beam echo sounding in the continental margin off Gujarat. Sub-bottom profiling survey was carried out along 10 E-W coast perpendicular lines of 128 l-km with a line spacing of 14 km and 4 coast parallel N-S lines of 122 l-km with a line spacing of 42 km. Samples were planned in a grid pattern of 42 km × 27 km representing the whole area. A total of 16 samples (9 spade core and 7 grab) were collected during the cruise.Three gravity highs have been noticed in the south-eastern, north-eastern and northern part of the study area whereas gravity low has been noticed towards the centre part of the area. The Free-air anomaly map trend corroborates with the bathymetric variations in the area. In the eastern side, the continental shelf boundary is clearly brought out with a comparatively steep gradient. From the MBES data, it has been identified that the continental shelf is characterised by flat topography with water depth varying from 70 m to 150 m and continental slope and rise are characterised by uneven topography with plateaus, isolated mounts, erosional ridges and valleys with water depth varying from 150 m to 1500 m. The south-west part of the area is characterised by irregular mounts and ridges and water depth varies from 1500 m to 2500 m.

2. Placer Mineral Resource Evaluation in the Territorial Waters off Santapalle, North of Bimunipatnam, Andhra Pradesh (R. V. Samudra Kaustubh)

An area of 51 sq km was taken up for evaluation of placer mineral resources, within the territorial waters off north of Bhimunipatnam (off Santapalle), Andhra Pradesh. Sixty-nine vibrocore seabed sediment samples, varying in length from 0.13 m to 2.77 m with an average core length of 1.30 m, were collected in 1×1 km grid pattern within 21 to 37 m depth under sea. The current observations and water samples from three stations, at surface and sub-surface levels were also collected. A total 70 l-km of bathymetric data along 13 coast perpendicular transects was carried out. The bathymetric survey reveals that the contours are parallel to the coast (NE-SW) with a gentle gradient of 1:327. The seabed sediment is brown to grey coloured medium to coarse sand at the surface with shell fragments and compact green clay at places at sub-surface level. The sea water analysis shows no significant change in the temperature, pH, conductivity and salinity from surface to sub-surface level and suggests near normal conditions. The sea water current is towards SW with an average speed of 55 cm/sec at surface level and towards WSW with an average speed 80 cm/sec at sub-surface level. The vibro core sediments were sub-sampled at half a meter interval for heavy mineral resources evaluation. The concentration of heavy minerals is in the range of 3-4% on the surface followed by 2-3% at the sub-surface level with grey to brown medium sand.

The important heavy minerals in the area include ilmenite (39.15%), sillimanite (28.84%) and garnet (23.02%) as major mineral constituents in the decreasing order of abundance. Whereas, zircon (1.22%), monazite (0.54%), rutile (0.59%) and others (6.64%) occur as minor minerals. The pyroxene, amphibole, epidote, stauroite, tourmaline, kyanite etc., occur as minor mineral constituents. A total of 2.95 million tonnes of heavy mineral resources has been estimated within the area - ilmenite 1.18 mt, sillimanite 0.83 mt, garnet 0.68 mt, zircon 0.035 mt, monazite 0.016 mt, rutile 0.016 mt and others 0.19 mt. The EPMA analysis reveals the following composition of heavy minerals : 51% of TiO_2 & 46% of FeO in ilmenite; 61% Al_2O_3 & 37% SiO_2 in sillimanite; 30% FeO, 21% Al_2O_3 & 38% SiO_2 in garnet; 67% ZrO_2 & 32% SiO_2 in zircon; 28% of P_2O_5, 11% La_2O_3, 26% Ce_2O_3, 11% Nd_2O_3 & 8.104% of ThO_2 as major constituents and 1.6% of Y_2O_3, 2.9% Pr_2O_3, 0.37% PbO & 0.26% of UO_2 as minor constituents in monazite and 98% of TiO_2 in rutile. Heavy mineral suite with ilmenite, garnet and sillimanite as major constituents followed by zircon, pyroxenes, epidote and monazite, suggest their source as crystalline host migmatites, khondalite, charnockites, granite gneiss, pyroxene granulite etc. of Eastern Ghat Mobile Belt (EGMB). The Rivers Vamsadhara, Nagavalli, Gosthani, Sarada, Varaha and Mahendratanaya that drain through the rocks of EGMB have contributed in these minerals deposit in there to the offshore areas.

3. Evaluation of Sand Resources beyond TW off Kodungallur, Kerala (R. V. Samudra Shaudhikama)

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

The reserve estimated for 0-50 cm is 99.74 MT; 50-100 cm is 22.44 MT; 100-150 cm is 16.58 MT; 150-200 cm is 11.02 MT; 200-250 cm is 5.72 MT; 250-300 cm is 1.85 MT and 300-350 cm is 0.45 MT. The total sand reserve estimated in the study area is about 157.68 MT.

4. Evaluation of Heavy Mineral Sands off Muttamtura, Tamil Nadu (R. V. Samudra Shaudhikama)

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

5. Placer Mineral Resource Evaluation in the Territorial Waters off Rushikulya River Mouth, Odisha (R. V. Samudra Kaustubh)

The survey carried out so far has delineated an elongated heavy mineral (HM) bearing block from Sonapurapeta in the south to Chilka in the north covering an area of about 600 sq km. The concentration of the HM varies from 0.5 to 17 wt % in the top one meter sediments which often extends up to 2 m depth. This promising sector was subsequently undertaken for closer grid vibro-coring for evaluation of placer mineral resources.

Assessment of the Heavy Mineral concentration shows encouraging results in the contiguous areas. Cruise ST-241 was taken as an alternative item for FS 2014-15 from 14-12-2014 to 05-01-2015 to survey the remaining gap area in closed grid vibrocoring for evaluating placer mineral resources in an area of 48 sq km area bounded by the coordinates: Lat. 19°20.064´N, Long. 85°5.589´E; 19°23.870', 85°11.024´; 19°22.009´, 85°12.333´ and 19°18.216´, 85°6.924´ in 1 km × 1 km optimum grid pattern to have a composite picture of the near shore placer mineral resources of southern Odisha coast.

During the cruise, a total of 58 vibrocore sediment samples were collected from the water depths of 16 m to 47.6 m, from 59 Stations occupied by covering an area of 44 sq km. The length of the core varied from 0.38 to 4.12 m, with an average length of 2.10 m. In addition to that 5 gravity core with bathymetric survey was carried out along 43 line km along with collection of water samples and current meter data.

The bathymetry reveals that the contours are aligned parallel to the coast configuration. The seafloor is smooth and seabed is gently sloping up to 30 m water depth. Gradient of sea floor varies from 1:269 to 1:281. Presence of submerged ridge could be identified by the nature of sediment. The top sediment in the near shore zone are dominantly very fine sand while the sediment collected from the deeper part are mainly medium to coarse sand and consists of lots of shells and shell fragments.The bottom sediments reflect all types of sand depending upon the recovery below sea floor. The 26 m bathymetry contour is marked by the presence of sub-aerially exposed variegated compact sticky silty sand / sandy silt at more than 50 cm b.s.f. The surface sediment collected from deepest part of the survey area ~ 45m or above water depth is dominated by clay.

Unconventional Hydrocarbons

Coal-Bed Methane

Coal-Bed Methane (CBM), is an eco-friendly natural gas, stored in coal seams which get generated during the process of coalification. The coal and lignite seams contain varying amounts of methane depending on the rank of the carbonaceous matter, the depth of burial and the geotectonic setting of basins. CBM exploration and exploitation has an important bearing on reducing the greenhouse effect and extraction of CBM through degassing of the coal seams prior to mining of coal is a cost-effective means of boosting coal production and maintaining safe methane level in working mines.

India, having the fifth largest proven coal reserves in the world, holds significant prospects for exploration and exploitation of CBM. The prognosticated CBM resources in the country are about 92 TCF (2600 BCM). In order to harness CBM potential in the country, the Government of India formulated CBM policy in 1997 to provide level playing platform for exploration and commercial exploitation of CBM by national and international entrepreneurs.

CBM blocks were carved out by DGH in close interaction with Ministry of Coal (MoC) & Central Mine Planning & Design Institute (CMPDI), Ranchi. Till date, four rounds of CBM bidding have been implemented by MoP&NG under the CBM policy, resulting in award of 33 CBM blocks {including 2 blocks on Nomination and 1 block through Foreign Investment Promotion Board (FIPB) route} which covers 16,613 sq km out of the total available coal-bearing areas for CBM exploration i.e. 26,000 sq km. Exploration under CBM policy has been undertaken by national and international companies. The total prognosticated CBM resource in the 33 CBM blocks awarded, is about 62.4 TCF (1767 BCM) of which, so far, 9.9 TCF (280.34 BCM) have been established as Gas in Place (GIP).

CBM production has started since July 2007 and current production is around 0.77 MMSCMD from 5 CBM blocks which includes test gas production from 4 CBM blocks and commercial production from 1 CBM block. Seven more CBM blocks are expected to start commercial production in near future. India has emerged as the fourth country in the world capable of producing CBM on commercial scale and within the next few years, CBM is expected to emerge as a new source of natural gas production in the country.

Gas Hydrates

Gas Hydrate is a crystalline solid, its building blocks consists of a gas molecule surrounded by a cage of water molecules. Gas hydrates are formed when gas and water mixtures are subjected to high pressure and low temperature conditions, usually in water depths of more than 800 m, within sediments just below the sea bottom. They are also formed in some permafrost region of the world. Gas hydrates may be an important source of hydrocarbon energy in the future. The gas hydrates also act as a cap under which natural gas can get accumulated.

India is the third country after USA and Japan, where R&D work on gas hydrates has commenced. Gas hydrate exploratory activities/research in India is being steered by the Ministry of Petroleum & Natural Gas under National Gas Hydrate Program (NGHP) which was initiated in 1997 with participation from Directorate General of Hydrocarbons (DGH), National E&P companies (Oil and Natural Gas Corporation Ltd, GAIL India Ltd, Indian Oil Corporation & Oil India Ltd) and National Research Institutions (National Institute of Oceanography, National Geophysical Research Institute and National Institute of Ocean Technology). To meet the challenges of exploring gas hydrate, which is at a research stage the world over, MoP&NG/DGH have signed MoUs with various agencies viz. USGS; US-DOE; US-MMS (now called US-BOEM); JOGMEC, Japan; GFZ-POTSDAM, Germany; IFM-GEOMAR, Germany; etc. for sharing of knowledge and scientific data.

There are numerous potential offshore areas of gas hydrates accumulation within India's Exclusive Economic Zone. During the period 1998 to 2003, data of Krishna-Godavari Basin (offshore), Cauvery Basin (offshore), Gulf of Mannar and Western offshore were studied by ONGC for assessing Gas Hydrate prospectivity. These studies provided technical support in formulating NGHP Expedition-01 program, wherein 21 sites were drilled/cored in Indian offshore in 2006 using the ship Joides Resolution under agreement between DGH and a consortium of US companies.

The NGHP Expedition-01 established the presence of gas hydrate in KG, Mahanadi and Andaman basins. Gas hydrate was found to occur in “combination reservoirs” consisting of horizontal or sub-horizontal coarse-grained permeable sediments (sands for the most part) and apparent vertical to sub-vertical fractures that provide the conduits for gas migration. NGHP-01 delineated and sampled one of the richest marine gas hydrate accumulations in the KG basin. It also discovered one of the thickest and deepest (612 m below sea floor) gas hydrate occurrences yet known in offshore region of the Andaman Islands.

Based on the findings of NGHP Expedition-

01, the Krishna-Godavari deepwater basin and the Mahanadi deep waters have been considered potential areas for Gas Hydrate. NGHP Expedition-02 aims at identifying sites which would ideally have (a) Sand dominated gas hydrate occurrence, (b) Reasonably compacted sediments, and (c) Occurrence of free gas below the gas hydrate stability zone. NGHP Expedition-02 consists of LWD (Logging while drilling), Coring and wireline logging program at about 20 sites (40 wells) in the deepwater KG & Mahanadi basins.

The Japanese drill ship CHIKYU has commenced operations under the NGHP Expedition-02 on 4th March 2015 to collect Gas Hydrate samples and related information thereof in Deep waters of Krishna-Godavari and Mahanadi basins in presence of DGH/ONGC personnel. Till 31st March 2015, Logging While Drilling (LWD) was completed at 13 wells. The NGHP Expedition-02, including the coring leg, was scheduled for completion by the 31st July 2015.

Production

Petroleum (crude) and natural gas (utilised) are the mineral items produced from Offshore region. The value of production of these two items in the region during 2014-15 at ₹ 54,955 crore was almost at the same level of the previous year. Offshore accounted for 20% of total value of mineral production in India.

Offshore accounted for 51% production of petroleum (crude) and 74% of natural gas (utilised) in the country during 2014-15. In the region, production of petroleum (crude) increased by 4% while that of natural gas (utilised) decreased by 6% as compared to the previous year (Table-3).

Table – 3: Mineral Production in Offshore, 2012-13 to 2014-15 (Excluding Atomic Minerals)

(Value in ₹ '000)

Mineral	Unit	2012-13		2013-14		2014-15 (P)	
		Quantity	Value	Quantity	Value	Quantity	Value
All Minerals			**597822525**		**549151895**		**549553710**
Natural Gas (utilised)	m c m	31802	263006611	26396	218298299	24860	205595382
Petroleum (crude)	'000t	18421	334815914	18203	330853596	18924	343958328

Future Plan

The hydrocarbon resource assessment for 15 sedimentary basins (combining Category-I, II and III basins) was carried out approximately two decades ago and became overdue at present in light of enormous data acquired during Pre-NELP and NELP rounds of G&G activities. During the course of implementation of work programme in Pre-NELP Blocks, NELP Blocks, nominations blocks awarded to NOC's and other exploration and production activities, substantial geo-scientific data have been generated. Government has constituted a Multi-organisation Team (MOT) to reassess the hydrocarbon resources of India covering all the 26 sedimentary basins of the country. It will generate better understanding of Indian sedimentary basins with integration of data and new interpretation techniques. These relook at basins will assist in future planning of exploration activities.

The first oil in India was found in North East part of India about 150 years ago. However, development of Oil and Gas Sector in North-Eastern India has been full of challenges and not been up to the mark. To identify the reasons for such slow development of Oil and Gas Sector, Government planned to conduct a specialised study for framing a policy for encouraging hydrocarbon exploration and production activities in the North-East Region of India. The report has been submitted and is under consideration for practical workable solutions with definite action plan.

After setting up of National Data Repository (NDR) for Oil and Gas Industry in India, Government plans to move to the OALP regime soon. OALP will enable upstream companies to bid for any oil and gas block without waiting for the announcement of bidding as under current model of offering.

To enable E&P operators to explore and extract all types of hydrocarbon resources covered under the Oilfields Regulation and Development (ORD) Act, 1948, and Petroleum and Natural Gas (PNG) Rules, 1959, Government of India is considering a Uniform Licensing Policy (ULP) that would subsume NELP and CBM policy. This will facilitate exploration and exploitation of both conventional and unconventional hydrocarbon resources together, in an awarded block under one PEL/PML.

CBM production that commenced in July 2007 has current production level of around 0.77 MMSCMD from 5 CBM blocks which include test gas production. Seven more CBM blocks are expected to start commercial production in near future. The total CBM production is expected to be around 4 MMSCMD by end of 12th plan as per XII plan document.

The NGHP geoscientists are planning to carry out pilot production testing of at least one site in the Indian deepwater environment during NGHP Expedition-03. However, the execution of Expedition-03 depends on the success of NGHP Expedition-02. The major challenge for the expedition is—evolving viable technology to extract gas from gas hydrate.