

Institutional Report

Keshava Deva Malaviya Institute of Petroleum Exploration

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Fig. 1: A view of KDMIPE, Dehradun

Introduction

The Keshava Deva Malaviya Institute of Petroleum Exploration, a premier R&D Institute of ONGC was set up in 1962 to provide geo-scientific back up to the exploratory efforts of India's National Oil Company, ONGC. The institute was rechristened as Keshava Deva Malaviya Institute of Petroleum Exploration (KDMIPE) from the existing Research and Training Institute (R&TI), on 19th December 1981 in memory of founding father of Indian Petroleum industry – Late Keshava Deva Malaviya.

Through its sheer competence, the Institute earned its reputation as being the mother R&D

institute of ONGC. With enhancement of exploration and development activities and new discoveries, especially Mumbai High, eight additional R&D institutes were later carved out of KDMIPE between 1978-2006 to cater to their respective needs in the fields of Reservoir (Institute of Reservoir Studies, IRS), Drilling (Institute of Drilling Technology, IDT), Production & Ocean Engineering (Institute of Oil & Gas Production Technology, IOGPT & Institute of Engineering and Ocean Technology, IEOT), Geo data processing and interpretation (GeoData Processing and Interpretation Centre, GEOPIC), Bio-Engineering (Institute of Biotechnology and Geotectonic Studies, INBIGS), Safety (Institute of Petroleum Safety,

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Health and Environment Management, IPSHEM) and well logging (Centre for Excellence in Well Logging Technology, CEWells).

The Institute is the nodal agency for multidisciplinary synergistic basin scale and domain specific research in exploration and development activities. Through its vision "To achieve excellence in Hydrocarbon Exploration through sustained R&D efforts including innovation and technology induction for value addition in the E&P business" the institute has been continuously providing intellectual support towards making more and more discoveries of oil and gas in various petroliferous basins of India and outside, wherever ONGC is seeking business.

The KDMIPE, a ISO 9001: 2008; ISO 14001:2004 and OHSAS 18001:2007 and DSIR Certified Institute, has grown manifold through successive planned stages of technology upgradation and refinement in geoscientific research. The institute has achieved global recognition by sheer adherence to the core competence in exploration and has multidisciplinary roles in the field of:

- Non-Seismic Prospecting
- Basin Analysis, Structural Modeling and 3D Petroleum Systems Modeling
- Exploration in Frontier and Foreign Basins
- Fundamental Geoscience Research in Geology and Geochemistry
- Petroleum Economics and Resource Appraisal
- Unconventional Hydrocarbon Research including Gas hydrate, Coal Bed Methane, Basin Centered gas and Shale gas & oil

Non-Seismic Exploration

Gravity-Magnetic and Magneto-Telluric

The institute is credited to have capability of API of onland Gravity, Magnetic and Magneto-telluric data and has contributed immensely over the years in mapping the sub-trappean sediments for Mesozoic exploration in Kutch – Saurashtra Basin and also the continent-ocean boundary in Kerala-Konkan and east coast basins. The Magneto-telluric (MT) supported by potential field computational methods in Trap covered areas in Vindhyan Basin helped in detecting low resistive and high density intrusives in upper crust in the Chambal valley. In Son valley, the basement

was found dipping towards south while in Chambal valley basement is dipping in either side of Singoli-Rajgarh high. Integrated study has deciphered that the Singoli-Rajgarh gravity high is caused due to basement high. It also suggests the presence of sedimentary thickness of ~3 km south of this gravity high. Further, gravity modelling shows that a ridge like basement connecting western part of Bundelkhand (exposed) with granite exposed areas of Hosangabad passing through Rajgarh is separating Vindhyan Basin into Son valley and Chambal valley and not Bundelkhand craton as assumed earlier.

Integrated Microgravity studies were carried out in Kanjirangudi field, Ramnad sub-basin, Cauvery Basin for mapping low density sands for field development and also delineation of oil and gas bearing Babaguru pay sands and its extension at shallow level in Ankleshwar field of Cambay Basin. The study shows that the producing wells in Kanjirangudi field are falling in the transition zone/high gravity gradient zone and the dry wells are falling in the low gravity gradient areas. The Gravity modeling along a few selected profiles in both the East Coast Margin of India and West Coast Margin of India were carried out to have better understanding of crustal architecture and mapping of Continental to Oceanic Boundary (COB).

A composite Gravity Atlas of India comprising 82 separate gravity maps in large scale has been prepared by merging available gravity data of India up to Exclusive Economic Zone (EEZ) with a contour interval of 4 mGal that will be helpful to plan all future exploration strategies in India.

Basin Research and Petroleum System Modeling

Green field exploration

- A 365 km long regional geological cross section from south western basin margin of Chambal valley near Mandsaur through Chechat-Baran-Jhiri upto Bundelkhand massif in the North West have brought out the subsurface configuration of the Vindhyan basin. The regional study indicated that the Mukandara reverse fault has acted as an effective barrier for migrating hydrocarbons.
- Integrated Geoscientific analysis of Punch-Rajauri area of Jammu sub-Himalayas has



Fig. 2: Domain Specialization and Key Verticals

suggested existence of Salt Range Formation (SRF) of Pakistan to east of Jhelum Syntaxis and there is likely presence of Paleozoics in the Indian part as well. The basin had been considered to host only Tertiary sediments underlain by Proterozoic with a large hiatus in between. Presence of Paleozoics in the area thus enhances the hydrocarbon prospectivity at least in the area covering Mansar in southern culmination of Surin-Mastgarh anticline and Chandak and Narsinghpura in Punch-Rajauri area in Jammu sub-Himalayas.

- The hydrocarbon prospectivity analysis of peninsular Gondwanic basins of India was carried out in multi-basin study covering Purnea, Rajmahal, Bengal, Damodar, Hasdo-Mahanadi, South Rewa, Satpura, part of Deccan Syncline, Pranrita-Godavari (PG) and Krishna-Godavari (onland) basins (Fig. 4). The palynological studies revealed that characteristic Gondwana in India is represented by fluvial to lacustrine Permian and Triassic sediments only. Good to very good source potential interval in early maturation to peak maturation stage has been identified in Lower Gondwana sediments on the basis of geochemical evaluation. Petroleum Systems Modelling carried out along key profiles helped in evaluation of the hydrocarbon prospectivity of Gondwana sediments and a number of new prospects were identified in Damodar, PG,

Purnea, South Rewa and Satpura Basins through seismic correlation.

- The basin architecture and Mesozoic sedimentation study along Western Continental Margin of India has suggested presence of thick Mesozoic sequences in Kutch Saurashtra area while in Kerala Konkan area these sediments (Late Cretaceous) were deposited consequent to separation of Madagascar and remained thin and confined to shallower part of the basin. The absence of Mesozoic sediments in Mumbai offshore basin is attributed to its later opening during separation of Seychelles.
- The regional study of the morphotectonics, structural and entrapment styles in Andaman Basin have indicated that the outer high and fore-arc areas have low prospectivity, while the East Andaman basin in the back-arc could be the potential areas for future exploration in light of the encouraging results of nearby petroliferous North Sumatra and Mergui Basin. The 2D petroleum system modelling in the basin predicts the presence of both thermogenic and biogenic petroleum system. The Mio-Pliocene source rocks indicate generation of biogenic gas in the basin.

Brown Field Exploration

- Tectono-stratigraphy and sedimentation model in eastern basin margin in Ahmedabad-Cambay-Tarapur area in Cambay Basin indicates that the initial rift fill sediments of Lowstand debris flow and mid fan have better reservoir quality in areas south of Chaklasi. The Transgressive and Highstand facies show an active fluvial system in the southern part. The Halisa-Gamij areas bordering Walod low are more favourable for alluvial fan deposition due to steep gradient towards the margin. A basin wide geological relook in Jambusar-Broach Block in Cambay Basin has further refined the depositional model of the hydrocarbon bearing Hazad Member through higher order sequence stratigraphy. The revised facies maps at each reservoir/hydrocarbon pay zone level have brought out a number of updip shale out in Middle Eocene TST. New prospective areas identified especially in Gandhar and Motwan structures were later proved to be oil bearing. Prospectivity evaluation

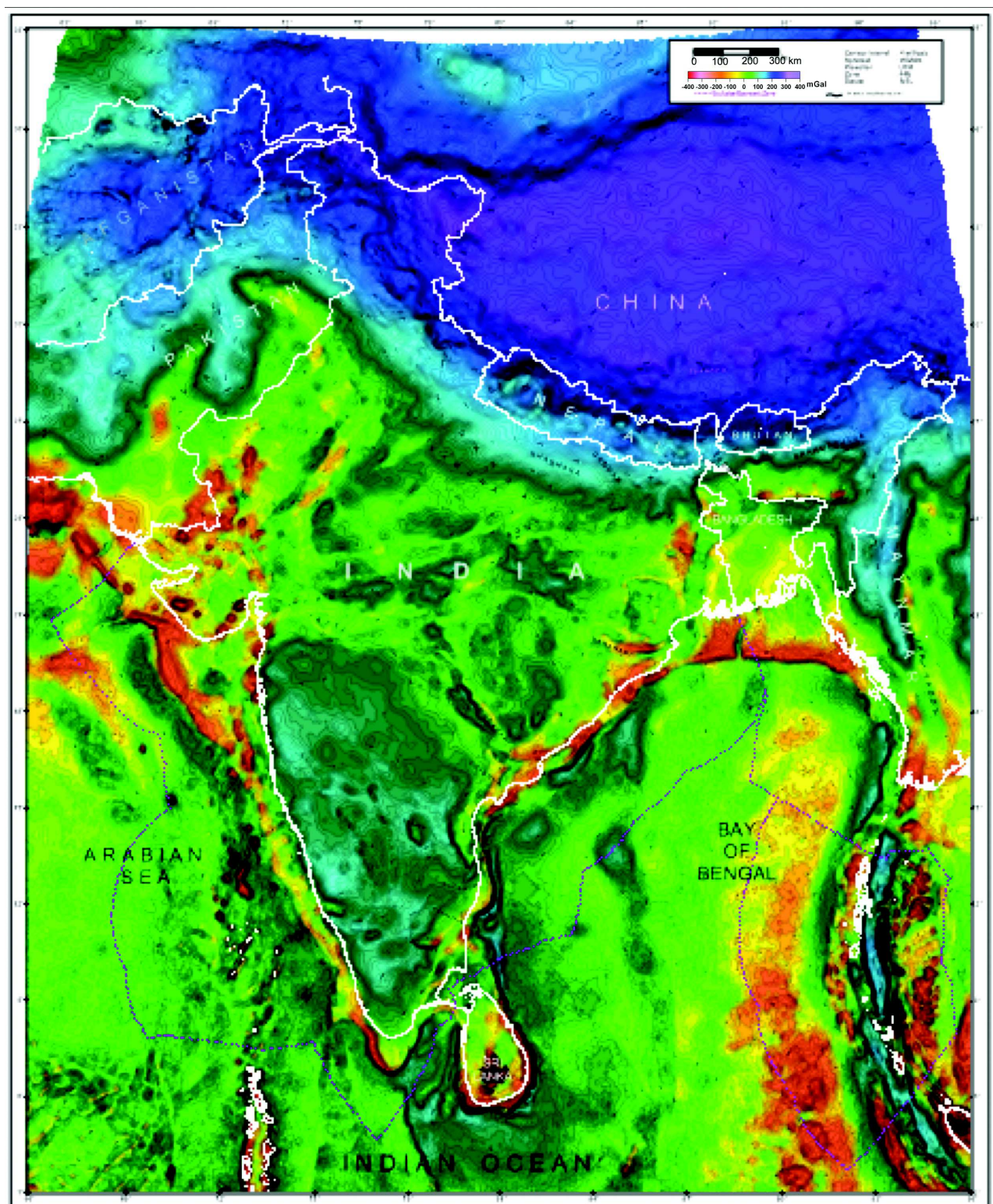
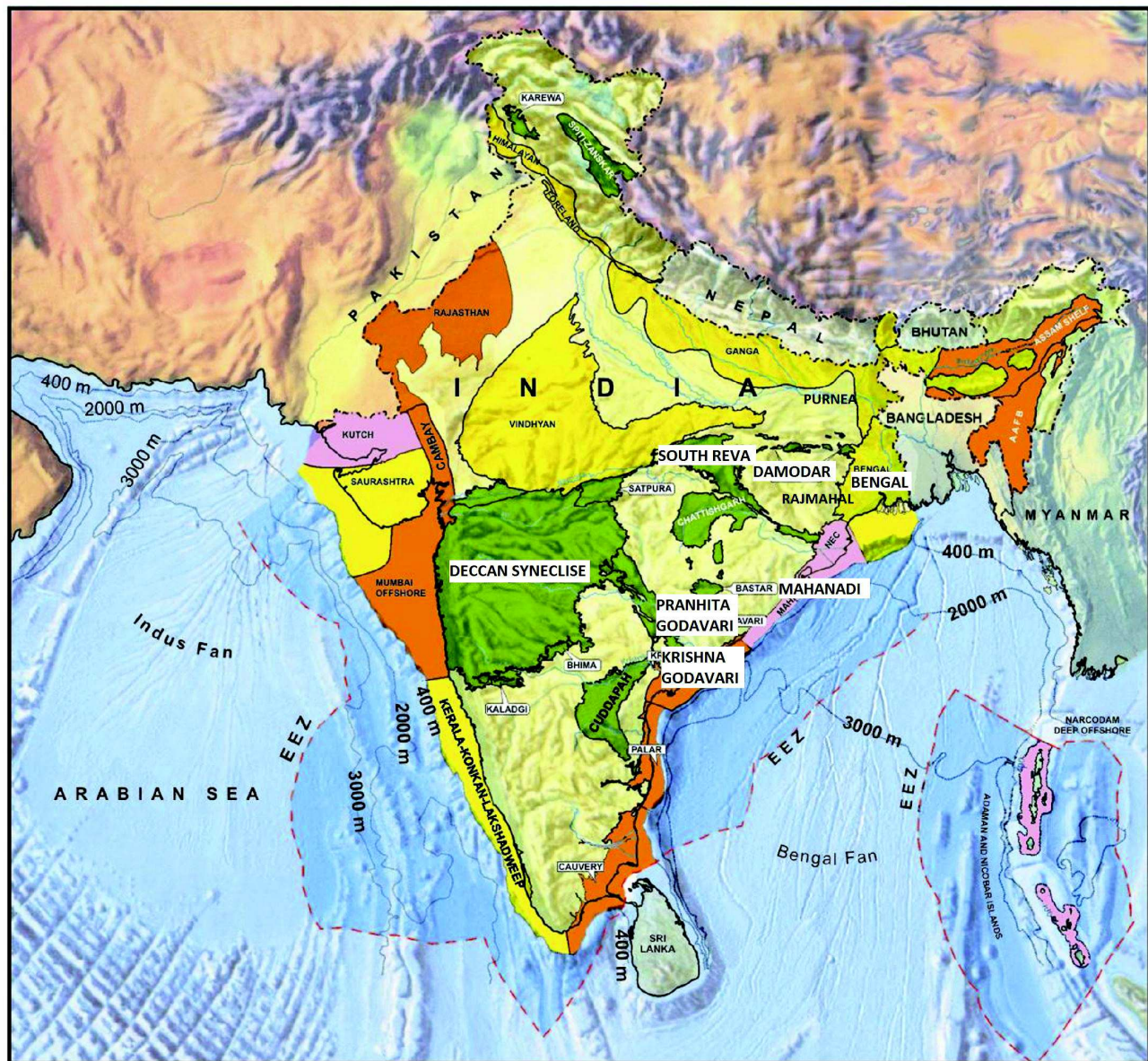


Fig. 3: Tectonic Map of India

of Syn rift sediments in Indian sedimentary basins has been the new focus of exploration. A number of syn-extensional wedges have been mapped within early rift sequence around

Nawagam, Mirol, Sanand and Wasna paleohighs in Ahmedabad Block in the form of syn-extensional wedge outs are new exploration targets.



LEGEND


	CATEGORY-I BASIN (Proven commercial productivity)		CATEGORY-IV BASIN (Potentially Prospective)
	CATEGORY-II BASIN (Identified prospectivity)		PRE-CAMBRIAN BASEMENT/ TECTONISED SEDIMENTS
	CATEGORY-III BASIN (Prospective Basins)		DEEP WATER AREAS WITHIN EEZ

Fig. 4: Sedimentary basins of India

- Detailed geological studies in Deep and Ultra deep water and its integration with shallow water and contiguous onland area in Krishna Godavari Basin have provided a comprehensive

understanding of sediment dispersal pattern, facies distribution, depositional architecture, and paleo-geography of various plays from Late Jurassic-Early Cretaceous Synrift plays to Plio-

Pleistocene plays. The study also brought out the nature and extent of continental crust, transitional crust/ rifted crust and continental ocean boundary (COB) including the nature and origin of 85° East Ridge complex and its role in the tectono-sedimentation in the deep offshore basinal part.

Sequence Stratigraphy

As follow up to Petroleum Systems Sequence Stratigraphy (PS Cube) studies in 7 Indian sedimentary basins by ONGC, higher frequency Sequence stratigraphic analysis have been attempted in North Cambay Basin and in Passive Margin & Foreland Sequences of Lakwa-Lakhmani-Geleki and surrounding areas of Upper Assam for identification of hydrocarbon bearing prospects within the deeper pays of Tura Formation in Lakwa and Geleki-Namti-Barsilla-Mekeypore area

Structural Modeling

Structural modelling in Chambal and Son valley substantiates the existence of compression and fracturing in the southern margin of the Son valley. The Son Narmada Lineament has undergone periodic reactivation throughout the evolution of Vindhyan Basin and also resulted in upthrusting of the Mahakoshal belt Palaita-1

- In Chambal Valley, sequential restoration revealed cumulative basement uplift in the vicinity of Mukandara Reverse Fault (MRF) at different stratigraphic levels. The formation of Chechat anticline and related folds with MRF trend are related to the post-Bhander tectonic events. In the Son Valley, sequential restoration carried out revealed that the Son Narmada North Fault was in existence since Archean time and Son Narmada South Fault came into existence during Bijawar deposition. During deposition of Karaundhi arenite, several extensional fault systems developed and deposition of the younger sequences continued in these fault blocks. The Great Vindhyan Syncline developed during Sirbu shale deposition. On the basis of the study, the area north of MRF confined to the Kota-Guna low is considered interesting for future exploration in Chambal Valley. The study substantiates the existence of compression in

the southern margin of Son Valley in the vicinity of SNL which can be targeted for future exploration.

In Assam Shelf and Assam Arakan Fold belt, by using state-of-the-art Move suite, in collaboration with Midland Valley Exploration (MVE), Glasgow, balanced and restored section and gave an insight into the evolution of the fold and Schuppen Belt and the Assam Foreland through time and an idea of the shortening involved due to compression. A comprehensive restudy of Tripura-Cachar-Mizoram fold belt through Move and Trap-Tester based Analysis established that while the dominant folding mechanism in the Tripura area was detachment folding, fault propagation folds predominate in the Cachar Fold Belt. The “Fracture network modelling and tectonic history of Mumbai High Basement” indicated that initially an extensional deformation during Late Cretaceous resulted in evolution of normal faults over the Basement. Further, inversion along the Mumbai High East fault initiated during Late Oligocene and continued up to Late Miocene time. 3D geomechanical sequential restoration of surfaces has brought out that most of the captured strain was generated during the initial deformation of the Basement.

- As a special initiative, the updation and refinement of the “**Tectonic Map of India**” (Fig. 3) has brought out a few morphological features like Laxmi ridge and Chagos-Laccadive ridge in Arabian Sea region. The Laxmi ridge is viewed as continental sliver while Chagos-Laccadive ridge represents Plume Trail formed when Indian plate passed over plume during its northward movement. The study has resulted in mapping of Continent-Oceanic Boundary (COB) covering the flanks of Indian peninsula. The COB along western margin is found to be often associated with presence of SDRs. The map provides evolutionary history of the Indian sub-continent including shallow and deep water areas within the ambit of global plate movements and gives insight into the sub crustal variation across the Indian continent.

Petroleum System Modeling

3D Petroleum System Modeling of all major hydrocarbon bearing sedimentary basins have been

carried out to assess the hydrocarbon resource and Yet To Find (YTF) potential.

- The 3D Petroleum system modelling of Mumbai Offshore, Krishna Godavari, Cauvery, Assam & Assam-Arakan, Mahanadi and Bengal Basins were carried out on a regional scale to understand their Petroleum system dynamics in time and space and to assess the hydrocarbon resources potential.
- In Mumbai Offshore, the Source rock tracking has established multiple petroleum systems viz. Palaeocene-Palaeocene, Paleocene-Early Eocene-Middle Eocene-Oligocene, Paleocene-Early Eocene-Middle Miocene and Middle Eocene-Middle Miocene.
- In Krishna Godavari Basin, Multiple Petroleum Systems from Permian to Pliocene for thermogenic as well as biogenic accumulations as Permian – Late Triassic (!) (Kommugudem – Mandapeta plays), Permian – Late Jurassic to Early Cretaceous (!) (Kommugudem Syn - Rift Plays), Late Jurassic/Early Cretaceous–Late Jurassic to Early Cretaceous (!) (Krishna/Gajulapadu/Gollapalli – Nandigama/Kanukollu/Gollapalli plays), Aptian-Albain–Aptian-Albian/Late Cretaceous (!) (HG-HR-Raghavapuram, Raghavapuram-Tirupati plays), Late Cretaceous & Late Paleocene - Early Eocene & Mid to Late Eocene - Oligo-Miocene- Pliocene (!) Raghavapuram/Palakollu/Vadaparru-Pasarlapudi-Matsyapuri-Ravva-Godavari plays).
- The studies in Mahanadi Basin corroborates the established Miocene/Pliocene-Pliocene biogenic petroleum system. The model infers that charging of Neogene reservoirs with thermogenic hydrocarbon is least promising from Late Cretaceous source rocks as the same attains critical moment by Late Oligocene in major part of the basin. The modelling results indicate that the generated hydrocarbon is mostly lost as side and top flows due to the absence of suitable entrapment conditions. Thermogenic gas generation is observed from the L. Cretaceous source rock, but most of the hydrocarbon generated is being lost due to model geometry. It can be inferred that Late Cretaceous-Paleogene (?) petroleum system may exist.

- The 3D petroleum system modelling for Assam shelf, established that the major part of the hydrocarbons in Assam Shelf have been sourced from the autochthonous block below the basal thrust in the Naga Schuppen Belt during a peak expulsion period at around 1.8 Ma.

Resource and Petroleum Economics

Resource appraisal and Petroleum Economic analysis is the key parameter for prioritization and selection of exploratory areas/blocks before any investment decisions in the E&P sector. Consequent upon earlier resource estimation in 1964 and 1976, a systematic in house approach for resource estimation in ONGC started in 1985 by KDMIPE and a comprehensive resource assessment effort was made by Indo Soviet Resource Assessment Group (ISRAG) in 1990 and Prognostic resources of 18.5 billion tons was estimated for ONGC area of activities as on 1.4.1996. Since then substantial additional data has been generated by ONGC and Oil India Limited (OIL) as well as private operators from blocks awarded under various pre-NELP/ NELP (New Exploration Licencing Policy) rounds and also from nomination blocks. All nine NELP rounds were conducted based on estimated resource base by KDMIPE. Ministry of Petroleum and Natural Gas (MoPNG), Government of India, had endorsed a proposal from Directorate General of Hydrocarbon (DGH) for fresh assessment/re-assessment of hydrocarbon resource potential of all the 26 sedimentary basins of India including deep water areas integrating all the available geo-scientific data. The mandated exercise of 'Re-assessment of hydrocarbon resources for sedimentary basins and deep water areas of India' has been taken up. ONGC in association with OIL and DGH is providing data for the other operator block. The project is being carried out at designated work centres of ONGC.

Geology and Geochemistry

Sedimentology-Biostratigraphy and Chemostratigraphy

Multi-disciplinary studies to evaluate the reservoir facies in Rohtas Limestone in Son Valley, Vindhyan Basin by integrating the microfacies, electro log attributes and high resolution sequence stratigraphy was carried out. The Rohtas Limestone has been subdivided in to 11 micro zones. Fracture analysis from

XMRI data indicated a dominant NE-SW fracture orientation with a second set in NW-SE direction. The fractures are better developed in the upper and middle units. Stable carbon and oxygen isotope and trace element data are also analyzed that show that the overall values are similar to Proterozoic oceans with two major negative excursion of isotope values (down to -5 to -7%) coupled with the presence of helically coiled filamentous algae, siliceous sponge spicules and small marine spinose acritarchs which are correlated with some major worldwide geological events. The lower negative shift is to be associated with cap carbonates immediately overlying the third and last Neo-Proterozoic glaciation events (Biskhop glaciation) whereas the upper negative shift represents close to the unconformity surface and is comparable with delta ^{13}C global curve present close to the Precambrian-Cambrian boundary.

Remote Sensing and Geomatics

Remote Sensing & Geomatics Division the only facility in ONGC having expertise in Image based Geological Mapping associated with field work that help in hydrocarbon exploration in various stages of E & D scenario. In the initial stage of exploration in a basin, it carries out outcrop analysis, basic lithological, structural input and regional lay out of the basins. The Synthetic Aperture Radar (SAR) based offshore hydrocarbon seepage detection study integrated with sea-bed mapping and seismic interpretations has been successfully used to detect oil seepages and relate them to the subsurface geological structures and petroleum system elements in the entire East Coast and Kerala-Konkan. SAR images has been properly supplemented by seismic interpretation as well as seep database, procured from M/S NPA, United Kingdom as an effective exploration screening tool. The Drainage, Image and DEM based structural analysis for delineation of subsurface structural elements and subtle structures that are beyond seismic resolution, fracture modelling had been successfully used in neotectonically active basins like Assam Shelf and Fold Belt areas, Foreland basins like Ganga and Bengal, for basement oil exploration in Cauvery and South Assam Shelf and for Coal Bed Methane exploration in Damodar Valley. This technique in combination with tectonic stress analysis had also served to be useful in delineating faults acting as re-migration conduits and structures acting as areas of

accumulation of the remigrated hydrocarbon.

- Other techniques used in exploration include onland detection of hydrocarbon micro-seepages and hydrocarbon alteration induced anomalies to target probable prospective zones in Yet-to-be-Explored basins, using image processing techniques like band ratioing and PCA of high resolution and multi-temporal images which in combination with high resolution magnetic data and adsorbed gas geochemical data in Ankleshwar-Kosamb areas of Cambay Basin and will be used in the Krishna Godavari Onland areas.

Geochronology

KDMIPE has one of the best Geochronology Laboratories of the country which is equipped with the new state-of-the-art TRITON-Thermal Ionization Mass Spectrometer (TIMS). The new facility, in addition to utilizing conventional dating techniques like Rb-Sr, Sm-Nd and Sr isotope stratigraphy, can also be used for implementing the emerging frontier exploration relevant technologies/studies related to reservoir characterization, dating of source rocks, HC migration and Oil-Oil and Oil-Source correlations based on various isotopic attributes.

- Radiometric age dating of basement in Western Offshore yielded radiometric ages for metamorphic events from the basement of Mumbai High which has provided new insights of the tectonothermal events taken place during the Palaeo-Mesoproterozoic and also could be correlated with the extension of the Central Indian Tectonic Zone (CITZ) suturing the North and South Indian Blocks, whereas in East Coast Basins the study provided new insights in the understanding of crustal evolution of the Eastern Ghats Belt and Madurai Block in the Southern Granulite Terrains. The study also provided new ages of Charnockite and Khondalites emplacements which fix the new age constraint for their magmatism in the Eastern Ghats Belt.
- The Strontium-Neodymium isotopic studies and major-trace elemental studies of basalts/intrusives from Western Offshore indicated that the Kerala-Konkan Offshore basalts are Enriched-type Mid Oceanic Ridge Basalts (E-MORB), and are different as compared to

Deccan basalts of Kutch and Mumbai Offshore and has important implications on sub-basalt exploration for Mesozoic sequences in the Western Offshore areas, especially in Kerala Konkan Offshore basin. Further, in Eastern Offshore, the study confirmed the basalts encountered in the deep water wells to be Rajmahal volcanics. This also has important implications for the origin of 85° E Ridge, which is indicated to be of Kerguelen Plume origin for the first time through the studies.

Geochemistry

- Surface geochemical prospecting as a direct method for exploration of hydrocarbons, involves analyzing soil samples for adsorbed hydrocarbons. Total 139 surface geochemical surveys in ONGC in 16 basins which include 67 surveys in West coast basins (Kerala-Konkan, Mumbai Offshore, Kutch-Saurashtra and Cambay), 46 in East coast basins (Cauvery, Krishna Godavari and Mahanadi-Bengal-Andaman), 3 in Assam and Assam-Arakan Basin and 23 in Frontier basins (Himalayan Foreland, Satpura and Vindhyan) have been integrated in a Pan India scale adsorbed gas anomaly map. The atlas has been prepared by collating all the adsorbed gas data generated (consisting of 138 sheets) on Pan India scale followed by regional/area maps depicting adsorbed gas concentrations in the survey/study areas.
- Oil to oil and oil to source correlations have been carried out in various basins of India through the molecular level characterization and stable carbon isotopic studies of oils and rock extracts, so as to have an understanding of the petroleum systems in these basins. In the oil to source correlation study with reference to Bassein Formation as source rock in Western Offshore Basin, it was observed that the oils of different fields of Mumbai offshore are genetically correlatable and Panna Formation is the major source for the oils of Mumbai Offshore Basin. Bassein Formation has not yet attained temperature to expel hydrocarbons. In another study, oil to source correlation in West Godavari sub-basin, Krishna Godavari Basin shows genetic correlation among Cretaceous oils and

existence of petroleum sources in Early Cretaceous Raghavapuram Shale and also within the Early Cretaceous shales interbedded in dominantly arenaceous facies of Kanukollu and Krishna formations.

- As an initiative, integration and evaluation of geochemical attributes of has been attempted for the East coast, West coast, A&AA and Frontier basins. Geochemistry data of sediments, oils and gases of East Coast basins (Cauvery, Krishna Godavari and Mahanadi-Bengal-Andaman), West coast basins (Kerala-Konkan, Mumbai offshore, Kutch-Saurashtra and Cambay), Assam and Assam-Arakan Basin and Frontier basins (Jaisalmer, Himalayan Foreland, Ganga, Satpura, South Rewa and Vindhyan) generated till date has been compiled, integrated and interpreted so as to have a basin-wise consolidation of geochemical database. The integration of the geochemical attributes of all the basins of India will facilitate the understanding of Petroleum Systems of these basins and hence may facilitate further exploration endeavours.

Well Logging and Reservoir

Well Logging and Petrophysics

The Petrophysics laboratory is equipped with state-of-the-art equipment viz. Coreval-30, Acoustic velocity system-700, KEYPHI and NGS system to carry out measurements on ambient and confining conditions, for petrophysical and acoustic parameters. Logging and petrophysical studies include formation evaluation, reservoir characterization, geomechanical modelling using “Drill works” software and development and standardization of multi-mineral. Petrophysical model with “Elan-plus” and Geolog softwares. The Petrophysics laboratory carries out extensive studies on cores for the determination of i) Petrophysical constants namely: α , m and n . ii) Petrophysical parameters such as Porosity, Permeability, Grain density, Bulk density, Matrix density, Pore volume and Bulk volume iii) Acoustic velocities (V_p , V_s) and mechanical properties such as Young’s modulus, Poisson’s ratio; Bulk modulus, Shear modulus, Lamé’s constant, rock Compressibility and iv) Concentration of radioactive elements U, TH and K on core plugs. Integrated log analysis and mineralogical studies have been carried out to identify

productive petrofacies in LBS unit of Laplingaon area in Assam Shelf. The reservoirs in LBS-III and LBS-IV are complex in nature and their identification and characterization is a challenging task. Three sets of reservoir petrofacies with variation in mica and clay content have been identified corresponding to predominant lithology/facies in reservoir section in LBS-III and IV. The study helped to identify a number of new hydrocarbon bearing layers within LBS-III and LBS-IV in all the wells studied in the area.

Study on “Reservoir characterization and development of petrophysical evaluation of complex lithology/low resistivity pays in north-eastern part of Cambay Basin” reduced the uncertainty in estimation of saturations and identifying interesting layers in clastic reservoirs where thin laminations and high clay-bound water fraction along with conductive and non-conductive minerals are present. The reasons of low resistivity in Middle Eocene Kalol Formation and Early Eocene Mandhali Member were ascertained primarily due to the shale cation exchange capacity (CEC) factor and presence of significant amount of conductive minerals. Similarly the dominant cause of low resistivity in pay sand GS-12 of Gandhar Field in Cambay Basin, was found to be due to Clay type and their mode of distribution, grain and pore size and presence of heavy conductive mineral-Pyrite. The studies are being carried out to predict pore pressure, fracture and temperature gradients through well logs and demarcation of HP/HT areas at the top of Raghavapuram shale, HG-HR, and other Syn-rift sequences and mapping of the high pressure-high temperature areas of Krishna Godavari Basin.

Reservoir

Reservoir analysis is being carried out field wise, sand wise and well wise using classical reservoir engineering techniques (MBAL, Chans analysis, WOJ etc.) for optimum exploration. Reservoir Simulation studies are also carried out for field development, and pressure maintenance to increase ultimate recovery of hydrocarbon. Flow assurance studies are being carried out for characterization of different types of crude specially waxy, asphaltic, bitumen and tar sands. Studies on paraffin problems in production flow line and tubing for smooth transportation of crude oil by using various chemical additives. The chemical additives are identified, evaluated and doses are

optimized on the basis of viscosity, pour point, wax inhibition and dispersion. The PVT studies for phase behaviour of reservoir fluid in oil and gas reservoir are being carried out to determine the major PVT parameters like oil compressibilities, saturation pressure, live oil viscosity, live oil density, oil and gas formation volume factor differential flash GOR and determination of bubble point pressure.

Unconventional Energy Research

Gas Hydrate

Gas hydrate exploratory research in India is being steered by the Ministry of Petroleum & Natural Gas under National Gas Hydrate Program (NGHP) with participation from Directorate General of Hydrocarbons (DGH), National E&P companies (ONGC, GAIL, OIL & IOC), NIO, NGRI, NIOT and GSI. ONGC has been playing a major role in the NGHP since its inception and has played a very crucial role in NGHP Expedition 01(Krishna Godavari, Mahanadi, Andaman and Kerala-Konkan). Huge amount of gas hydrate deposits were thus established in the Indian deep water areas particularly in Krishna Godavari and Andaman Deep Offshore areas. Further studies were carried out at KDMIPE from 2007 to 2014 to identify the gas hydrate occurrences in sand dominated reservoirs in the Eastern Offshore. Total of 83 locations were identified in Krishna Godavari and Mahanadi Offshore areas and 25 most prospective sites were identified for NGHP Expedition 02.

KDMIPE coordinated the execution of NGHP R&D Expedition 02 from 3rd March to 28th July 2015 for drilling/coring/logging of 42 wells in the Krishna Godavari and Mahanadi deep offshore areas with an objective to find gas hydrates in sand facies. Two areas in Krishna Godavari deep offshore have been identified as world class gas hydrate bearing sand reservoir systems and represent ideal sites for future gas hydrate pilot production test(s). This has projected India as a world leader in the area of gas hydrate Exploration.

Shale Gas

KDMIPE has been making sustained efforts to establish the shale gas potential of Indian sedimentary basins. In India, prospective shale formations are

spread over several sedimentary basins such as Cambay, Krishna-Godavari, Cauvery, Assam and Assam-Arakan and Gondwana. Basin Information dockets for eight prioritized basins viz. Cambay, Krishna-Godavari, Cauvery, Ganga, Assam and Assam-Arakan, Rajasthan (Jaisalmer), Vindhyan, and Kutch have been prepared by KDMIPE developed expertise in evaluating the shale selections of wells drilled in various Indian Sedimentary Basins by field and laboratory investigations including conventional coring, on-site desorption followed by long-term desorption at Shale Gas laboratory at KDMIPE together with geochemical and sedimentological analysis of shale core and desorbed gas samples. These observations are critical for prioritization of prospective areas and making exploration-exploitation decisions.

Basin Centred Gas (BCG)

Assessment of Depocenters of Cambay Basin for Deep Gas exploration was taken up to understand the basic concept of Deep gas and assess the feasibility of exploration. Four depocenters namely Patan & Warason lows in Mehsana block, Wamaj low in Ahmedabad block and Tankari low in Jambusar – Broach block of Cambay Basin were assessed for deep gas exploration as they contain ample volume of syn-rift deposits.

In September 2006, “Basin Centred Gas Exploration” group was constituted under Non Conventional Research Division of KDMIPE and prospects were identified in Wamaj and Tankari lows in Cambay Basin. Since then, a number of R&D Projects were taken by KDMIPE towards identification and evaluation of prospective locales for BCG accumulation in Kavitam Low & Bantumilli Graben in Krishna Godavari Basin India.

Coal Bed Methane (CBM)

CBM Division in KDMIPE plays an important role and carried out various works and contributed immensely for Evaluation of CBM Potential of Gondwana and Tertiary Coalfields of India. Determination of Gas Content of coal seams including onsite Desorption Studies (Canister Tests) as well as Proximate Analysis of coal samples are carried out for coal rank classification for Tertiary and Gondwana coals in various basins. In addition Cleat

Characterization through high resolution SEM-EDS and XRD studies are also carried out for evaluation and final prioritization of the Low Rank coalfields. Coalbed methane resource of for Tertiary coals have been estimated for CBM Potential in different areas like, Tharad-Patan, Mehsana and Ahmedabad tectonic blocks in Cambay basin, in addition to Barmer basin and Purnea Basin. Further, Integrated Cleat Characterisation studies with Image and Acoustic Logsin Jharia, Raniganj, Bokaro and North Karanpura CBM Blocks have also been carried out.

Key Achievements

- Tectonic Map of India covering offshore areas within the ambit of concepts of Plate Tectonics.
- First ever integrated Geological map of Tertiary belt of Himalayan foothills
- First ever ‘Basic Gravity Map of India’ for visualizing crustal variations in the sedimentary basins of India
- Integrated Geomorphic (morphotectonic) maps of entire Cachar, Tripura and Mizoram using LANDSAT imageries, geological field and subsurface structural data.
- Pan India scale Geochemical C2-C4 anomaly map
- Development of application software for GM data and Pre-stack elastic wave equation
- Credited with Reserve Estimation of all the fields of ONGC and other sedimentary basins
- Initiated the resource appraisal of Category I to IV sedimentary basins of India and estimated the resource base, a first of its kind in the world.
- Played lead role in appraisal of gas hydrate prospectivities and prioritized successful drilling in both eastern and western offshore during NGHPI & II in collaboration with international agencies USGS, USDOE, JOGMEC & JDC Japan.
- Preparation of gas-hydrate anomaly map of India.
- Established Resource base for Coal Bed Methane in India

Major R&D Facilities

- Geophysics: High Precision GNSS System Survey equipment; CG-5 AutoGrav Gravimeter;

Proton Precision Magnetometer; ADU-06 and ADU-07e MT Systems; Geosoft Oasis-Montaj platform software for mapping, data processing and modeling facilities, Winglink software for MT data interpretation.

- Basin Research and Resource Appraisal: Areal yield method in areas/basins with inadequate geological information; Basin and Petroleum System modeling approach; Softwares like Petro-mod, Petrel, Arch-Info, Crystal ball, Questor, Asset; E & P global G & G database 'Tellus' for detailed understanding of regional and basinal level prospectivity of hydrocarbon along with techno-stratigraphy history of the basins.
- Sedimentology: X-Ray Diffractometer; Scanning Electron Microscope with EDS; and Motorised auto focus Fluorescence petrological microscope
- Geochronology: Triton-Thermal Ionization Mass Spectrometer (TIMS) for Rb-Sr and Sm-Nd isotopic studies; Autoscan System for AFTA studies.
- Remote Sensing: ARC GIS 10.3 with 3 D analyst and spatial analyst for GIS based data interpretation, correlation and analysis; TNT Mips for advanced image processing technique; Microstation 95 with image analyst for basic image processing and digitization.
- Geochemistry: GC-MS-MS; GC-IRMS; Gas Chromatograph; Rock Eval 6; Fluorescence microscope with image analysis system; Elemental analyzer; Inductively Coupled Plasma Spectrometer; Total Sulphur and Nitrogen Analyser; Automatic Kerogenatron System; Total scanning fluorescence; FT-IR Spectrophotometer; UV-Vis spectrophotometer; Natural Gas Analyser.
- Petrophysics: Advanced Natural Gamma Ray Spectroscopy and NMR labs
- Reservoir :PVT and Flow Assurance studies
- UCRG: Desorption and proximate analysis

Technology Upgradation Plan

- Setting up of Biotechnology lab in collaboration with ONGC Energy Centre, New Delhi, to carry out R & D studies on biofuels and bioenergy

and improvise microbial activities for E&P industry.

- Shale gas module within Petromod suite of software is planned to be used for assessment of Shale gas prospectivity through Petroleum System Modeling. It will enable to estimate shale gas resources for different basins.
- State-of-the-art Gravimeters, MT systems and precision survey equipment with latest modelling softwares
- FE SEM with automatic mineralogy software for high resolution reservoir characterization especially for Shale gas – oil exploration
- Noble Gas Mass Spectrometer (NGMS) for Ar-Ar dating of basalts and intrusives and for studying low-temperature thermal history of basins
- Core Gamma Ray scanner for accurate positioning of cores and quantification of U, Th and K content
- Automated Core Saturation System, Dean Stark Setup, Geometric Bulk Volume Measuring Equipment, Electrical Properties Measuring equipment

Awards

- The KDMIPE has received two Major "Energy and Environment Foundation Global Awards-2014" during the 5th World Renewable Energy Technology Congress and Expo-2014 held on 23rd August, 2014 at New Delhi under the categories of Sustainability Management - Rainwater Harvesting (GOLD AWARD) and Renewable Energy for Sustainable Development and Energy Efficiency (SILVER AWARD).
- Prestigious Golden Peacock Award for Occupational Health & Safety in the Oil & Gas Upstream category (GPOHSA-2012) for the year 2011-12 in the 14th World Congress on Environment Management.
- CMD-ONGC Trophy for Best Performing R&D Institute for the year 2011-12 and 2014-15 for excellence in performance and significant contribution leading to overall performance of the organization.

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