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Mesozoic Prospectivity of Kerala Konkan Offshore Basin

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Summary

The Mesozoic sediments contribute around 54% of the Oil and 44% of the Gas reserves globally. Indian Mesozoic Basins occupy an area of around 390,000 sq. km and are usually characterized as frontier basins under category II-IV. These basins are mostly overlain by the Basaltic Deccan Traps of late Cretaceous age.

The imaging problem of sediments underlying basalt layers is caused due to several factors. The main element is the high reflectivity at the top basalt interface which impedes penetration of seismic energy into the deeper layers. Another is the scattering of energy; particularly of high frequency components caused by the rugged topography of the basaltic surface and the heterogeneity within the basalt, caused by successive lava flow. Extensive peg-leg multiple within stacked basaltic layers amplify the problem. In addition the seismic wave velocity in basalt is higher than those of surrounding sediments resulting in ray turning and wave- mode conversion of the seismic wave.

Studies have been done to find out the possible solutions of the seismic imaging problem in acquisition as well as at the processing stage and the followings are some feasible approach 1.) Radon filtering for multiple suppression, 2) Pre- stack depth migration (with anisotropy correction), 3) Angle domain analysis to reduce the angle dependent wave propagation effect. 4) Use of low-frequency seismic source to reduce scattering. 5) Inverse Q-filtering to compensate for the effect of attenuation. 6) Multi-component seismic (7) Long offset seismic data acquisition.

The results of deep water wells drilled in Kerala Konkan basin, led to a conclusion that the Prospectivity of Tertiary sediments in the basin is weak due to the absence of mature source facies and lack of generation potential. However the success results in well GK-28-2 in the Mesozoic sediments below the volcanic in Kutch Basin shifts the exploration interest to Mesozoic sediments below Deccan trap. In this paper, Attempts have been made to find the Mesozoic Prospectivity in Kerala Konkan basin below Deccan Trap using the advanced acquisition, processing and interpretation techniques. To overcome the Trap problem mentioned above, 2D Long Offset seismic data have been acquired to gather the information of interested zones. Pre-STM & Beam PSDM is followed for imaging the data and the processed data is interpreted to identify the Prospectivity of Mesozoic sediments in Kerala Konkan Basin.

Though the available seismic data does not indicate the presence of significant structural deformations but the regional understanding and geological analogy of the basin do suggest the existence of major rift system in the area during Mesozoic period. It is presumed that the hydrocarbon generated in the sediments would have converted into gas in view of the high geothermal gradient derived from basal heat flow during rifting and volcanic eruption.

So any structural highs in Mesozoic related to basement or any stratigraphic pinch out against the Deccan trap may trap hydrocarbon.

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Introduction

The Kerala-Konkan basin located at South of 16º N latitude. Kerala-Konkan offshore basin forms the southern part of the western continental margin of India and extends from Goa in the north to Cape Comorin in the south. Westward, the basin extends to Arabian Abyssal plain. On the eastern side it is bounded by Indian peninsular shield.

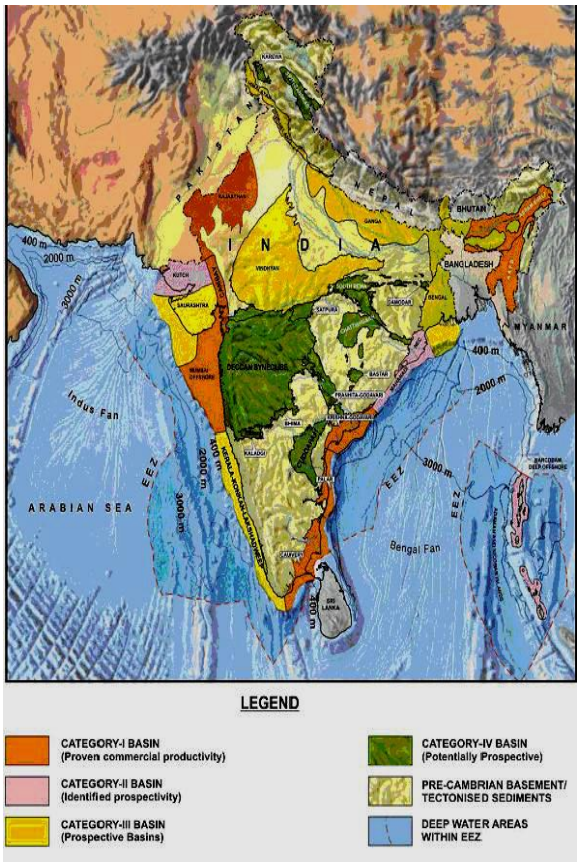

Fig 1: Geographic Location of Kerala-Konkan Basin

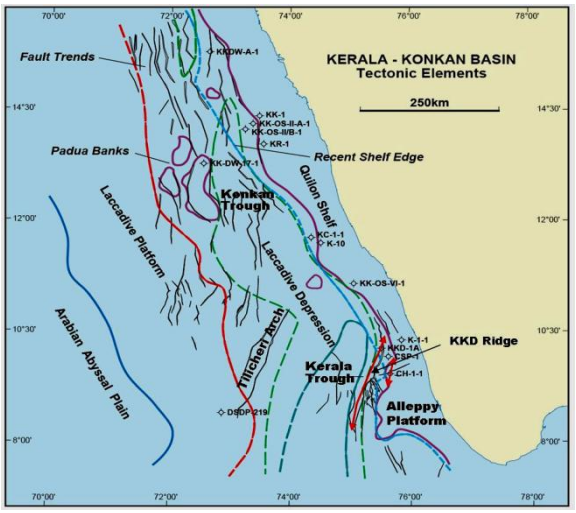

Fig 2: Tectonic Elements of Kerala Konkan Basin

Hydrocarbon has been discovered all through coastal areas of India except Kerala-Konkan basin. In Kerala-Konkan the Tertiary and Mesozoic sediments are separated by a thick Basaltic layer. Imaging below basalts has always been a problem in oil exploration. The thick basalt is opaque and masks deeper seismic events below the basalt. Only few wells have penetrated and drilled below the basalt till date. The Geophysical Survey includes Gravity and Magnetic Surveys which covers an area of 45,000 LKM. The seismic survey includes 2D and 3D Surveys. The 2D Surveys cover an area of 146,445 LKM and 3D Surveys cover an area of 9734 SKM. ONGC acquired around 110,968 LKM of 2D and 5495 SKM of 3D Seismic data. Shell India and BHP Petroleum acquired 9,898 LKM and 2,384 LKM of 2D respectively. DGH has acquired 10,218 LKM of 2D seismic data in deep waters. Reliance Industries Ltd. has acquired 10,977 LKM of 2D and 4,239 SKM of 3D data.

None of these surveys targeted the Mesozoic sediments below the Deccan traps. The thick basalt masks the deeper seismic events below. So the clear idea of Mesozoic sediments is unfamiliar to the industry.

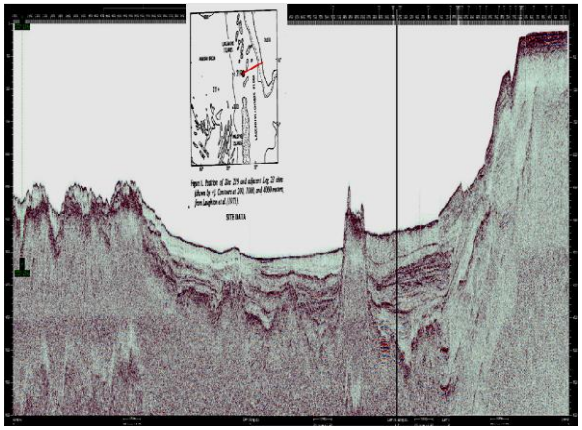

Fig 3: One representative W-E seismic section across the basin.

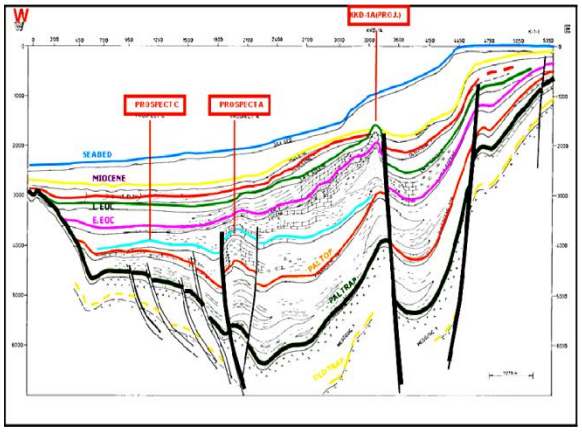

Fig 4: The schematic geological cross section drawn from a seismic section (W-E) across the basin.

The Tertiary sediments rest over Paleocene trap. No clear idea could also be formed about the thickness distribution pattern of Basalt using existing seismic information. The section gives enough information about the sediments above the Paleocene Trap and the top of the Trap. Based on the conventional seismic and other survey leads/prospects have been identified within Tertiary and a number of wells have been drilled targeting these sediments but till now no encouraging results found. The prospectivity of Tertiary is lean due to absence of good source sediments and lack of generation potential. So the exploration objective is shifted to Mesozoic sediments underlined Deccan Trap.

Theory

The structural setting of Kerala-Konkan Basin is similar to Bombay Offshore Basin. However the horst and graben features on continental shelf are comparatively less pronounced. Long offset data yields better sub-surface images below the trap which were masked earlier. Multibeam survey, done in few RIL blocks, have given the direct indication of Hydrocarbons, may be extended to other area also. Sea bed logging survey has given indication of Hydrocarbons, can also be extended regionally.

Moreover success in well GK-28-2 in the Mesozoic sediments below the volcanic in Kutch Basin shifts the exploration interest to Mesozoic sediments below Deccan trap. The main objective is to establish the Mesozoic Prospectivity in Kerala Konkan basin below Deccan Trap using the 2D long offset seismic process with Pre-STM & Beam PSDM to overcome the Trap problem mentioned above and acquire information below Deccan Trap and analyze the data and establish the prospectivity in Mesozoic sequence.

Workflow

In the view of Mapping of Mesozoic sediments 2D long offset seismic data is acquired with appropriate Source/Receiver parameters. Some of the important parameters are given below

Recording Parameters

Recording Length	12S
Total recording delay	
Sample rate	2ms
Polarity	First Break is negative
Low-Cut	Analog 3 Hz
Hi-Cut	200Hz@370 dB/oct

Sourcs Parameters

Total Volume	6300 cu.in
Work Pressure	2000 psi. +/-10%
Duel Source	No
Depth	15.0m+/-0.5
Array Separation	10m
Center Source to Nav Antenna	130.8

Steamer Parameter

Length	12000m
Auxiliaries	12
Shot point Interval	50m
Offset CS-CFG	173m
Group Interval:	12.5m
Number of channels	960

Processing Sequence

Likewise after the acquisition a special processing sequence is followed to enhance the S/N ration specially in the Mesozoic level. The data is processed Onboard and Onshore in two stages -

Onboard processing sequence-

- Reformatting
- Removal of bad traces and shot editing
- De-ghosting, de-signature and de-bubbling
- Zero phase low cut filter
- Anti alias filter
- De-spiking
- Spatial antialias
- Amplitude compensation including offset term
- Swell noise attenuation in CDP domain
- Linear noise attenuation
- SRME
- Q compensation
- Acquisition foot print removal
- Tau P interpolation
- Linear Tau P decon for multiple attenuation
- Reverse NMO
- Decon before stack

On shore Processing Sequence:

- Surface consistent decon
- Diffracted multiple attenuation
- Full Kirchhoff 2D migration
- PSTM velocity field creation
- Final 2D anisotropic PSTM using Kirchhoff algorithm
- Close grid velocity analysis
- Final stacking velocity field creation
- High resolution radon multiple attenuation
- Full offset PSTM stack
- Random Noise attenuation
- Time variant filter

Examples

In this paper, attempts has been made to get determine the nature of Mesozoic sediments and the basin configuration with the help of suitably processed 2D Long offset seismic and regional understanding of the Kerala Konkan offshore Basin.

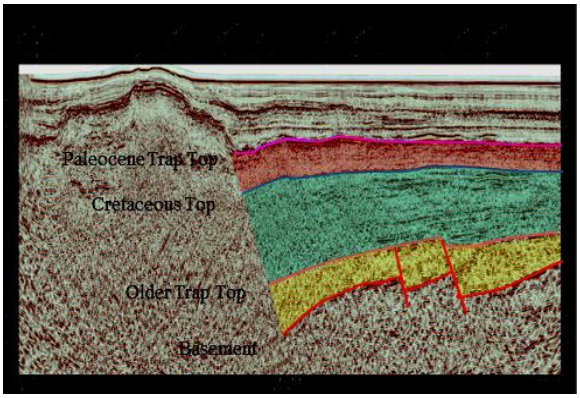

Fig 5: One representative 2D long offset PSDM beam migrated stack reduced back to time (NW-SE) seismic section across the basin processed

This seismic section shows some parallel reflection events below the Deccan Trap which may envisage to be Mesozoic sequence.

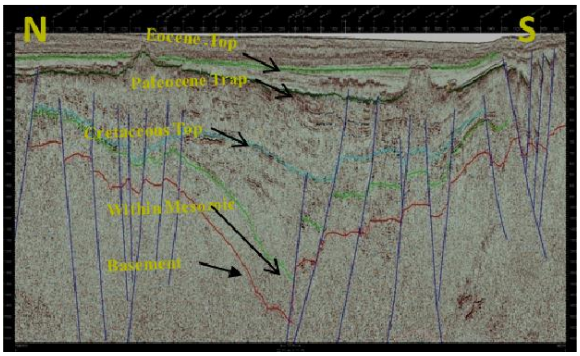

Fig 6: One interpreted 2D long offset PSDM beam migrated stack reduced back to time (W-E) seismic section across the basin.

In these seismic profiles, a good number of reflection packages are seen between the Paleocene & Santonian Trap reflectors. Patchy reflection packages are seen below the older Trap reflector also. While there is a significant improvement in the data quality below the Paleocene Trap

as shown above. The presences of these reflection packages do suggest the possibility of Mesozoic sedimentary sequences.

Geological Analogy

In this context, I would like to generously quote certain valuable observations by Nathaniel et al in their Paper presented at WPC (2008) on the SW Continental Margin of India (i.e. Kerala Deep Offshore).

"The volcanic infested SW Margin of India is a composite tectono-stratigraphic imprint of episodic crustal unrests related to rift-drift transitions of Permo-Triassic (Karoo), Early Cretaceous (Madagascar), Cretaceous-Early Paleocene (Seychelles-India) and Miocene compressional tectonics of Himalayan Orogeny."

Improved plate tectonic models demonstrated regional westerly tilt of India during pre-Deccan volcanism indicating Antarctica-India as the major provenance for the southern part of Indian western margin which was the NE flank of an independent proto-oceanic basin implying sedimentation since at least from Triassic times.

As regards the hydrocarbon prospectivity, it is worth referring to Plate Tectonic reconstruction done by Jablonski (2006).

The model demonstrates that he Basin was situated in the NE part of Proto-Mozambique Ocean, with Antarctica-India as the major provenance of sediment supply under favorable oceanic and climatic conditions for organic productivity. The Mozambique Ridge acted as a barrier for deep water circulation between Mozambique Proto-Ocean and Weddell Sea creating suitable conditions for the deposition of source facies.

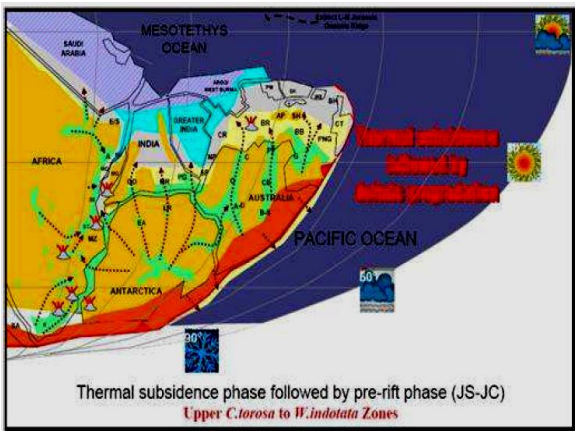

Fig 7: Plate-tectonic reconstruction longitudinal ocean adjoining southern and western sectors near the geological period of Late Jurassic-Early Cretaceous. (After Dariusz Jablonski, 2006)

Considering the signatures of the Mesozoic rift system from integrated studies in the region, the analogy of active source rocks from Permo-Triassic rift system in east Africa and Western Madagascar with enormous hydrocarbon potential can be applied to the Kerala Deep Offshore Basin also.

Conclusions and Recommendations

The details analysis of the 2D long offset data leads to presence of Mesozoic Rift graben system below the Deccan Trap.

Good quality Lacustrine Source Rocks within Mesozoic Rift graben is also envisage.

It is also visualized that the refection packages seen below the older Basalt may possibly represent syn–rift sequence.

It is predicted that there could be thicker Mesozoic sequences and would certainly contain source rich sequence with the requisite burial conditions for hydrocarbon generation.

Thus one can conclude with reasonable level of confidence that the Kerala Deep Offshore Basin would contain Mesozoic sediments of significant thickness and good source potential.

Marine Magneto-Telluric Surveys (MMT) is a cost-effective, useful complement to seismic techniques and as a substitute where seismic cannot be used at all. Both natural-source methods (MT) and man-made, controlled-source methods (CSEM) have made valuable contributions in refining geologic models, reducing exploration risk, and improving production monitoring.

The Controlled Source Electromagnetic Surveys (CSEM) though uses similar receiver technology to the passive MMT method; it combines them with an active electrical dipole EM source. This provides CSEM the ability to image much thinner resistive layers down to some 10's of meters rather than the 100's of meters as in passive EM. Thus CSEM offers an entirely new set of applications for EM.

It is envisaged that Joint Inversion approach would lead to a much improved sub-basalt imaging.

Thus it can be envisaged that MMT / CSEM and Joint Inversion Approach would certainly improve the sub Basalt Imaging and would lead to better appreciation of Mesozoic history of the Kerala Deep Offshore Basin which is expected to have significant hydrocarbon potential.

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