# A Unique Methodology for Sub Basalt Imaging-Case Study

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**Abstract**

During the past few years new ideas and techniques have been suggested to image below Basalt but fix all solutions has yet to emerge. Long offset data acquisition and processing is one such solutions which has been tried here with a specialized workflow bypreserving the informations in the far offset wavefield and illuminating the weak signal content. Looking at the complexities of the area and inherent difficulty of imaging below Basalt, special thrust has been given for Multiple attenuation and performed the velocity modelling incorporating the geology with apt selection of migration algorithm. The improved image helped the interpreters in better understanding the Sub Basalt geology.

## Introduction

Mesozoic sediments trapped under Deccan basalt in the western flank of India have been a challenge for petroleum exploration. Analysing sub-basalt sediments by seismic surveys has always been a challenge due to the massive nature of basalt. Modern seismic Acquisition techniques coupled with advanced processing techniques have upgraded the quality of seismic imaging. Processing strategies need to focus on addressing the fundamental geologic features that impact seismic data quality. In this study an attempt has been made to better understand the sub surface features which were possible by processing of long offset data set of KK Blocks of Western Offshore, India, using the advanced seismic processing s/w. A specialised processing strategy is applied to the data set of KK Block. The improved results through optimal processing parameter selection led to decipher the deeper events.

## Geological Background:

Kerala Konkan Offshore Basin is located south of 16$^{o}$N latitude and forms the southern part of the western continental margin of India. On the eastern side it is bounded by the peninsular shield. Fringe of the Basin extends onto the land in the coastal area where isolated outcrops of Miocene and younger sediments are preserved in alluvial covered narrow strips along Malabar coast and Konkan coast up to north of Goa. Towards west and south it opens up into deep sea. Northern limit is ENE-WSW trending Vengurla arch. (Fig.1). Kerala-Konkan Basin has developed after the break-up of West Gondwana plate splitting Madagascar and India. A series of linear rifts and grabens developed parallel to the dominant basement NNW-SSE trend. The major tectonic events which have affected western Indian Basins are (a) rifting from Madagascar, (b) reorientation of drainage system from east to west and its effect on sediment supply to the west coast, (c) Decan/Reunion mantle plume initiation with associated uplift, extension and subsidence, (d) drift of India towards north latitude and development of carbonate systems and (e) Himalayan orogeny and resultant tectonic reactivation.

Kerala-Konkan Basin witnessed the early rift phase in Late Cretaceous -Paleocene time dominantly along NNW-SSE trends. Major part of the Basin experienced volcanic episodes. Initial marine transgression reached Kerala-Konkan Basin during Late Cretaceous and continued up to early part of Early Paleocene resulting in deposition of calcareous sandstones and clays of Cochin Formation. Late

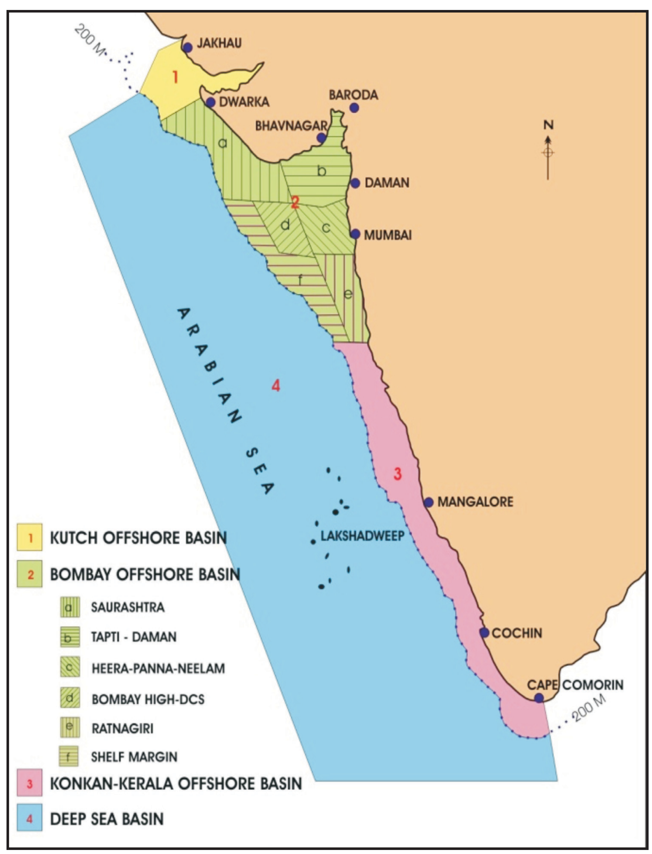


**Fig. 1:** West coast Offshore Sedimentary Basins

Paleocene marine transgression all over the Basin resulted in deposition of Kasargod Formation.

The post-rift phase of KK Basin included Eocene and the later depositions. Post-rift mature sediments with sufficient organic carbon content are present in the Basin. Drilling results and adsorbed gas anomalies confirm generation of hydrocarbons in the Basin.

The sedimentary sequence is comprised of Mesozoic and Tertiary sediments. A series of regional and local horsts and grabens resulted in response to rifting along the dominant basement tectonic trends. The process of rifting gradually advanced towards south and by Cretaceous time almost all the rift-related horsts and grabens came into existence.

The deposition started with continental environment, changed gradually to paralic and finally to pulsating marine conditions, punctuated by basic lava flows (Deccan Trap) in the terminal stages towards the end of Cretaceous and Early Paleocene. Towards the end of the early rift phase, most of the rift related grabens and horsts, located in the deeper parts were covered up with sediments and the continental margin became less intricately differentiated.

The Deccan Traps (Cretaceous-Early Paleocene) form the technical basement of the Tertiary Basin. The depocenters kept shifting from west to east during Paleocene to Mid-Eocene period. During late Eocene-early Oligocene period finer differentiation into second order horst and graben features became more pronounced, and in some cases the direction of radial movement could have been reversed, and resulted in minor epochs of alternating transgression and regression; and consequent lateral shifting of the depocenters. Thus, the late Eocene-Early Oligocene period witnessed relative intensification of the oscillatory / pulsating movements of medium magnitude, and dominance of paralic to shallow marine depositional environment in Lakshadweep Depression.

In the post-Oligocene period, the Basin acquired a marked westerly tilt, evidenced by numerous sigmoidal/ progradational features observed in the Mio-Pliocene sections. Numerous channels, levees and turbidities observed on south westerly slope have accommodated thick pile of post-Miocene sediments.

## Data Acquisition:

GX Technology conducted long offset deep imaging India SPAN - I seismic campaign in 2006-07 in the West Coast of India to understand the petroleum systems of the deep water of the Western Indian Margin. This seismic campaign was mainly aimed to understand the current tertiary plays and provide better understanding of the new Cretaceous plays beneath the Deccan traps. In late 2008, a second India SPAN campaign was carried out by GX Technology to better image the Juro-Cretaceous sediments through the basalts.

Taking the advantage of the information provided by India SPAN surveys, ONGC has carried out detailed 2D Long offset surveys in KK blocks (Fig-2&3) of Western offshore during the year 2007-08 through M/s Seabird Exploration with the vessel M/V Munin Explorer. The acquisition parameters were carefully chosen for the source to enable deeper penetration without significantly impacting recording bandwidth. The survey was acquired with a streamer length of 12 Km, Group interval and shot interval of 12.5 m and 25 m respectively. The source was towed at 14 m and the streamer at 15m. The source volume was 6180 cu.in. This configuration helps excellent acquisition compromise for recording good signal and bandwidth beneath basalt layer.

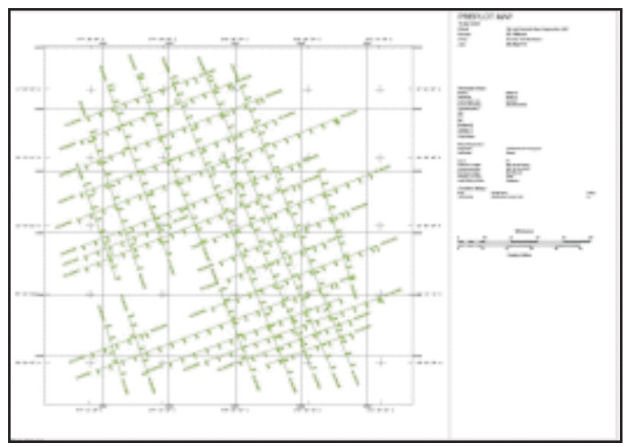

**Fig. 2:** Location Map

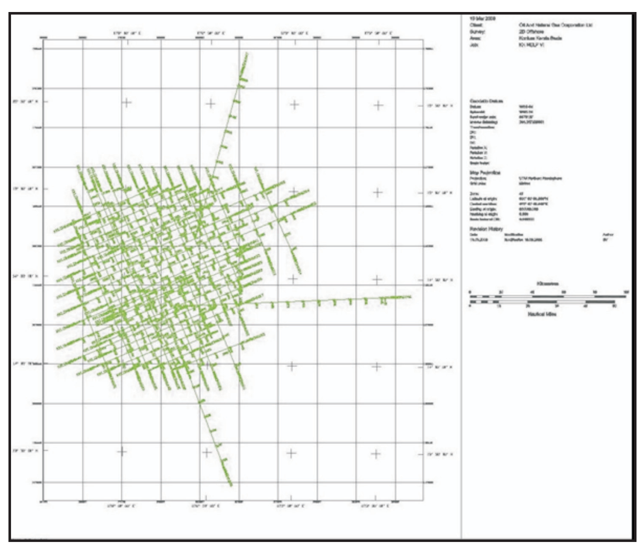

**Fig. 3:** Location Map

## Processing Issues and Methodology adopted

Long offset data aim to image the subsurface beneath Basalt. Emphasis was laid on improving sub-surface imaging especially below basalt to understand Mesozoic Basin configuration. There are some basic problems when processing the long offset data in any region where basaltic layers severely degrade the incidence energy (Fig. 4). Due to high heterogeneity, lot of interbed multiples are generated and the S/N ratio deteriorates. Our main challenge is to preserve the S/N ratio underneath the basalt and to improve the multiple suppression by addressing interbed multiples and diffracted multiples. Dip filtering has been applied to remove the direct and refracted wave energy (Fig. 5).

The other major issue was to identify and attenuate the different types of multiple infecting the data particularly when seismic character gets distorted after application of NMO. At first step water bottom multiple was removed from the data (Fig 6 and Fig 7.) Here the multiple was modelled and subtracted from the data as it was easier to assume the water bottom velocity. At this step it was important to preserve the water bottom amplitude intact. Then these gathers after attenuation of water bottom multiples were conditioned in offset domain. After this the Inter bedded multiples generated from the heterogeneity of basalt was suppressed.

The conventional processing gave a better result at this stage because of transform limitation of frequency range used for parabolic Radon.

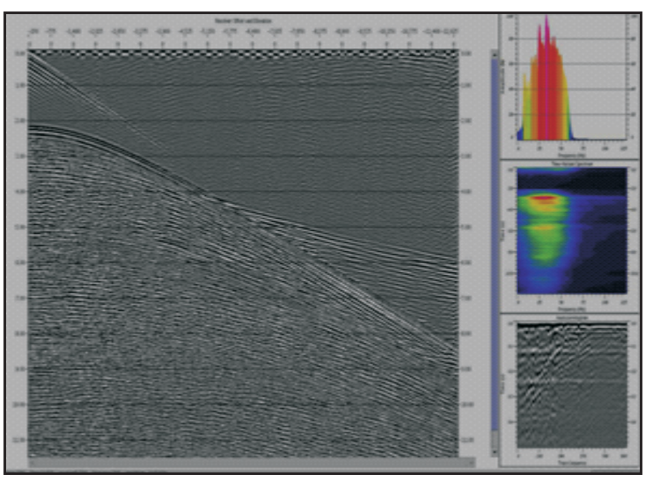

**Fig. 4:** Raw Record

After Noise removal and Water bottom multiple attenuation the next step had been the high resolution Velocity analysis using constant velocity migration stack cube, wherein the geological concepts have to be incorporated to get appropriate velocity model, which to some extent takes care of non-hyperbolic nature at farther

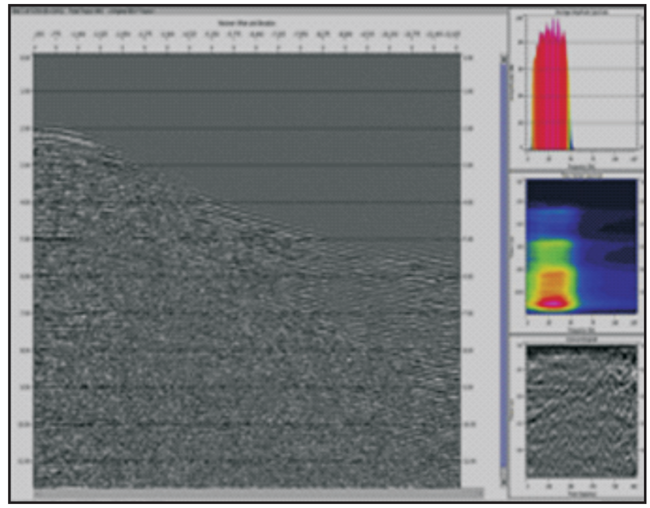

**Fig. 5:** Conditioned Record

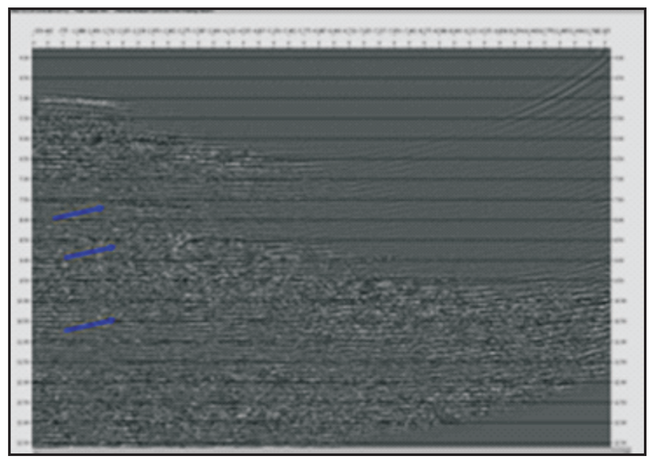

**Fig. 6:** Gather before WB Demultiple

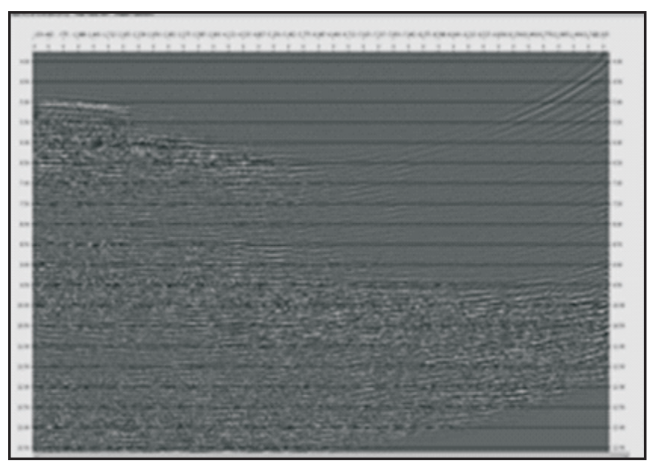

**Fig. 7:** Gather after WB Demultiple

offsets. BENDING RAY PRESTACK MIGRATION of this software would also to account for the higher order NMO correction to take care of the primaries at the farther offset. Second pass of Radon transform over PSTM gathers (Fig 8 and Fig 9) has brought out a significant improvement in the Sub basalt imaging (Fig. 10).

Similar flow was attempted to process the many of the Long offset lines of KK block, and the result of one of the Dip line are shown in fig(11).

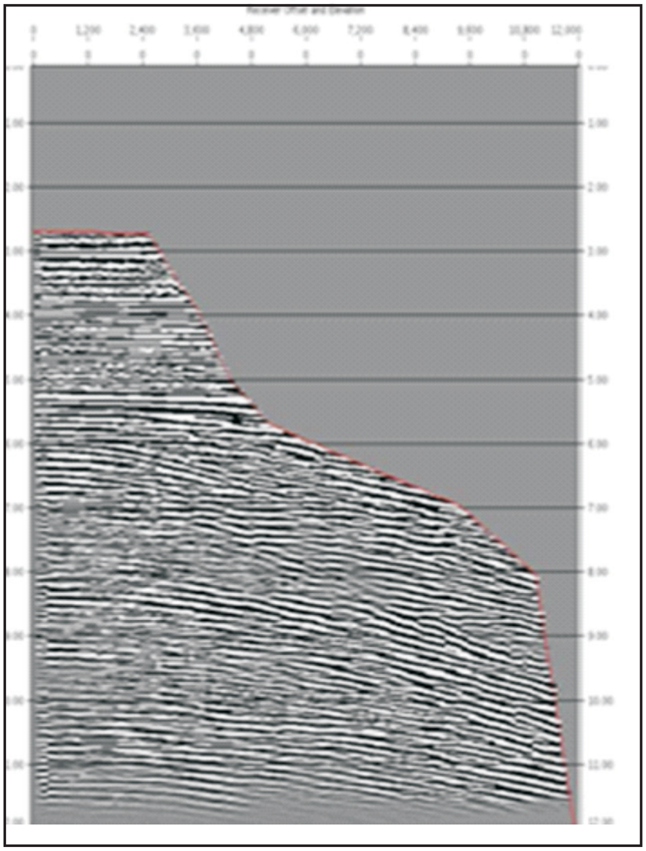

**Fig. 8:** PSTM Gather before Radon

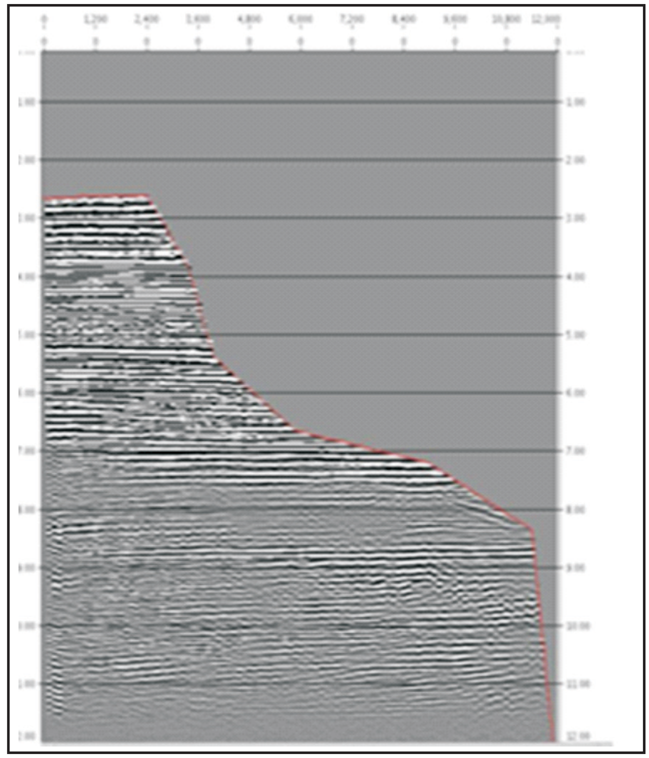

**Fig. 9:** PSTM Gather after Radon

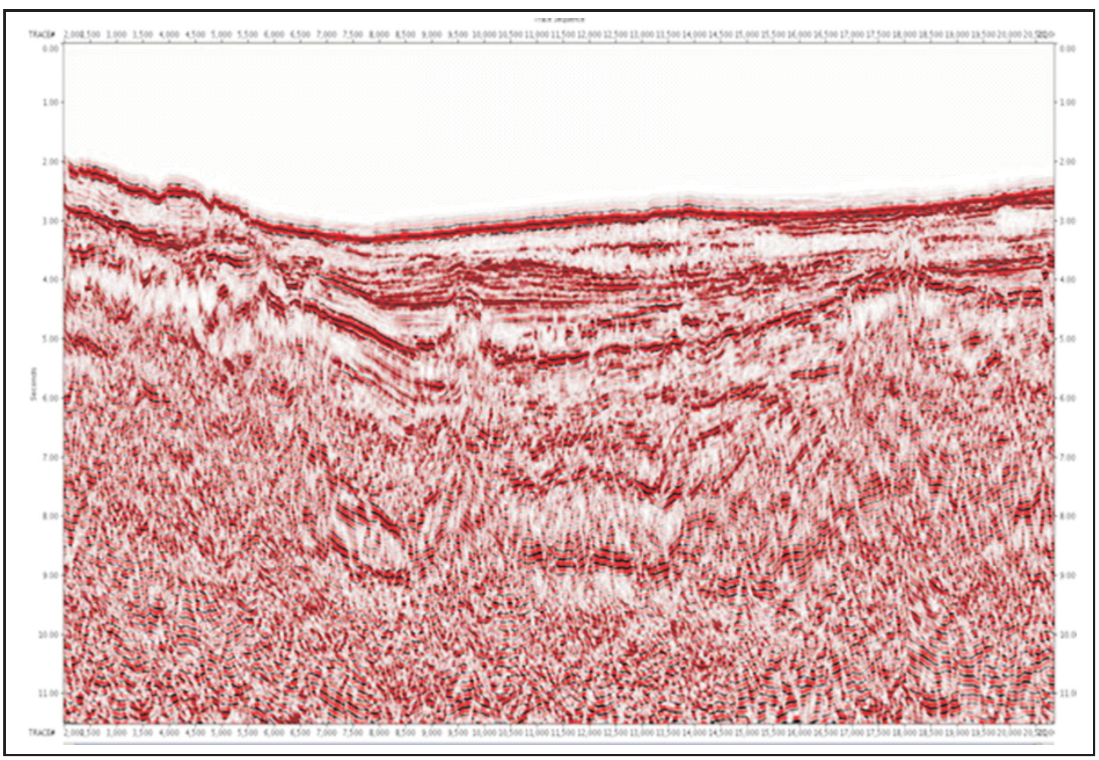

**Fig. 10:** Final PSTM Stack

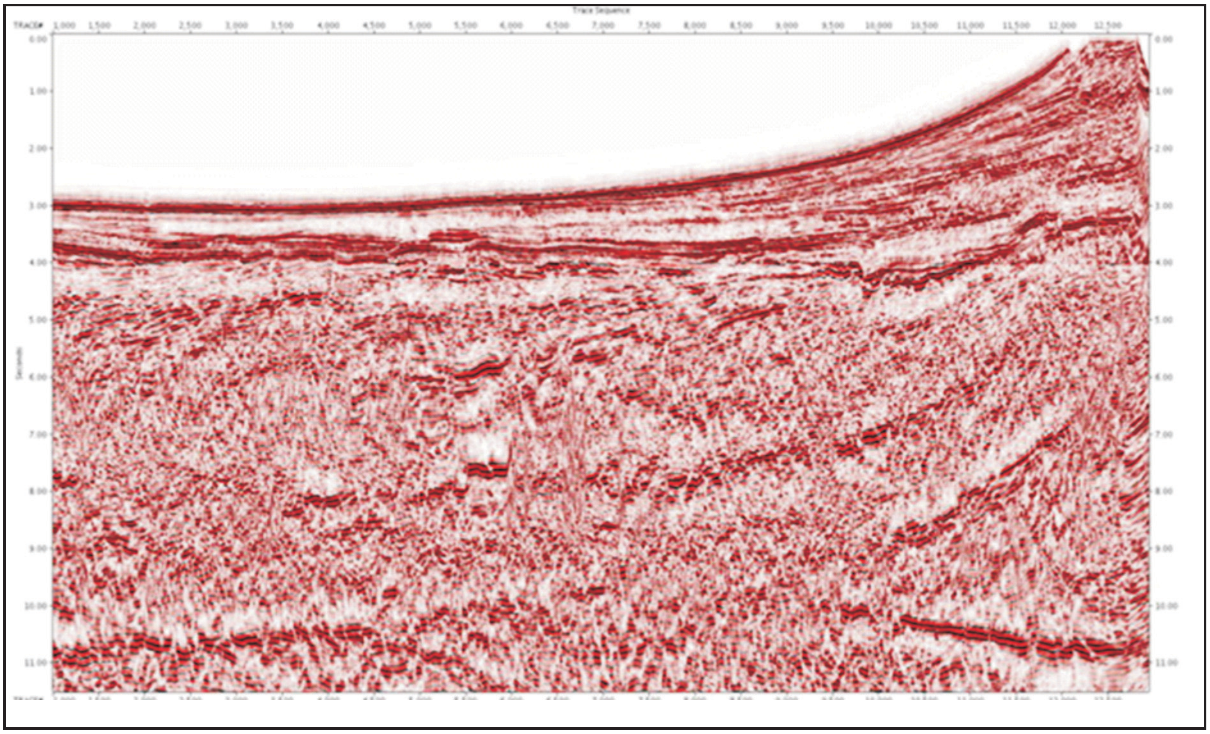

**Fig. 11:** Final PSTM Stack of Dip Line

## Conclusions

There is no single work flow which can be used for long offset processing in all geological settings. However, we have been successful in using a workflow which has resulted in better imaging. The specialized workflow addressed the different problems of separation of refractions, attenuation of different types of multiple, move out stretching etc. And this flow can be used in such areas. Although a convincing stack images could be obtained, there are still other processing techniques to be explored like Prestack depth migration with anisotropic correction, use of low frequency sources to retain amplitude lost due to scattering, Inverse Q to compensate for the attenuation of amplitudes and the use of mode converted data.


## Acknowledgements

Authors express their heartfelt thanks to ED-COED, WOB for constant encouragement. Authors wish to express their gratitude to Shri. D.P. Sinha, Ex.GGM-Head SPIC for continuous guidance and helping in to bring out better processing outputs through mentoring and inspiration. Thanks to Dr. S. Viswanathan, GM (GP)-Head SPIC for providing a clear picture of the geological setup in the area. Authors also wish to express their sincere thanks to all who directly or indirectly involved in this project.


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