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Reflections Below the Interpreted Basement in KG Deep Offshore Basin

O.P.Singh*, C. R. C. Sekaran, B.N.Singh & Dr. R.C.Iyer

RCC, Geophysical Services, ONGC, Chennai, opsingh57@gmail.com

Summary

Recently ONGC acquired 3D seismic data in KG deep offshore basin in number of blocks. Data of one such block of 1267 sq. km. with data length of 10.0 sec. was processed by authors. Earlier data in this block is 2D sparse lines with 8.0.sec. data length.

The data set was about 3.7 TB. Such large volume 3D seismic data entails in itself the issue of data management, more so when the resources are being shared by different processing projects under simultaneous execution.

In order to achieve the objective of processing as defined by client, a processing sequence was designed involving application of shot domain DMO and post stack migration as an alternative to more intense PSTM processing.

The processed output has been compared with existing 2D data. The imaging of present interpreted basement is much better in 3D volume than in 2D lines. Also a strong reflection has been observed below the present interpreted basement. This event may trigger new exploration strategy in this part of KG – Deep water basin in the light of grand success in exploration in the East coast of India.

Introduction

Krishna Godavari Basin is a peri-cratonic passive margin basin on the east coast of India. It is orthogonally juxtaposed to NW-SE trending Pranhita – Godavari Gondavana Graben in the north. The NE-SW basin margin is the most extensive fault trend over the area. The basin's characteristic feature is its enechelon horst and graben system which is filled with a thick pile of sediments of Permian to recent age and emerging as one of India's most promising petroliferous areas (S.K.Gupta, 2006).

Major exploration work in deep water of KG basin started after the year 2000 (Bastia R., 2006). The whole area has been divided in to no. of blocks. The authors got the opportunity to process the data of one block which is about 1267 Sq. Km. The acquisition of data was completed in March 2007. The location map of the area is shown in Fig. 1.

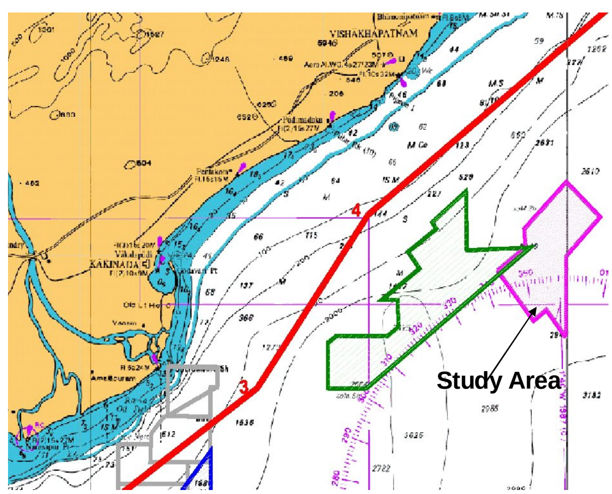


Fig.1 Location Map of the area

Brief Geology of the Area

Regional Geological Setup

The study of regional 2D lines indicates the presence of shelf, slope and basinal setting in the area (Bhargava M.K. et. al., 2005). The bathymetry ranges from 2565-3000 m in the area. Tectonically, the area in the North is bounded by Kakinada Graben & Vizag High, to the West by Pithapuram cross trend, to the South by deep basinal part, and towards the East and North-East it merges with the Mahanadi deep water with similar setting. The area to the West of Pithapuram cross trend is under the influence of Godavari river input, where the deltaic environment in the shelfal part in the shallower bathymetry, and channel fan complex in the shelf slope part in deeper bathymetry, has a proven hydrocarbon system.

The Mio-Pliocene boundary that is a well established unconformity surface in Godavari shallow offshore area turns in to a correlative conformity in the deeper settings. Possibility of thick Pliocene section within the present area is envisaged. The median high located to the South of Kakinada graben is envisaged to be COB based on the gravity magnetic data. Oceanic basement forms the floor for the Cretaceous sedimentation followed by Paleogene & Neogene sediments.

Sedimentation Pattern and Reservoir Facies

The Vizag high, which remained as a positive area for a major period during Cretaceous appears to have acted as the main source of coarser clastics. At the close of Cretaceous, Vizag high was submerged by Cretaceous sea and deposited a thin sequence of Cretacious sediments. During the period Kakinada graben also attained peniplanation. As a consequence the river system from the onland transgressed further basin ward and deposited considerable amount of coarser clastics south of Vizag High in the deep basinal set up. The Khondalites and Charnokites country rock in the onland provided rich sedimentary input. This depositional setup and provenance continued from Paleocene to Late Miocene. Subsequent to late Miocene the Bengal fan became active and became the second source of coarser clastic.

Petroleum System

The petroleum system in this area presumes thick shales present within Cretaceous and Paleocene sequences to act as source rocks, high amplitude events within Late Cretaceous and Paleocene interpreted as basin floor/ponded turbidite and channel-fan complex respectively and channel-fan complexes within Lower and Upper packs of Pliocene age as reservoir, the entrapment is strati – structural for late Cretaceous and Paleocene reservoirs and predominantly statigraphic for Pliocene reservoirs. The shales below and above the interpreted reservoirs, and also the intervening shales within channel-fan complex are envisaged to provide the vertical as well as lateral seal. The major strike slip fault passing through the area oriented in NE-SW direction and the network of faults of minor magnitude are envisaged to act as conduits for migration.

3D Seismic Data Acquisition

Main parameters of survey are summarized in the following table:

Number of streamers	8
Streamer separation	100 m
Streamer length	6000 m
Number of traces	240 / streamer
CDP interval	12.5 m
CDP Line interval	25 m
Nominal Fold	60
Line direction	231 / 51 deg
Sail lines interval	400 m
Surface of Survey	2000.5 sq km

Seismic Data Processing

As the data volume was big (3.7 TB), handling of the data with limited disk space was a challenging task. The processing sequence involved DMO plus Post Stack Migration as an equivalent to PSTM. Major processing steps like multiple removal and DMO were run in parts giving required overlap.

The processing sequence adopted is summarized below:

- Re-formatting of field tapes
- Data editing (Bad traces , Bad shot points)
- SOD Correction (-100 ms)
- Butterworth Filter (4/12-120/72)
- Automatic de-spiking
- Swell Noise attenuation
- Geometry Assignment
- Amplitude recovery -$T^{2.5}$
- De-signature to zero phase using far field signature
- Sort to 2D CMP

    Velocity Analysis-I (1Km x 1Km)
- NMO Correction
- Radon de-multiple
- NMO removal

    Velocity Analysis - II (500m x 500m)
- SORT to Shot order (shot & offset)
- SHOT DMO with velocity-II
- Residual Move Out picking and updating the velocity-II

- DMO Stack
- FX Decon
  31X31 traces, filter 3x3, window length = 2000m
- Interpolation
- 3D Kirchhoff Mig. (Aperture = 6000 mts.)
- DAS, GAP = 38 ms, OL = 300 ms
- TVF

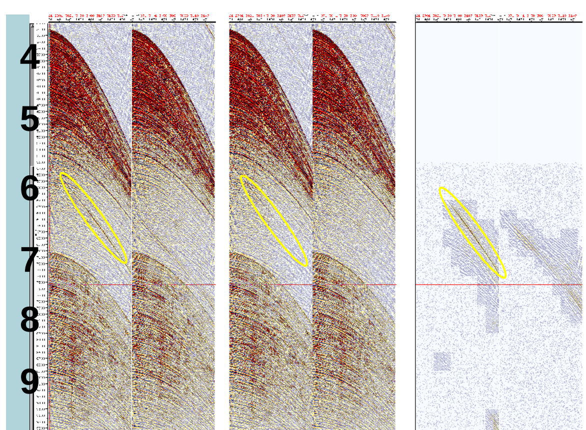
3000 - 4500	4/18- 100/72
5000 - 6000	4/18 - 60/72
6500 - 7500	4 /18 - 40/56
8000 - 9990	4 /18 - 30/156

- Area Mute (To have only full fold output)

Main Processing steps are described below:

i) Attenuation of Seismic Interferences:

As another vessel was working in the nearby area, seismic interference with strong linear events was observed on the shot data. The RMS amplitude of this noise trend was analyzed in all the swaths and observed that it is found intermittently, in portion of the data whenever noise is more than 10 micro bars, a special program named SINAT (Seismic Interference Noise Attenuation) was applied on the data. SINAT is a prediction filter and seismic interference can be attenuated due to its non-predictability from shot to shot in common offset or common receiver domain. There were such 26 sequences in the full data set of 200 sequences. An example of this application is shown in Fig.2. Seismic interference noise as encircled in the input record has been attenuated very effectively as shown in the difference section. The input record has strong multiples at ~ 7.0 sec onward generated from the water bottom column which was removed by anti-multiple program described later.

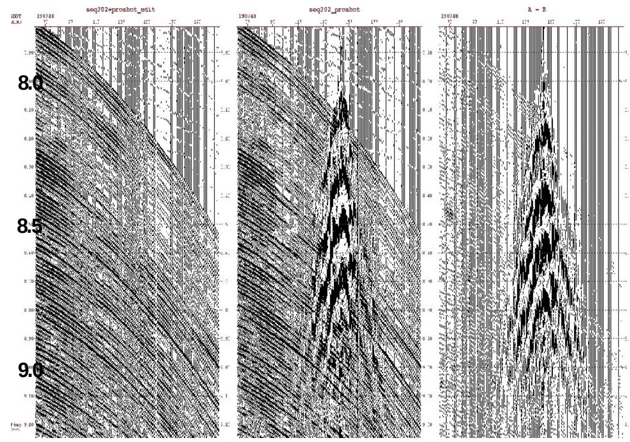


Input Output Difference

Fig. 2 Attenuation of Seismic Interferences

ii) Suppression of Noise Bursts:

High amplitude noise events were attenuated using amplitude scaling program preserving the genuine amplitude variations. The effect of this cleaning process is shown in Fig. 3

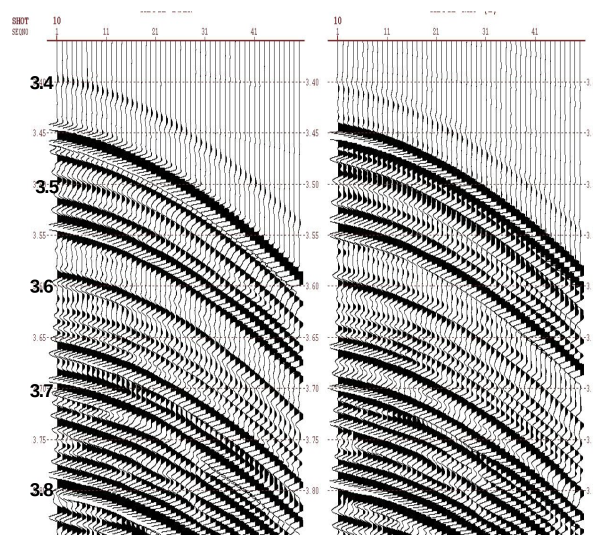


Output Input Difference

Fig.3 Suppression of noise burst

iii) Zero Phasing:

The data was subjected to signature deconvolution by using the far field signature provided by acquisition crew. The effect is seen as shown in Fig. 4. The output was zero phase and thus no further pre stack deconvolution was required.



Input Output

Fig. 4 Zero Phasing of the data

iv) Attenuation of Multiples:

Parabolic radon anti- multiple program was used to suppress the strong multiples generated from the sea bottom and other layers. The program was run after NMO application in CDP domain and applied in time window from double of TWT of water bottom reflection time to end of data (~ 7.0 sec to 10.0 sec). The process was very effective as shown in Fig. 5. Horizontal events seen inside the left box are multiple events which are clearly absent in the right hand box. Primary events are more clearly visible after the removal of multiples.

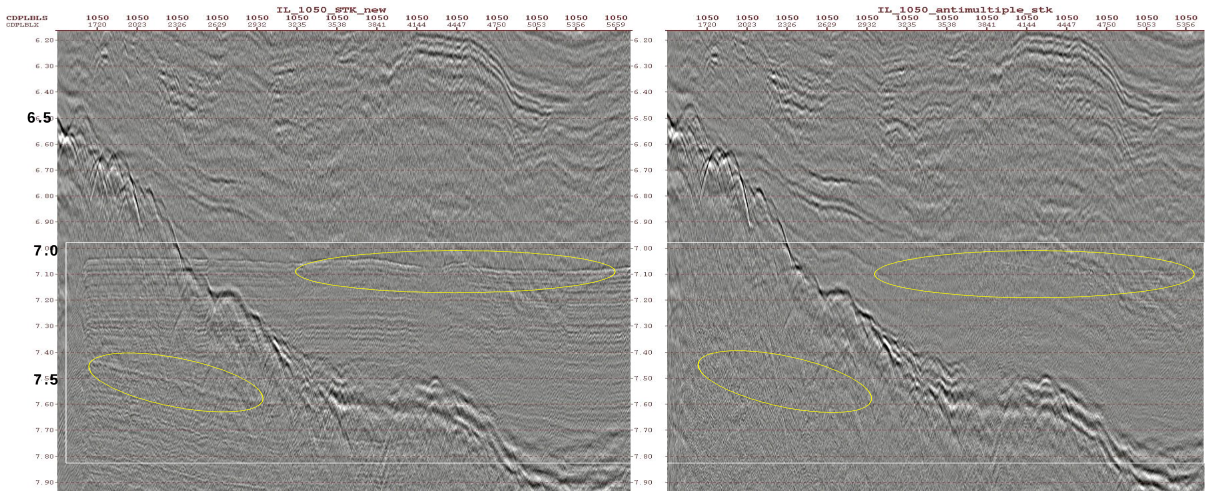


Fig. 5 NMO stack Sections without and with anti multiple

v) DMO:
As there was disk space limitation, Shot Dip move out program was run after the NMO correction. The program was equally effective and also saved time as it runs in parallel CPUs. The effectiveness of SHOT DMO method is already proved by J Cabrera & S. Levy (1989).

vi) Velocity Analysis after DMO:
Velocities were again picked at every 500m X500 m after DMO correction. Also residual NMO correction has been recoursed to further refine the picked velocities.

vii) Post Stack Migration:
DMO Stack data was interpolated in X Line direction to get inline and cross line bin size same (12.5 m X 12.5 m). Inline numbers were doubled in this process. 3D Kirchhoff Migration was performed on this interpolated data using velocities picked after DMO and residual updated and output only original Inlines. Aperture was kept 6000 m.
Post stack Deconvolution and Time Variant Filters were applied and full fold 3D volume was prepared for interpretation

Comparison with old data and finding of new event

2D seismic data have been acquired earlier in this area. Two nos. of 2D lines have been compared with respective RC lines generated from 3D volume. Data above 7.0 sec. TWT is comparable but imaging of the basement, TWT 7.0 sec to 8.2 sec, is much better in present 3D data set. 2D & 3D sections are shown in Fig.6a -6b and Fig. 7a-7b.

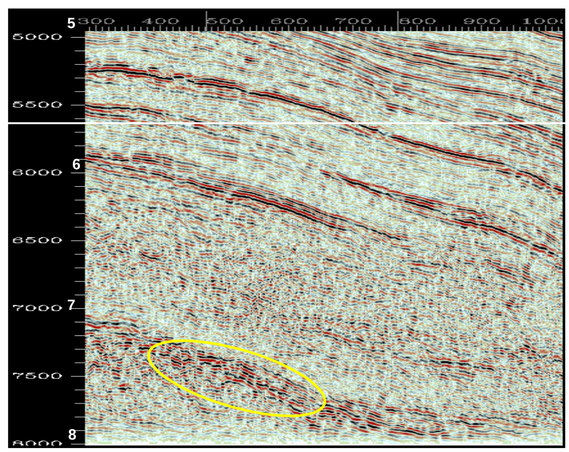


Fig. 6a 2D line

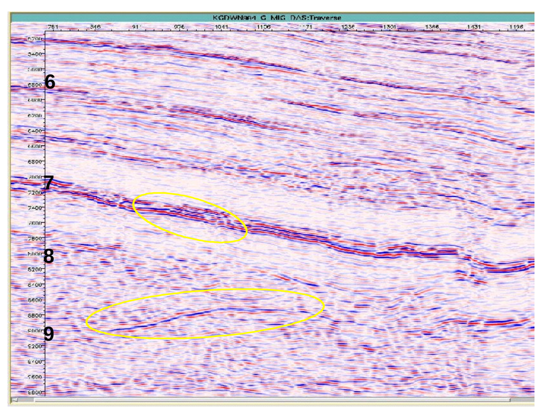


Fig. 6b Equivalent RC line from 3D volume

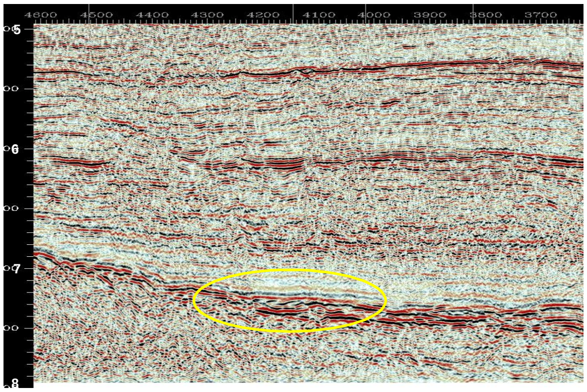


Fig. 7a 2D line

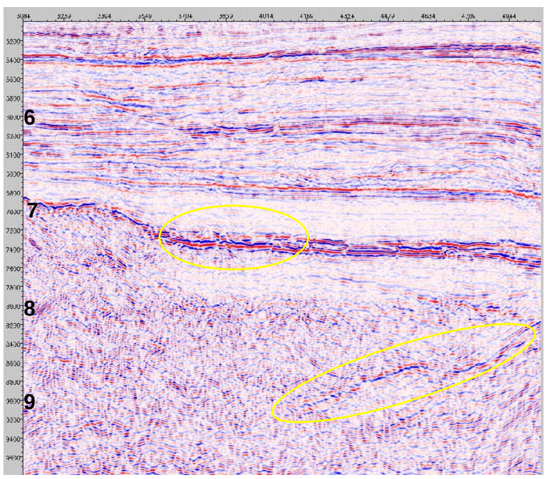


Fig. 7b Equivalent RC line from 3D volume

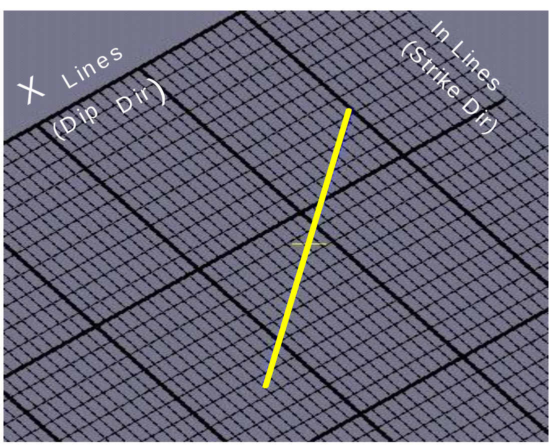


Fig. 8a Location of the RC line shown in Fig.8b

One strong seismic event at TWT 8.0 to 9.0 sec which is below the interpreted basement is seen as shown in Fig. 6b & 7b. This seems to be a reflection from a half graven. This event is not seen in old 2D data as data length was 8.0 sec. only. The event is much clear in another RC line generated in basin dip direction as shown in Fig. 8b.This deeper event may indicate towards deeper formations opening the newer concepts of prospectivity in deeper Mesozoic/Permian sequences.

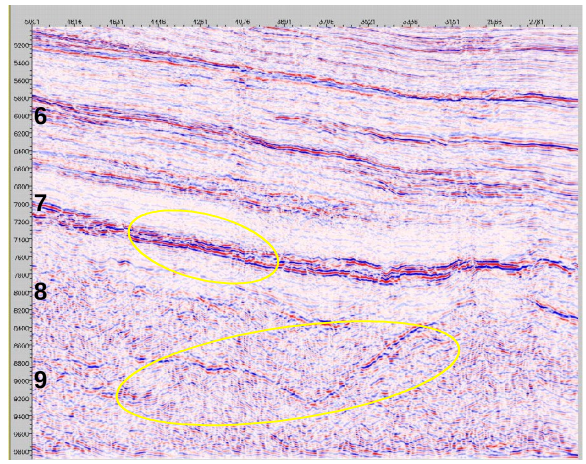


Fig. 8b RC line along the basinal dip direction

Such deep sequences have also been observed in 2D data recently acquired under the India Span Project with longer record length of 16 sec. in the near by area in similar tectonic set up. One line from this project has been shown in Fig. 9b. The correlation of present basement is shown on this line and it is very clearly seen that seismic events are present below this correlated basement.

Fig. 9a Location of line shown in Fig. 9b

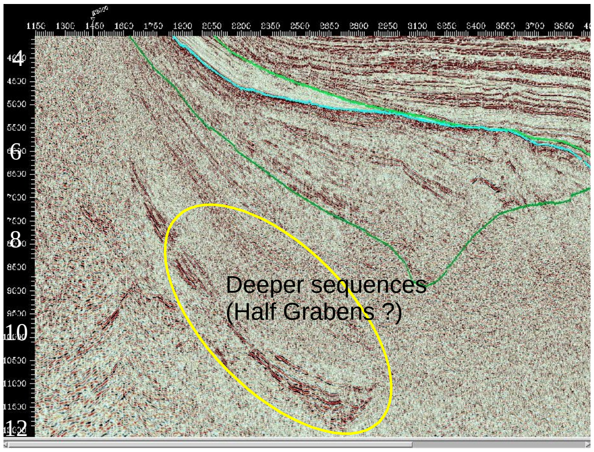


Fig. 9b 2D line from India Span Project

Conclusions

- The large volume 3D seismic processing involves the hardware resource management in an environment where multiple jobs are vying for the same resource. Secondly coupled to hardware resource, relevant processing algorithms and their implementation (both parameter optimization and parallel execution) plays a significant role in not only meeting the client objectives but also supplementing the hardware resource crunch.

- Imaging of present interpreted basement is better in the present 3D data than earlier 2D data.

- Events deeper than the present interpreted basement has been brought out opening the newer concept of prospectivity.

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