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# 3D seismic Survey in transition zone in Krishna-Godavari basin -A case study

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***Summary***

*Oil India Limited recently conducted 3D seismic survey in transition zone of Krishna-Godavari basin (Dynamite+Airgun) within the block KG-ONN-2004/1 consists of different logistics such as human habitat, oil & gas pipe lines, fish ponds, prawn ponds, Tributaries of Godavari (Goutami Godavari) and paddy fields, coconut gardens, mangroves and coastal belt. Seismic data acquisition in different kinds of logistics needs various kinds of planning & implementation to achieve quality data and as well as time management for cost effectiveness. Often the data quality is controlled by the terrain logistics within the operational area where as the inaccessibility due to difficult logistics necessitated displacement of the source and receivers from their original position which in turn leading to either uneven sampling or data gaps in seismic imaging.*

*The present paper describes the case study of the acquisition of 3D seismic data in the transition zone ( logistically challenging area in K-G basin) by deploying suitable state of art Air gun, marine cables & hydrophones for shooting in the water covered river area along with the conventional land equipment. The paper presents how the geophysical and logistical challenges were overcome through the design of optimized acquisition parameters to achieve quality data.*


***Keywords****: Transition zone, Dynamic recovery, difficult logistics, Air gun and explosive, Hydrophones and Geophones, Quality of seismic data, cost-effective, Time-management.*

## Introduction

Oil India Limited was awarded a block in KG basin onshore- covering a total area of 549 sqkm. It has decided to acquire 3D seismic data over 400 sqkm within the block .The Present area under study (235 sqkm) is shown in figure-1.The objective of the survey is to **evaluate prospects of Tertiary/cretaceous** for hydrocarbon exploration. The block lies in the **East Godavari sub basin** surrounded by Oil and gas fields like the major D6 gas field of Reliance Industry, Rava field of Cairn Energy, Yanam field of ONGCL and Deendayal of GSPC in the offshore areas. This is one of the most promising hydrocarbon provinces on the east coast and OIL is highly committed to optimally explore the promising area for establishing and exploiting hydrocarbons.

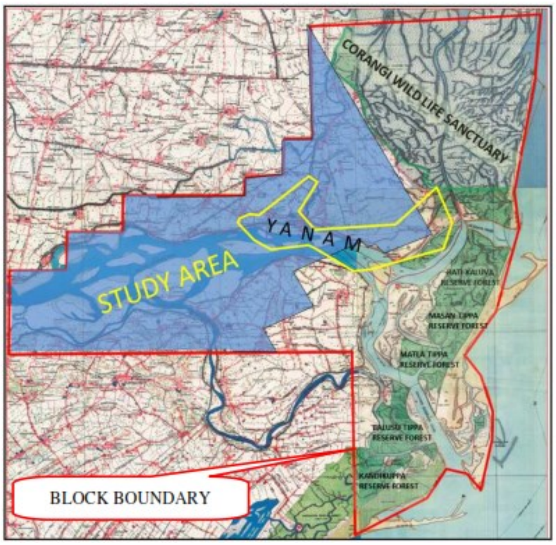


Fig: 1- Showing the block diagram

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The area where 3D seismic data to be acquired in the block consists of various logistic features shown in Fig: 2.Acquiring 3D seismic data in such logistically difficult areas was a challenging task. However owing to the large habitat and other difficult logistics in the area data gaps in the seismic sections are un-avoidable and care is taken to maintain full fold even in such circumstances by planning proper recovery shots.

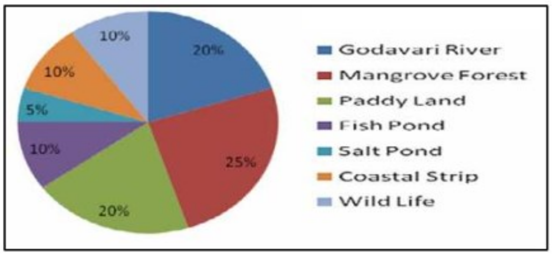

Fig: 2 various logistic features in the block

| | | |
|---|---|---|
| 1 | Depth of interest | 1500m-5500m |
| 2 | Maximum dip | 25°-30° |
| 3 | Bin size | 30 X 30 m |
| 4 | Desired fold | 64 |

Table -1: Seismo- geological parameters

## Operational area &challenges:

The main challenge with logistics is due to the meandering river and small islands, where the transportation of the equipment has to be carried out by country boats which consumed more time than usual. Oil& gas pipe lines in the block (Fig:3) have become another challenge for data acquisition. A minimum of 300 meters offset from these pipe lines was maintained for shot points to avoid the damage.

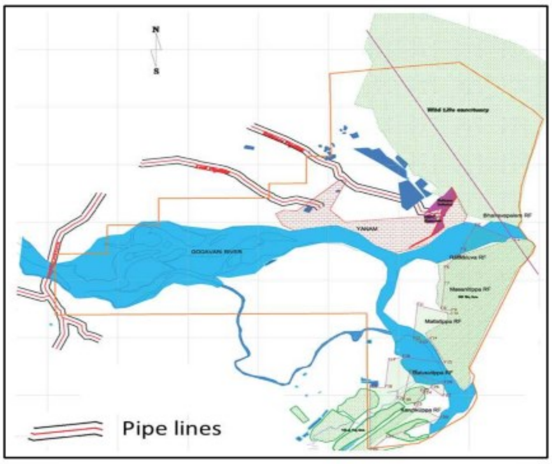

Fig: 3-showing Oil gas pipe lines in the area

The marine cable layout and hydrophone plantation often become difficult due to logistics of the area and the radio net -link systems were deployed both sides of the small river banks to acquire the data. In case of mangroves and swamps in the block the layout & shooting operations would be more complicated.

## Methodology:

A full fold (64) area of 400 sqkm was planned and simulated for 3D seismic survey within the block. The geometry used here is orthogonal (Fig:4) kind as it is convenient in support of field operations and to maintain uniform foldage coverage. The kind of shooting pattern in the design is **single line rollover** and the shot points in the area between two receiver lines constitute a single swath. This kind of shooting pattern speed up the operations in a zigzag shaped block and also cost effective compared to regular swath roll over shooting pattern and to achieve full fold. Based on the analysis of 2D-seismic data available in the block, the following acquisition parameters (shown in table-2) were finalized to acquire 3D seismic data. The block falls in the transition zone and is crisscrossed by the tributaries of the river Godavari whose length is about 44 km and width varies from 1-5 km with water depth varying from 1.5 mts-15 mts. Marine cables and Hydrophones are used

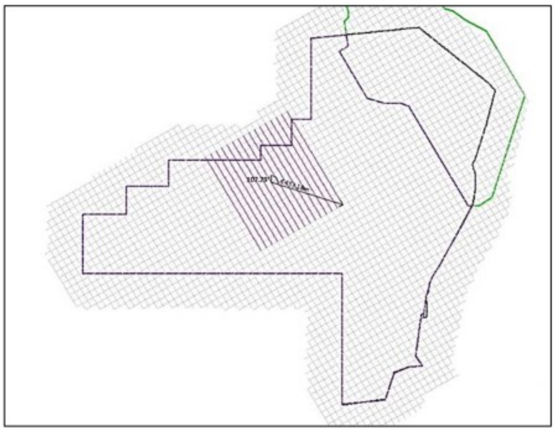
Fig: 4- showing the 16 line operation in the block

(in place of land cables and geophones) in water covered areas in the tributaries of Godavari. These marine cables are tied with a weight of 5 kg at the hydrophone positions wherever required to see that the cables do not have large feathering due to the current in the river during low and high tides. Fig: 5 shows source lines passing through the Transition zone in an ideal case simulation. After planning for recovery the source points were shifted from their original position. Wherever water depths are reasonably high, Air guns are deployed as energy source (Fig: 6).

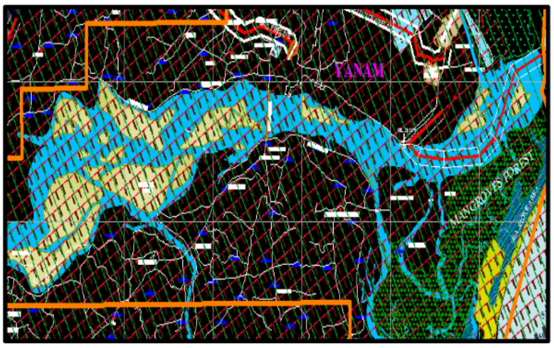


Fig: 5- source lines passing through T-Z zone

Table: 2- Acquisition Parameters

| DETAILS | PARAMETER |
|---|---|
| Receiver Interval | 60 m |
| Receiver Line Interval | 540 m |
| Receiver Geophone/station | 12 (1 in case of hydrophone) |
| Number of Receiver Line | 16 |
| Active channel per Line | 160 |
| Total live channel per shot | 2560 |
| Source Interval | 60 m |
| Source Line Interval | 600m |
| *Shot hole depth | About 20 m (loading depth) |
| Bin Size | 30 x 30 m |
| Source | Explosives and air guns (array) |
| Sampling rate | 2 ms |
| Record length | 7 secs. |
| Inline offset | 4770 m |
| Cross line offset- min | 3780 m |
| Inline Fold | 8 |
| X line fold | 8 |
| Nominal Fold | 64 |
| Source Line Direction | Orthogonal (240 degree) |
| Receiver line bearing | NNW-SSE (330 degree) |
| Aspect Ratio | 0.90 |
| Swath Roll On | Single Line Roll |

**The Air-Gun specifications used in the transition zone survey are :**

1. Air gun Volume: 82 cubic inch
2. Air gun Array used : 2
3. No of Guns per array: 5
4. Guns spacing: 1mtr
5. Total Volume per shot: 820 cubic inch
6. Floating depth: 4.8mtr
7. Gun pressure: 2000psi
8. Gun firing Interval: 10msec
9. PP Strength: 9.9v

Fig: 6- Air gun operations in river Godavari in the block

## Dynamic Recovery:

Before start of the work reconnaissance survey was conductedin the operational area. It was decided to maintain minimum possible source& receiver offsets (while recovery planning) due to obstacles in the area .The receiver lines are positioned with a considerable minimum offset. Where ever the water depths are low the shot points were taken at reasonable offsets on land or nearby sand patches by compensating the spread in order to cover the same subsurface locations for maintaining full fold.

In case of recovery points for an inline shift (shift of SP perpendicular to SL, that is, parallel to RL), It was planned a deviation up to 10 meters and subsequent shifts are in multiples of 60 meters with matching shift of the template patch in the opposite direction. For cross line shift (shift of SP perpendicular to RL, that is, parallel to SL), It was planned a deviation up to 15 meters and if a suitable point is not available, the location is given a shift of 540 (Source line interval) meters with *addition of a receiver line in the backward / opposite direction and inactivation of a receiver line in the forward direction. By this approach best effort was made to maintain required foldage. The pattern of the shifting of source and receiver lines while acquisition due to logistics in the area can be seen from the Fig: 7.

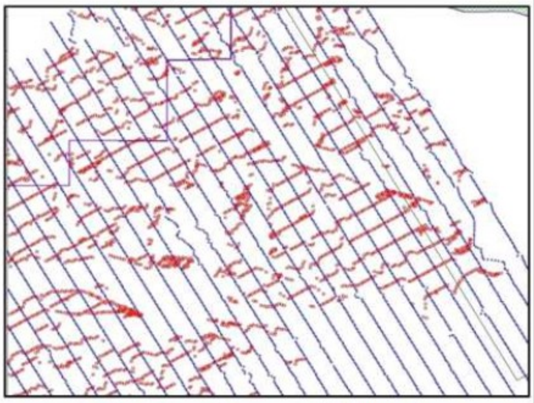

Fig: 7- Layout of source & receivers in the habitat and river areas



The near offset (0-800m), mid offset (800-4800m) and far offset (4800-8800m) foldage distribution maps are shown in the Fig: 8. Missing of foldage at places

in near offset is due to (i) offsets taken for the shot points which are falling under shallow water depths in the river (ii) offsets taken for the shot points due to habitat. Whereas foldage at mid and long offsets are maintained satisfactorily (equal to ideal case) preserving deeper information so that fluffing the survey objective.

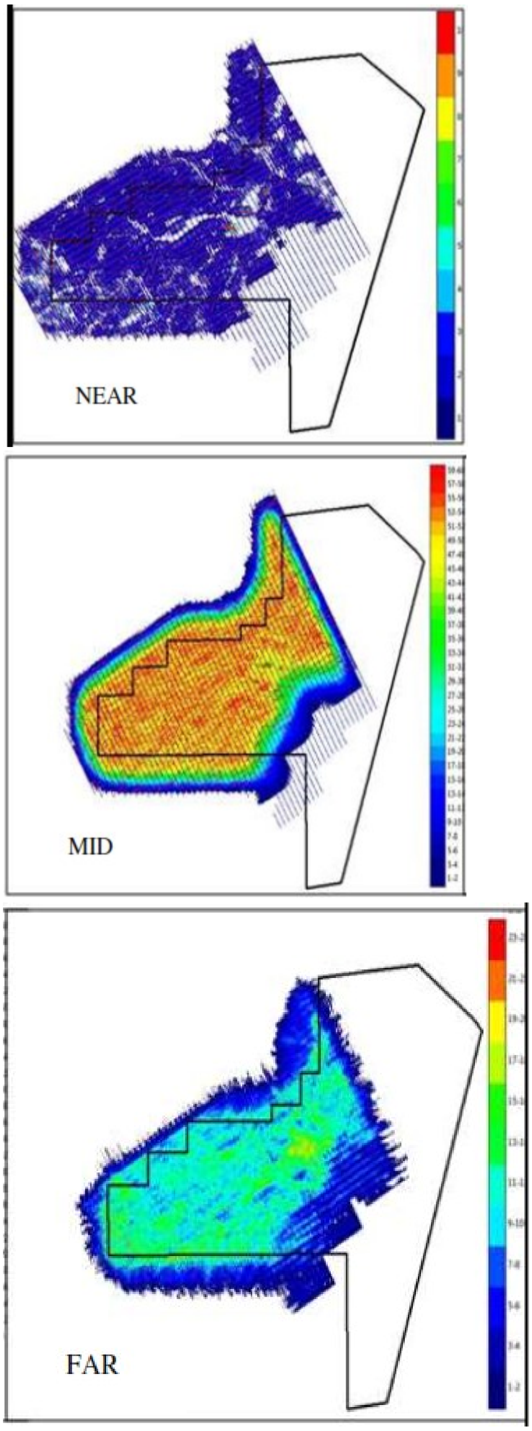



Fig: 8- Foldage distribution maps for Near, Mid and Far offsets

The recovery shots are planned in such a way that no shot point is skipped in the source lines to maintain maximum foldage. The resulting foldage diagram in the area is shown in Fig: 9. As the shooting is started from the Western corner of the block, initially extra receiver lines could not be laid out for few recovery shots (*as they are required) existing in the habitat resulting in the striping effect in the foldage in the receiver line direction (NW-SE). However the reduction in the foldage indicated by striping effect is marginal.

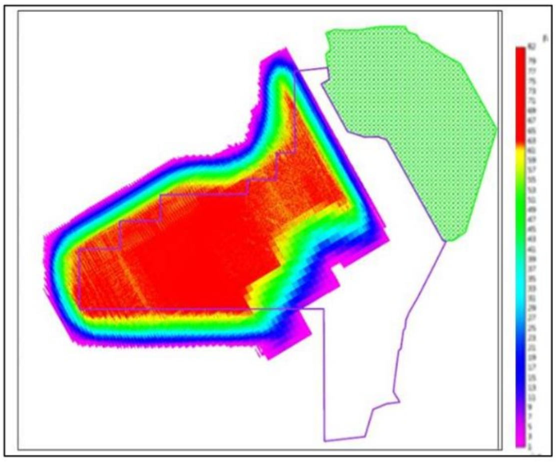

Fig: 9- Final foldage map (including recovery shots)

## Results:

The acquired data after completion of each swath was stacked in the field using SPW (field) processing software for QC/QA purpose. As mentioned above it can be clearly seen from the representative field processed seismic sections (Fig: 10), data quality here is constrained by various difficult field logistics and hence the data gaps in the sections which are inevitable. But still even under such circumstances the quality of seismic sections is fair to good and events up to 5 second are visible on the sections. During the seismic data processing at processing center a phase correction is applied for both sources (dynamite & Air-gun) and receivers (Geophones& Hydrophones) and a representative cross line section is shown in Fig: 11.CGG'S Geocluster software was used to process the data at processing center.

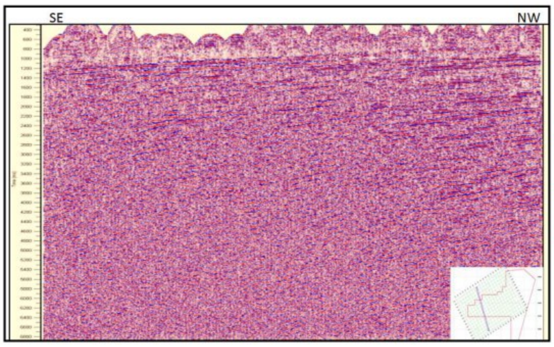


Fig: 10-field processed seismic section (Brut stack) In-line

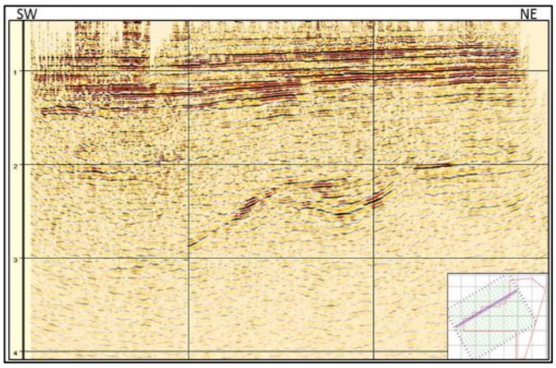


Fig: 11- representatives cross line section processed at processing center

## Conclusion:

Acquiring Transition Zone 3D seismic data with in a logistically challenging area consisting of river tributaries, islands, dense habitat etc. has been successfully completed by Oil India Limited for the first time. For negating the logistics, meticulous planning was made for acquiring full fold data with appropriate recovery plan. These include (i) Acquiring 3D data with a huge template of around 80 sqkm(ii) Deploying the highest possible standards of appropriate specialized equipment for land and water covered river areas (iii) preplanning to acquire the data in minimum operational time.

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