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3D seismic data acquisition in logistically challenged area due to fish/prawn ponds in KG Basin – a case history

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Summary

Seismic data acquisition in logistically challenged area remains one of the key challenges in the oil exploration world. The quality of the acquired seismic data is often adversely affected by access limitations in severe logistically difficult area that prevent optimal placement of sources and receivers, in turn leading to either data gaps or inconsistent sampling of the seismic imaging.

This paper demonstrates how the geophysical and logistical challenges were overcome through the design, optimization, and implementation of acquisition field parameters and varying survey designs as the logistics demanded. The authors also explained about logistical hurdles encountered during the data acquisition in many gigantic fish/prawn ponds and large Kolleru Lake in the operational area, consequently strategy adopted with the result there off.

Introduction

One of the seismic crews was assigned to acquire 3D seismic data at Lakshmipuram-Sanarudravaram Phase-III area to evaluate hydrocarbon prospectivity in Cretaceous sediments and identify structural/strati-structural entrapments in Krishna – Godavari Basin in India. The seismo-geological inputs for the operational area are summarized in Table-1.

Depth of interest	1500 m to 4500 m
Time zone of interest	1200 ms to 3200 ms
Bin Size	20 m X 20 m
Maximum Dip	10º - 15º
Desired Fold	70

Table-1: Seismo-Geological Inputs

The area in which 3D data was acquired in logistically tough conditions constituting large water bodies like Back water with creeks, lakes and intense aquaculture activity. The satellite images are shown in Figure-1(a) to 1(f) taken from the Google map showing logistics of ponds, rivers & islands which depicts tough logistical condition.

(a)

(b)

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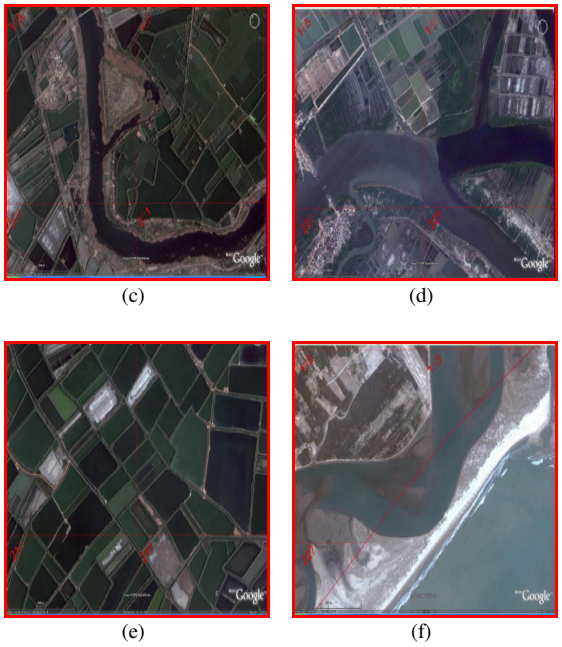


(c) (d)

(e) (f)

Figure-1(a) to 1(f): Satellite Images showing Logistics of Ponds, Rivers & Islands in the operational area.

Acquiring data across these logistically difficult areas was a Herculean task which was successfully carried out by the party. Major logistic challenge faced by the party was fish and prawn ponds which constituted around 71% of the operational area.

However, the challenges of acquiring seismic data without data gap to fulfill the objectives were inevitable; the crew put best efforts in circumventing the main hurdles and with effective strategy for acquiring 3D data with desired fold.

Methodology

Pre survey studies were carried out in details in the operational area. Seismic responses and frequency analysis were also estimated from the earlier investigations available in that area. Based on the results of pre-planning studies, the acquisition parameters were finalized subsequently to acquire the data (shown in Table-2).

Parameters	Values
Type of Spread	Orthogonal Asymmetric Split Spread
Bin Size (m x m)	20 X 20
No of Receiver lines / swath	14
No of active channels / line	160
Total no of active channels	2240
Shot Interval (m)	40
Group Interval (m)	40
Inline fold	10
Cross line fold	7
Absolute fold	10 X 7 = 70
Shot Line Interval (m)	320
Receiver Line Interval (m)	280
No of Shots / Template	49
Cross Line Swath Roll (m)	1960
No. of geophones per group	6
Array	Bunch
Min. Min. Offset (m)	28
Max. Max. Offset (m)	5530
Min. Max.Offset (m)	4780
Max. Min.Offset (m)	425
Aspect Ratio	0.57

Table-2: Parameters of Acquisition Geometry.

As already explained earlier concerning tough ground conditions, it was not possible to lay out the above mentioned spread uniformly. As the logistics demands every day need to edit the acquisition template.

The stern logistics available in the study area are shown in Figure-2 and were divided into four categories namely,

1) Fish ponds
2) Shrimp culture
3) Creek with back water
4) Fresh water lake and paddy field

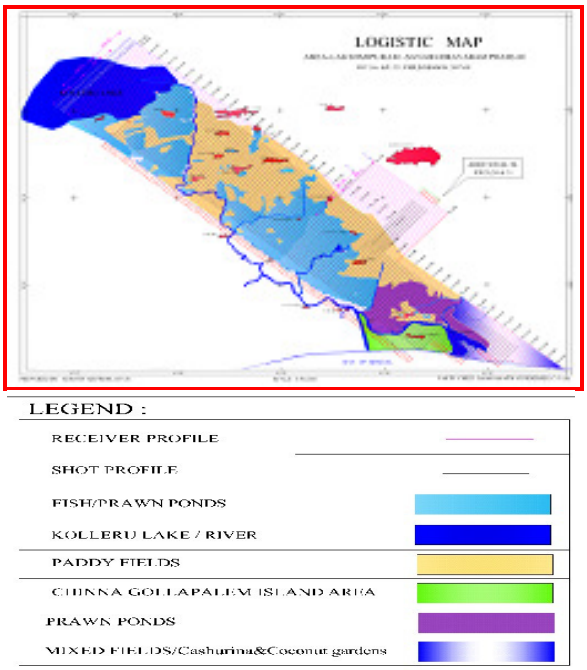


Figure-2: Logistic Map along with Legend of operational area.

As the major portions of the study area were full of fish and prawn ponds, laying of the receivers in a straight line were not possible. With the assistance of the Google map and with the villagers' co-operation, the crew planned to put the shots and receivers on fish pond bunds. Most of the fish ponds were in the middle part of the area. Hence, data in this area was acquired during summer because at that time the canals made for the aqua culture were dried up.

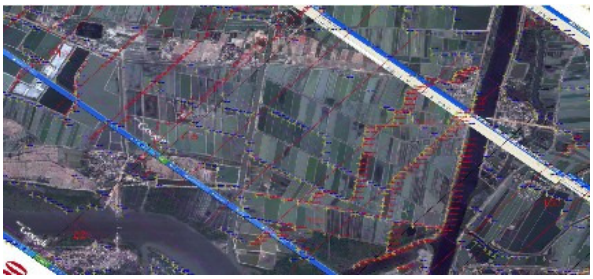
Consequently, in the fresh water and lake area, the crew also acquired the data during the month of May and June because this area was dried up at that time which was having easy accessibility for data acquisition.

Southern part of the area near coastal area was full of shrimp culture activities. Judicious planning of seismic activities to acquire data in this area including China Gollapalem Island was made between February to march as this is the best period because one season of shrimp culture ends in February and again they start breeding, seeding in end of March.

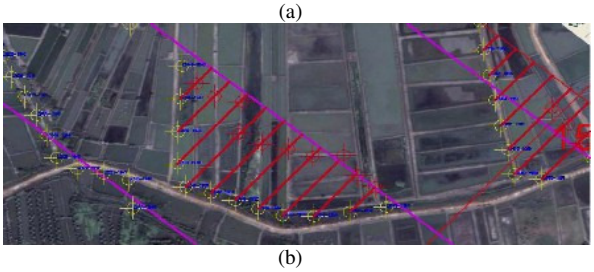
As mentioned earlier, due to logistic problems, neither receiver lines nor shot lines of the shooting template are straight. In this non-linear spread, Geophysicist and the survey crew did incredible exercise to get correct co-ordinates for each shot & receiver location for accurate sub-surface imaging through onward processing.

Data for creek and the back water portion was acquired along with coverage of portion with shrimp culture. In the agricultural paddy area the crew acquired the data in some portions in the beginning of the paddy and some portions after the cultivation harvested.

The scope of work has been planned with the help of Google map which contributed the excellent quality check over topographic survey. Satellite images from Google map were used optimally to get the minimum near offset. Hence the operational crew had the enhanced control for navigation data in the area specially ponds, creeks / coast lines. In Figure-3(a) to 3(c), proper planning of placement of sources and receivers were superimposed on satellite images taken from the Google map to maintain requisite acquisition fold.



(a)



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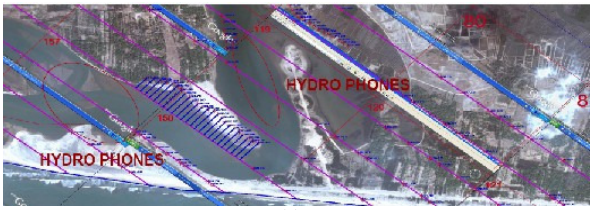


(c)

Figure-3(a) to 3(c): Sources and Receivers were superimposed on satellite images from Google map.

Layout of sources & receivers are shown in Figure-4 as per availability of place mostly on bunds in ponds area. Before final production with such kind of layouts, the results were generated and checked in advance.

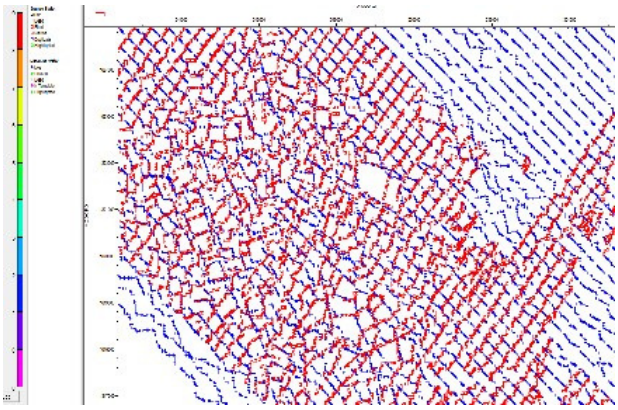
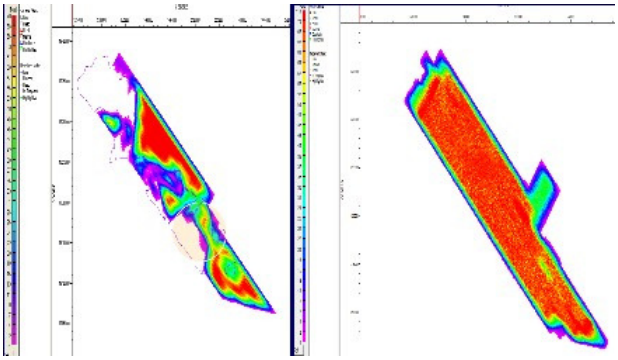


Figure-4: Layout of Sources and Receivers in Fish/Prawn Ponds

Dynamic Recovery

Before start of the work, party conducted the reconnaissance survey for the logistics in the operational area. It was estimated that by skipping the shots and receivers in the fish / prawn ponds, Kolleru lake and rivers, nearly 70-75% of the area would fall under Zero fold as shown in Figure-5(a).



(a) (b)

Figure-5: (a) Estimated fold map before acquisition; (b) Actual fold map after acquisition.

During regular survey work, the logistics (Non-Seismic Objects) mainly fish / prawn ponds, rivers and villages were identified and limits were estimated through which the shot lines were passing. Geophysical crew then planned the recovery for the shot line (where more than two consecutive shots could not be placed at the planned position) taking into account the actual fold loss due to skipped shot points and the fold likely to be developed by planned recovery shots.

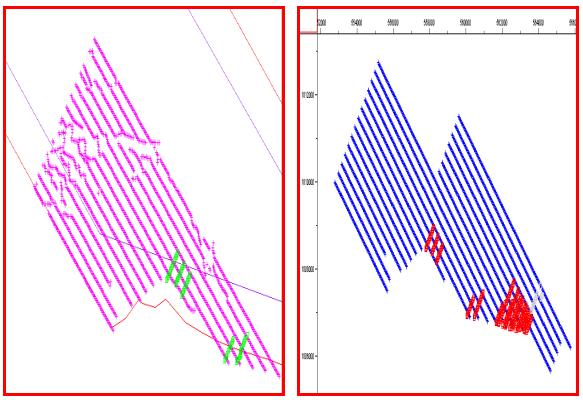
By comparing the fold in the pre & post recovery scenario, the appropriate placement of recovery shot points were identified. However, if those shots points fall within the safety-limits and were likely to be skipped again, alternate positions for the same were provided through generation of fold map and if found suitable, were used for production. The recovery of all skipped shot points in the operational area were thus planned & executed along with the regular shot lines and result in desired fold (68 to 70) is shown in Figure-5(b).

The satellite images taken from Google site proved to be of great help in identifying the logistics which were not available in topo-sheets because of recent development in the area.

Coastal Recovery

In order to get the optimal fold up to the coastal boundary, party adopted shooting through spread technique and

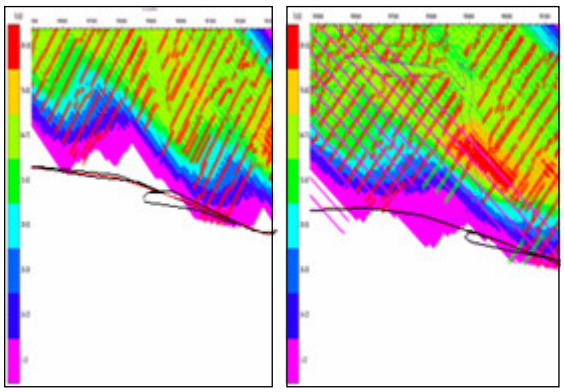
suitable customized template to build the fold up to the coast shown in Figure-6(a) & 6(b).



(a) (b)

Figure-6(a) & 6(b): Customized templates along east cost and Uputheru River mouth.

Party endeavored to take shots in possible places wherever available for drilling of shots in logistically challenged area comprising mainly fish ponds and the prawn ponds. This enabled the party to acquire data of 65 fold and above up to the coastal boundary. Fold distribution map with and without east coast recovery plan are shown below in Figure-7(a) & 7(b).



(a) (b)

Figure-7: (a) Fold near coast before recovery; (b) Fold near coast after recovery.

Special efforts

The work plan was chalked out as per judicious time plan keeping in mind about the environmental constraints. The southern part up to coastal area which was mostly covered with prawn culture activities was completed before the breeding time i.e., March and then proceeded over to northern and middle part where paddy cultivation and big fish ponds are prominent. Following special efforts were also taken to improve upon the data quality by and large:

- Advance planning to avoid skips and maintain required fold in fish / prawn ponds area on day to day basis.
- Party utilized satellite images from Google Earth for dynamic as well as special recovery planning in fish / prawn ponds, river and villages falling in operational areas. It helped to maintain fold by proper placement of sources.
- Party adopted dynamic recovery and costal recovery of the east coast in the operational area to provide the data with requisite fold.
- Party took as a challenge working in the Chinagollapalem island overcoming tidal variations and high current of upstream river and successfully completed campaign with required full fold.
- Besides the logistics (fish and the prawn ponds) of the area the party achieved the full fold data without any data gap within the stipulated operational time.

Results & Comparisons

The crew completed the assigned area and achieved the target maintaining the optimum fold in such a logistically difficult area. The processed migrated section provided by processing centre on the acquired data in this logistically challenged area is also shown below in Figure-8.

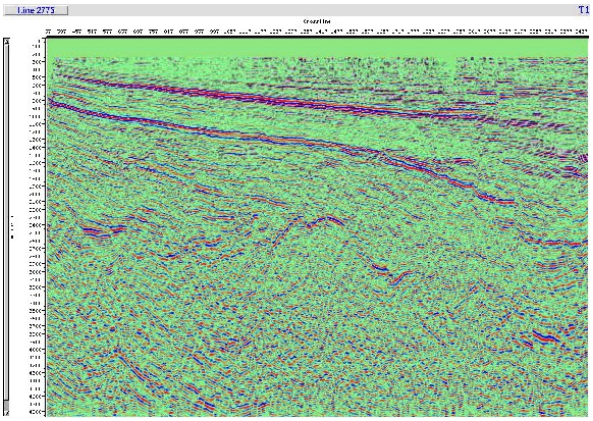
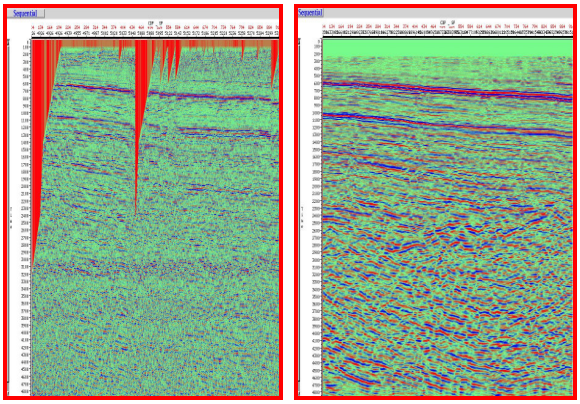


Figure-8: Processed Migrated Section provided by processing centre on the acquired data in this logistically challenged area.

The comparison of the earlier 2D migrated section with the RC line of newly acquired 3D PSTM stack is shown in Figure-9.



(a) (b)

Figure-9: The comparison of (a) earlier 2D migrated section; and (b) RC line of newly acquired 3D PSTM stack.

There is quite improvements over previous data as shown in the above figures even data gaps in earlier section were observed due to logistical difficulties. Appearance of processed sections of the recent acquired data, the deeper events are quite visible even beyond 4.5 seconds which is no doubt a value addition for the exploration of hydrocarbon in the vicinity of such logistically difficult area. The sufficient efforts of the field crew have yielded the result of such excellence. Seamless 3D seismic data had been acquired in logistically tough area upto coast line which was not available earlier except only 2D data with gap and missing continuity. Syn-rift feature alongwith deeper event upto 6.0 sec has been observed first time in KG Basin.

Conclusions

Seismic exploration in logistically challenged area involves considerable operational and geophysical challenges. It is important to deploy the highest possible standards of specialized equipment, best pre-survey planning & design, crew's paramount strategic and expertise efforts and effective zero-impact on environment.

Once the seismic data is recorded through optimal acquisition field parameters & best-fit varying survey design as the logistics demand, it is still possible to meet the challenges for sub-surface imaging accurately in logistically difficult areas.

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