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3D Seismic data acquisition across Godavari River & Oil & Gas pipe lines grid in KG Basin – A Task accomplished

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Summary

On account of increasing demand of oil and gas, it has become the necessity to explore hydrocarbons even in toughest logistic conditions. 3D Seismic data acquisition in toughest logistical area remains one of the key challenges in the oil exploration work. 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 exhibits how the geophysical and logistical challenges were overcome through the design, optimization, and implementation of acquisition field parameters and varying the survey designs as the logistics demanded. The authors also explained about logistical hurdles encountered during the data acquisition across the Vainetiyam Godavari River, gas and oil pipelines network and gigantic fish and prawn ponds in the operational area, consequently strategy adopted with the result thereof.

Introduction

The operational area Tatipaka-Bandamurulanka (Fig: 1) is in the East Godavari sub basin of Krishna–Godavari basin. Sandstone reservoirs of Eocene age forms one of the major hydrocarbon play in the area. The discovery of hydrocarbon bearing sands in the cretaceous formation in one of the well drilled in the north east of assigned area, opened the area for exploration of the deeper levels. 3D seismic survey was conducted in the area with more number of channels to evaluate hydrocarbon prospectivity in Cretaceous sediments. The seismo-geological inputs for the operational area are summarized in Table-1.

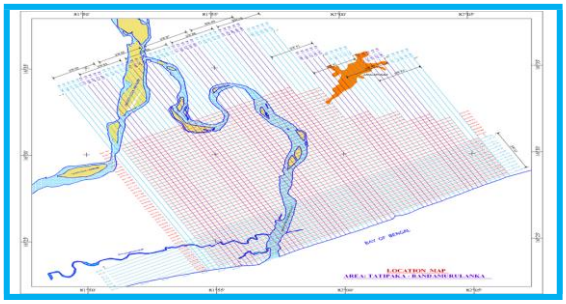

Figure-1: Study Area

Table-1: Seismo-Geological Inputs

Depth of interest	1000 m to 5500 m
Time zone of interest	1000 ms to 4500 ms
Bin Size	20 m X 20 m
Desired Fold	70

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The area of operation is logistically very challenging due to presence of mighty Godavari river, water bodies, fish/prawn ponds, thorny bushes and network of oil/gas pipelines. The satellite images are shown in Figure-2(a) to2(d) taken from the Google map showing logistics of ponds, rivers & riverine islands which depicts tough logistical condition.

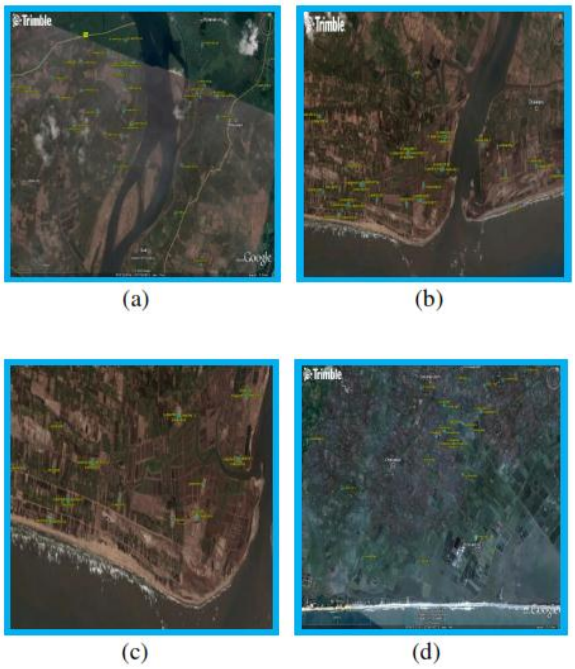


Figure-2(a) to 1(d): Satellite Images showing Logistics of Fish/Prawn Ponds, Rivers & Riverine Islands in the operational area.

Acquiring data across these logistically difficult areas was a herculean task which was successfully carried out. Major logistic challenges faced in the operational area were rivers, network of pipelines and fish and prawn ponds. 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

Detailed pre survey studies were carried out 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-survey studies, the acquisition parameters were subsequently finalized to acquire the seismic data. (shown in Table-2).

Table-2: Parameters of Acquisition Geometry.

Parameters	**Values**
Type of Spread	Orthogonal Asymmetric Split Spread
Bin Size (m x m)	20 X 20
No of Receiver lines / swath	10
No of active channels / line	224(170+54)
Total no of active channels	2240
Shot Interval (m)	40
Group Interval (m)	40
Inline fold	14
Cross line fold	5
Total fold	14 X 5 = 70
Shot Line Interval (m)	320
Receiver Line Interval (m)	360
No of Shots / Template	45
Cross Line Swath Roll (m)	1800
No. of geophones per group	6
Array	Bunch
Min. Offset (m)	28
Max. Offset (m)	7226
Min. Max.Offset (m)	6350
Max. Min.Offset (m)	6862

As already explained concerning tough logistic conditions, it was not possible to lay out the above mentioned spread uniformly. Hence the acquisition template was edited as the logistics demand to acquire seamless data.

The stern logistics available in the study area are shown in Figure-3 and were divided into four categories namely,

1) Rivers
2) Network of oil and gas pipelines
3) Mangroves with back water
4) Fish and Prawn ponds

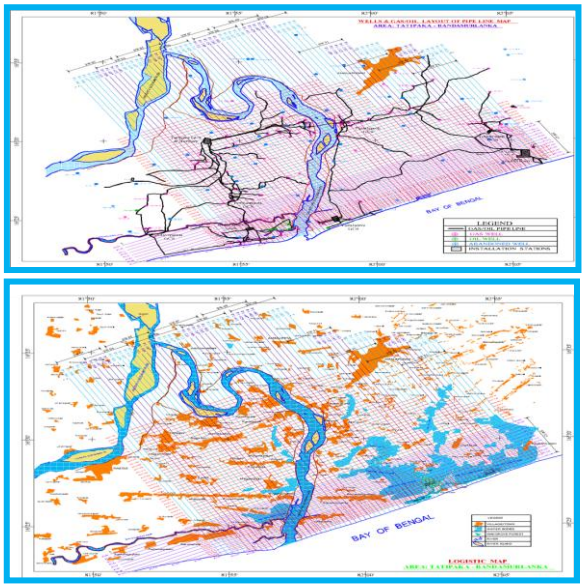


Figure-3: Logistic Map of the operational area.

The operational area is bifurcated by the Vainetiyam-Godavari river. The width of river varies from 700m to 1.5Km. and depth from 2m to 25m. with very high water current. With thorough reconnaissance along and across the river, some riverine islands were identified inside and shots were placed in these islands to cover the area and thus could provide a data link for the first time across the river.

Consequently, in the fresh water and back water area, the crew acquired the data during the time of low tide and planning was done and executed on day to day basis.

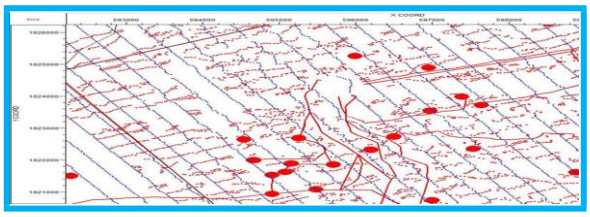
Southern part of the operational area near coast was full of shrimp culture activities and thorny bushes. Judicious planning of seismic activities to acquire data in this area were made.

The other main hurdle was that the entire area having a network of underground pipe lines which were connecting many of the producing wells. About 211 wells are present in the area, out of which 131 gas producing and 18 are oil producing. In addition to this GGS, EPS and refinery were also in the operational area. All these wells and installations were connected through pipe lines, however exact layout map of these pipelines network was not available. The party was in need of exact lay out map before start of field operation as safety of these pipe lines was main concern.

To overcome this problem before start of field activity the area of survey was thoroughly explored and some indication boards showing the direction of pipelines were found. The survey team with the help of Hand Held GPS coordinated all the wells and prepared the layout map of these pipelines before commencement of the field work. The source points were staked at safe distance from these pipelines.(Figure 4a & 4b)

To further firm up the safety of these pipelines, the staked coordinate of shot points were uploaded in Hand held GPS and two surveyors along with GPS were deployed to ensure the position of drilled shot points. The holes were loaded only after proper verification. This enables to acquire data without gap and complete the task without any damage to these pipelines.

(a)



(b)

Figure-4(a) &4(b): Source layout in network of Oil and Gas pipelines.

Layout of shot points and receivers in fish/prawn ponds, riverine islands, river bank etc. are shown in Figure-5. Before final production with such kind of layouts, the results were generated and checked in advance.

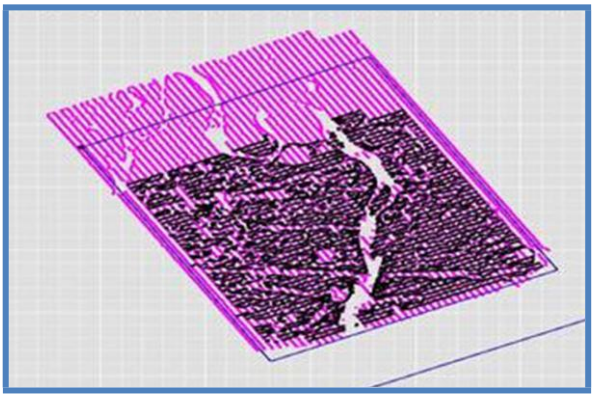


Figure-5: Layout of Sources and Receivers.

Dynamic Recovery

Before start of the work, reconnaissance survey conducted for the logistics in the operational area. Based on these studies it was found that by skipping the shots and receivers which are falling in the river, the actual fold would fall below nominal fold as shown in Figure-6(a).

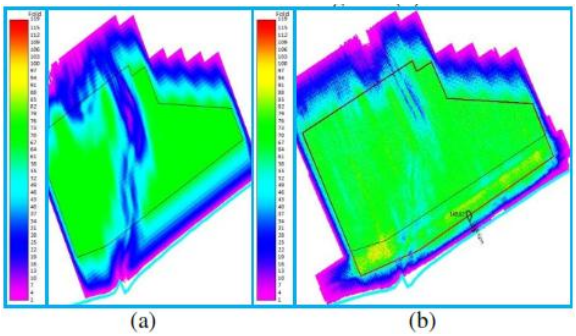


Figure-6: (a) Estimated fold map before acquisition; (b) Actual fold map after acquisition.

During regular survey work, the logistics (Non-Seismic Objects) mainly across and along the rivers, oil and gas installations, fish / prawn ponds and towns/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 planned & executed along with the regular shot lines and as a result desired fold was achieved as shown in Figure-6(b).

The satellite images taken from Google site also proved to be of great help in identifying the logistics.

Coastal Recovery

In order to get the optimal fold as close as possible to the coastal boundary, party planned recovery swath along the coast. Party endeavored to take shots in possible places wherever available for drilling of shots in logistically challenged area comprising mainly back water, mangroves, and fish/prawn ponds. This enabled to acquire full fold data up to 1.5 Km and approximately 45 fold data up to 700m away from the coastal boundary. Fold distribution map without and with coastal recovery plan are shown below in Figure-7(a) & 7(b).

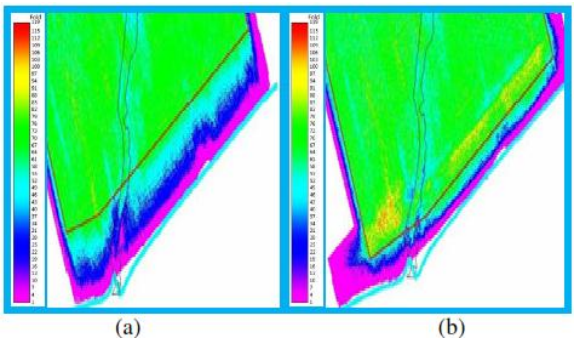


Figure-7: Fold near coast (a) before recovery; (b) after recovery.

Special efforts

The work plan was chalked out as per judicious time plan, keeping in mind about the environmental constraints. The area towards the western part of Vainetiyam-Godavary river which was logistically very challenging and was far from the base camp was taken initially and covered by mid

of May. The eastern part of the area which was near to camp was taken in the end of field season. Following special efforts were also taken to improve upon the data quality by and large:

- Advance planning on day to day basis to avoid skips and maintain required fold in river portion of the area.
- Seismic data was successfully acquired in network of oil and gas pipelines and installations.
- Utilized satellite images from Google Earth for dynamic as well as special recovery planning in fish / prawn ponds, river and villages falling in operational area. It helped for proper placement of source points and thus desired fold was maintained.
- Adopted dynamic recovery and costal recovery in the operational area to provide the data with requisite fold.
- In spite of the logistics, party achieved the full fold data without any data gap within the stipulated operational time.
- Radial gain application of recording system i.e. to increase the gain with increase in offsets from shot points was used for improving data quality.
- Instead of theoretical coordinates, the actual Staked coordinates of receivers and shot points were used in the recording system for on line quality monitoring and to full fill the radial gain application.

Results & Comparisons

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

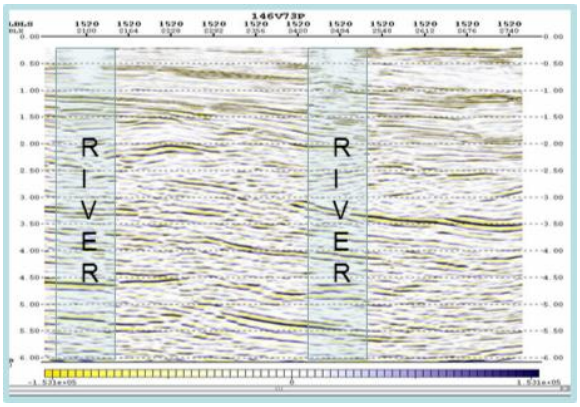
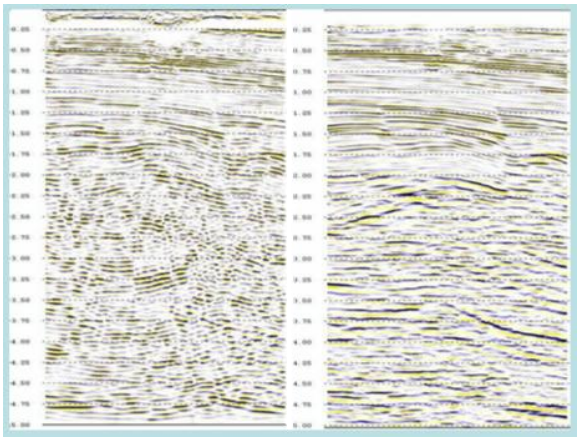


Figure-8: Processed Migrated Section along the river

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



(a) (b)

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

There is a remarkable improvement over previous data as shown in the above figures. Appearance of processed sections of the recent acquired data, the deeper events are clearly visible even beyond 4.5 seconds which is no doubt a value addition for the exploration of hydrocarbon in such kind of 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 up to coast line.

Conclusions

Seismic exploration in logistically challenged area involves considerable operational and geophysical challenges. Using available technical capabilities and with best pre-planning and designing recovery, enabled to provide data link across the Vainetiyam-Godavari river for the first time. Putting expertise efforts and innovative ideas, data in network of oil & gas pipelines and installations was acquired safely.

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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