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Efficient and meticulous planning for 3D seismic data exploration in severe logistically challenged terrain in Krishna-Godavari Basin – a case history

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Summary

In recent days of oil exploration endeavor, 3D seamless seismic data acquisition in logistically challenged area is a stern crisis offering great geophysical challenges to many global oil industries. Modern seismic data is generally having higher fold, better sampled and more consistent. Subsequent efforts are being made by the frontline geoscientists in the world to acquire consistent data even in logistically difficult area in quest of getting more seismic information subsequently.

In the present study, the authors elucidated how the good quality seismic data with the planned fold was acquired in major logistically challenged area of having major giant water bodies by proper and careful planning, swath changeover to upcoming fishpond areas, prioritizing operations at prawn pond areas, ensuring cooperation from local commune to fulfill the geological objectives to evaluate hydrocarbon prospectivity in Cretaceous sediments and to identify strati structural entrapments.

Introduction

Three areas, namely Kaza-Nandigama (2 blocks), Lakshmipuram- Sanarudravaram (3 blocks) and Akividu-Gandhinagaram (1 block) in KG-PG Basin were earmarked for out-sourcing because of the acute logistic challenges. Due to lawful compulsions and contractual complications, the departmental crews were assigned the job of acquiring 3-D seismic data in these areas (Figure-1).

Figure-1: Tectonic Map showing Operational Area.

After carrying out a thorough reconnaissance survey, it was found that, the assigned operational area, Lakshmipuram - Sanarudravaram phase2 has nearly 51% of the operational area is occupied by perennial fish ponds, prawn ponds and other water bodies like drains, canals etc. Mesa software was used and fold map was generated killing sources and receivers falling in water bodies. The

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fold map showed a big hole with literally zero fold and at many other places with very low fold. The requisite fold is attainable only in 20 SKM out of total 220 SKM operational area.

Management mooted the idea of a crop holiday to get the data with requisite fold. 40000 acres of the operational area was of fish ponds. Even with a minimum compensation of Rs 20000/acre, it would be 80 crores against total project cost of 10 to 12 crores. Also lakhs of people are dependent on these fish ponds directly or indirectly. Getting permissions from the state administration would be difficult or time consuming.

Under the above backdrop, the party took this venture as a challenge to acquire full fold data.

Party tried successfully few pronged approach.

- As the fish ponds are perennial in nature and large numbers of shots are falling in the fishpond area, there is no alternative to locating the shots and receivers on the bunds.
- This could be made feasible by dispelling the fears of the fish pond owners & convince them that no damage will be done by small charge blasted below 40 mtrs. That is good public relations and use of CSR funds –good will measures.
- Around 2700 shots are located in prawn pond areas: completed the areas before seeding as the bunds are narrow and ponds are shallow.—time management.
- Rivers by proper recoveries. Exploiting all the instrument capabilities & proper recoveries.
- Mesa software was extensively used to plan recoveries, to check the fold map on day to day basis as this area is not amenable to regular geometry.

By appropriate planning and opportune scheduling to accomplish the project, party could achieve successfully 258 SKM against a target of 240 SKM with 52 and above fold. The acquisition could delineate events clearly underneath trap.

Methodology

The party has conducted preliminary studies before going to field. The seismic representation in that area was studied including fold test, synthetic seismogram, and correlation with VSP as well as surface seismic data. Different spread geometries were studied to optimize the field parameters.

In addition to the seismic response, the party also carried out logistic survey. The severe logistics as revealed in Figure-2, present in the operational area are:

- Large perennial fish ponds, Prawn ponds, Crab ponds, Gogulleru creek, Pedalanka drain, Upputeru river and backwaters
- Mangroves & Marshy land
- Upputeru Reserve Forest
- New Fish ponds coming up in short duration putting pressure to complete that area
- Time constraint for completing prawn pond area
- No proper approach roads available. Available roads are in very bad condition

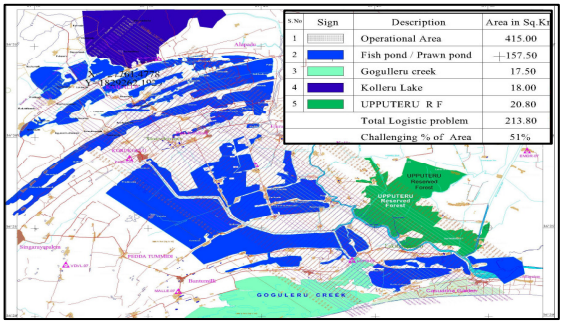


Figure-2: Operational area showing all kinds of logistics.

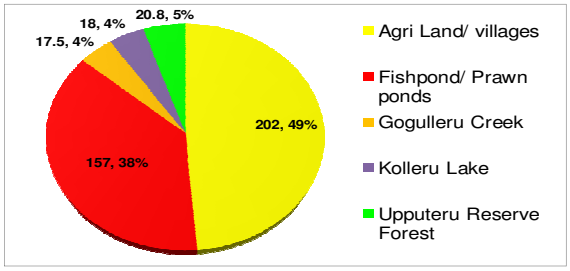


Figure-3: Severe logistics in operational area showing nearly 51% of the area.

The party also carried out an analysis to find out the normal seismic coverage with regular spread geometry in such logistically difficult area. Out of the 24000 shots nearly 12500 shots fall in fish, prawn and crab ponds and river/drains, which amount to 51% of the operational area as shown in Figure-3.

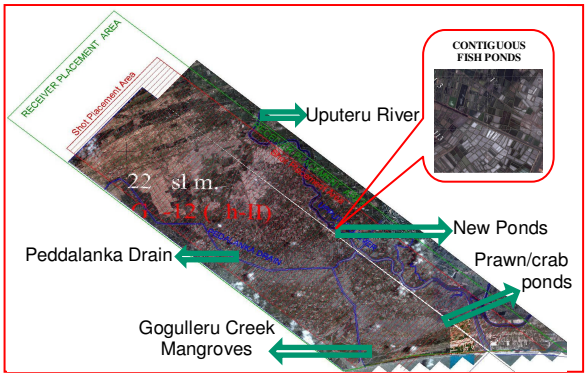


Figure-4: Google images showing logistics in operational area.

The contiguous vast expanse of these water bodies shown in Figure-4, where no sources and receivers could be placed would have resulted in zero fold in the southern part of the operational area (Figure-5). With that challenge in their hand, the party moved to the field with a strong determination to achieve full fold coverage of the entire area with suitable recoveries.

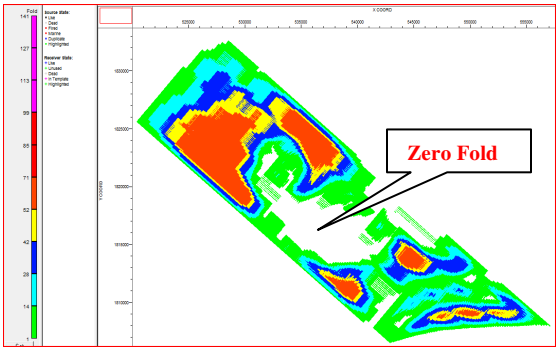


Figure-5: Area showing zero fold in the southern part of the operational area.

Survey Efforts

Since the area is full of fish ponds, the shot points and receivers are located along the bunds which are separating the ponds. This leads to the Herculean efforts in topographic survey. Since each receiver and shot point to be defined with correct co-ordinates which necessitated an extensive DGPS/ETS survey occupying almost each and every shot point and receiver. In any normal survey the GPS control points are of the order of 15000, where as the GPS/ETS control points for the current survey are 59892. This includes the efforts during recovery plan. Google maps came handy to locate areas of hurdles. GPS Points and Actual Shot Points position by ETS are shown in Figure-6.

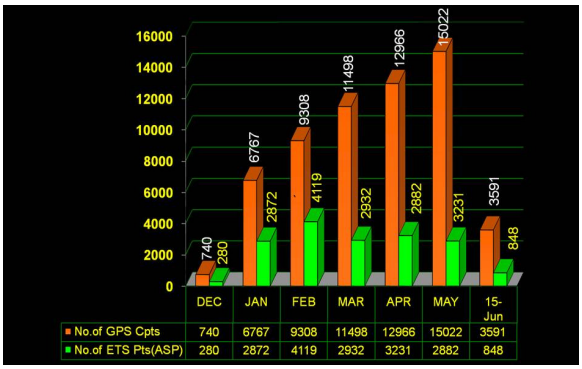


Figure-6: GPS Points and Actual Shot Point position by ETS.

Receiver/Source efforts

Due to the vast expanse of the water bodies present in the area, at the first instance, the party concluded that regular spread/swath geometry cannot be deployed in such area. The only way is to keep shot points and receivers along bunds of the fish ponds, provided the villagers/aqua farmers agreed to such type of strategy. Figure-7 indicates planned, normal and offset locations of shot points swathwise.

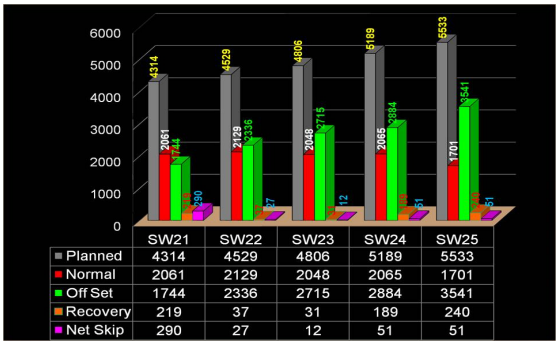


Figure-7: The numbers of offset shot points are indicative of the logistics in comparison to the planned locations.

The numbers of offset locations are dominantly contributing than the normal locations. Particularly, in swath 25, the numbers of offset locations are more than double of the normal locations. This indicates the vast dimension of the logistics of the area. In The party realized that until and unless there is strong support and co-operation from the public this staggering task cannot be achieved.

An effective PR strategy was slated and implemented. The leading personalities, the fish pond owners and govt. officials of the area were invited for Republic day celebrations and explained the necessity of seismic surveys for the development of the area. The public got convinced that if exploration yields success, the area can be socio-economically uplifted. That is how the party accomplished the road map for completion of the area. Party could earn the good will and faith of the public through CCP funds 4.86 lacs and Medical camps in the operational area.

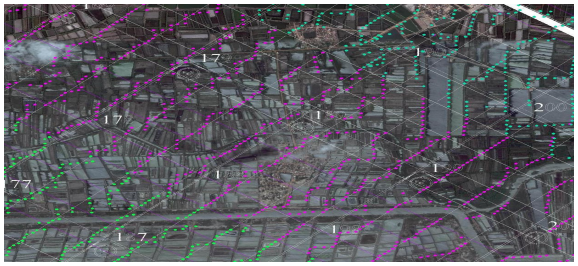


Figure-7: Position of source/receivers was superimposed in satellite image.

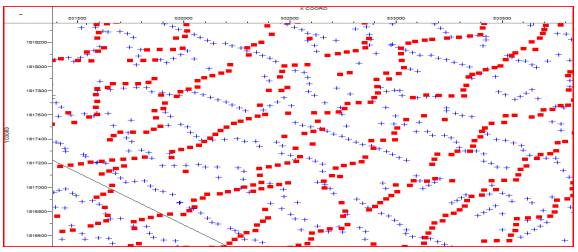


Figure-8: Superimposed Positions of shot points (red dots) and receiver points (blue dots) due to logistics.

The source/receivers were kept in the bund area (Figure-7). About 200 no's of cables were frequently used for detours to overcome the hurdles. Snaking and data bridge option available in the I/O instrument was used extensively to circumvent rivers and other logistics. As mentioned above the co-ordinates of such receivers/shot points were obtained through GPS/ETS measurements and the superimposed positions of source/receivers are shown in Figure-8.

Skips were monitored on day to day basis in MESA as well as FPU and recovery plans (dynamic / planned) were executed. Planned full fold boundary and acquired full fold boundary was superimposed in satellite image as shown in Figure-9. In the costal portion of Bay of Bengal an effective recovery plan was designed which resulted in satisfactory fold up to sea coast (Figure-10).

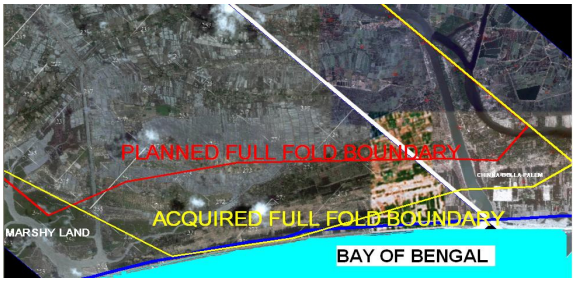
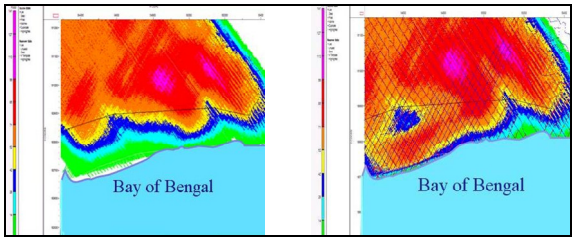


Figure-9: Planned full fold boundary (Red line) and acquired full fold boundary (yellow line) was superimposed in satellite image.



(a) Before Coastal Recovery (b) After Coastal Recovery

Figure-10: Fold map showing (a) Before Coastal Recovery; and (b) After Coastal Recovery.

Special Efforts

The party thoroughly studied the chronological events in aqua culture and identified the pockets where the aqua culture could have started in the latter part of the field season. The party identified prawn culture areas (as shown in Figure-11) where the seeding season would start in first week of March.

Figure-11: Prawn culture pockets in the operational area.

The party suspended the operations in the area where they were acquiring the data and switched over the operations where the prawn culture was not started and completed successfully (nearly 2700 shots) achieving satisfactory fold in the area.

Many new fishponds were coming up in the operational area in short notice. The party prioritized these areas and completed the area before filling & seeding. Around 500 shots were acquired by adopting this strategy. Preparation of SPS for the data thus acquired is a complicated task, which was completed with great care.

The difficult logistics necessitated the criss-crossing of receivers at many places. Meticulous check using Field processing Unit has been taken up by the party to realize the actual positional values. Merging of navigation data with acquired seismic data to confirm the shot and receiver positions for the sub-weathered layer velocity to check the first break was done for each and every shot. The shots are checked in the shot and offset domains. A sample of the merged shot in the offset domain is shown in Figure-12.

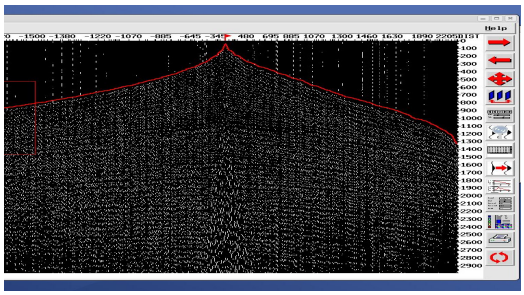
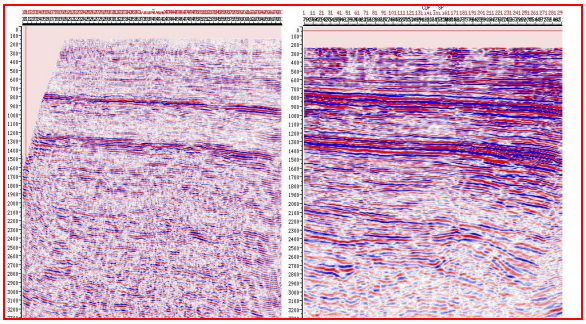


Figure-12: QC check for geometry of a representative merged shots in Offset domain.

Comparative Analysis

The reconstructed lines from seismic volume oriented from NE to SW, parallel to the earlier 2D lines depicts the deeper events clearly below the trap in recently acquired data comparing to old vintage. Figure-13 shows the comparison of recently acquired PSTM Stack with earlier 2D migrated section.



(a) (b)

Figure-13: The comparison of (a) earlier 2D migrated section; and (b) RC line of recently acquired 3D PSTM stack.

The reconstructed line passing through the giant fishponds is shown below in Figure-14 and a fold map without shots and receivers in fishponds is shown in inset. The section demonstrates how efficiently the shots and receivers are placed along the bunds to get proper coverage. The continuity of events and consistency in the amplitude gives a clear indication of the successful disposition of the shot and receivers in the logistically difficult terrain, thereby establishing the success of this 3D campaign.

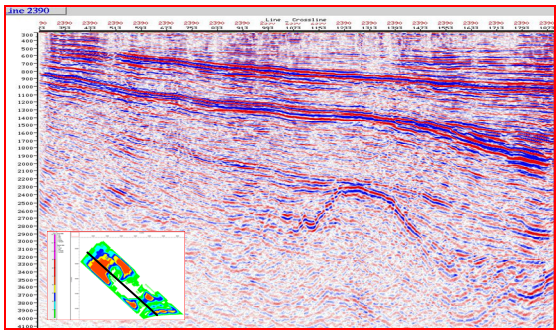


Figure-14: The reconstructed line passing through the giant fishponds in the operational area.

Through careful planning and proficient accomplishment, the party could achieve 258 SKM against a target of 240 SKM with appreciably achieved 52 and above fold comparing much lower anticipated fold all along the study locale as replicated in Figure-15 & 16.

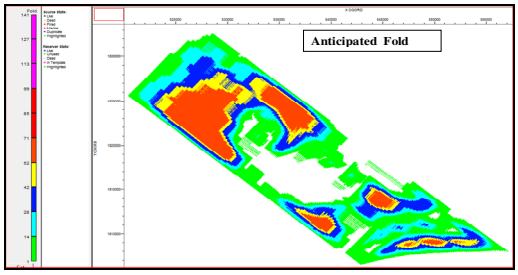


Figure-15: Anticipated fold as per logistics in the operational area.

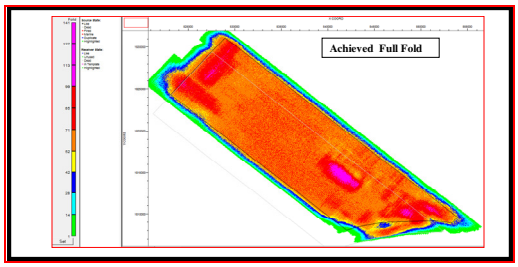


Figure-16: Actual fold after acquiring data surmounting logistics in the same operational area.

Conclusions

The area posed twin challenges of 'Mounting logistics' and 'Improvement of data quality below trap – a long persisting requirement in this area of KG basin'. Though the study area is of extremely logistic terrain, the brilliant completion of this incredible task was only possible by efficient and meticulous planning, concerted efforts, very good public relations, Time management, extensive use of instrument capabilities and mesa software for recoveries. All these things put together could give very good quality data with the planned fold despite of having more than 50 % area under water.

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