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Subsurface Mapping through Objective Based Geometry Designing - A Case Study

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Summary

3-D seismic surveys have become a major tool in the exploration and exploitation of hydrocarbons. The advantages of 3D acquisition and processing techniques have long been recognized. By providing a finer sampling of the subsurface and using 3D migration techniques, anomalies can be better defined. To achieve an optimum image of the sub-surface, we need both wide-azimuth recording and sufficiently dense sampling to obtain a full representation of the seismic wavefield.

The area of study is in the Cambay-Tarapur tectonic block of Cambay Basin. In this area 3D seismic data was acquired with different acquisition parameters. After studying the earlier 2D & 3D data it was observed that the deeper events were not well mapped and the Dip of the events is not exactly in E-W direction it is in ENE-WSW direction. Modelling studies were carried out before the start acquisition in order to know which geometry with best possible bearing will obtain better results. This paper deals with the various aspects of modelling studies with its attributes to finalize the acquisition parameters. Acquired seismic data shows remarkable improvement in the deeper events.

Introduction

Cambay Basin is an intra-cratonic rift basin with narrow elongated graben running approximately NNW – SSE direction, takes a swing in southern part and aligns approximately in NNE – SSW direction. It is flanked in the NE by the Aravali Swell and on the west by the Saurashtra craton. The Basin came into existence during Late Jurassic. During the Late Cretaceous major volcanic activity took place, and the Deccan Trap formed is considered as the technical basement of the Basin. Subsequently, different lithological units came into existence in different depositional environment. The major longitudinal faults are aligned in Dharwarian trend running parallel to the basintrend. The entire Cambay basin is divided into five tectonic blocks based on transverse fault system.

The south-eastern part of the Tarapur block is differentiated at trap level with the presence of horst and graben features. The depositional slope was from East to West and the Eastern flank is dissected by a number of enechelon faults. However, all the faults in this area are Basement controlled faults which appears to be extending beyond Miocene base. The Olpad, Cambay shale and Vaso formations were thickening towards west and thinning towards East except for the variations over Paleo lows and highs. Olpad formation often has wedge like deposits against faults of high magnitude and has intertounging relationship with Cambay shale.

The study area (Fig.1) was sparsely covered different 2D & 3D campaigns. These campaigns were carried out with large variations in survey objectives and data acquisition parameters. Most of the 2D surveys were inadequate to map features in Olpad level except in case of latest 2D-3C survey where far offset was kept 4590 m. Some fault features with limited aerial extent were mapped on the basis of 2D seismic data. However, the actual geometry of the faults could not be mapped with high level of confidence. Earlier two 3D surveys were conducted with shallow objectives. Considering the size and distribution of these features, it was felt necessary to

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conduct 3-D seismic survey in the area to get the detailed subsurface features.

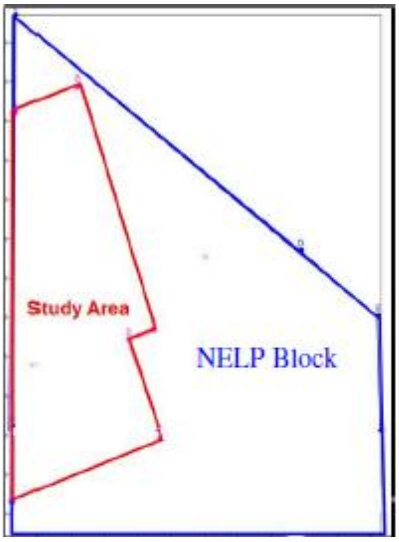

Fig.1: Area of investigation

Methodology

a. Understanding of the Area:

Based on available 2D and 3D seismic data (Fig.2) acquired in the past, the subsurface features of the area have been mapped up to EP-IV level. The sand geometry and fault features have been mapped in the area with high degree of confidence. After studying Time structure map at Olpad level (Fig.3) and Time slices at deeper level (Fig.4) it was noticed that the features at Olpad level have the axis orientation in ENE-WSW with a bearing of 2500 N. A comparative study was carried out on 2D seismic sections which data acquired with receiver line bearing of 2500 N with that of RC line extracted from 3D data which acquired with a line bearing of 2700 N. Deeper events were much better delineated in case of 2D data. It suggested that seismic data should be acquired with a bearing of 2500 N. In order to strengthen this idea detailed 3D modeling study was done in MESA software taking both the bearings into account separately. Inferences drawn from modeling study were also in favour of bearing of 2500 N. Therefore it was decided to conduct a 3-D seismic survey with a bearing of 2500 N in the area to get a clear and detailed subsurface image.

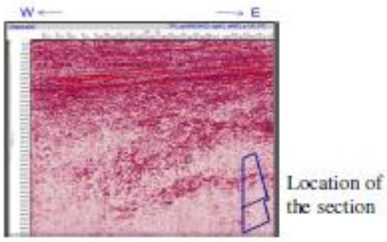

Fig.2: PSTM of earlier data

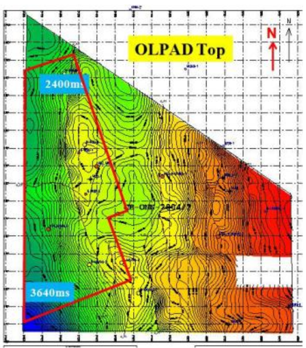

Fig.3: Time structure map near top of Olpad

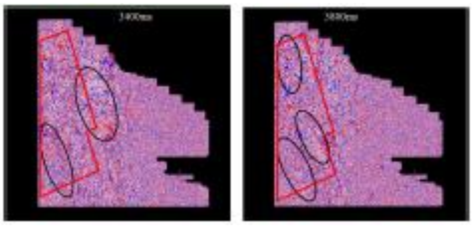
Fig.4: Time slice of 3400ms & 3800ms

b. Modelling Studies:

The goal of modelling was to analyse the geometry parameters for data acquisition and to study the effect of change for various parameters. The model area is located at centre of area. Two horizons namely EP-IV & Olpad

(Fig.5) were selected for model building. A total of 780 shots were fired to study different modelling attributes and also to generate synthetic seismogram.

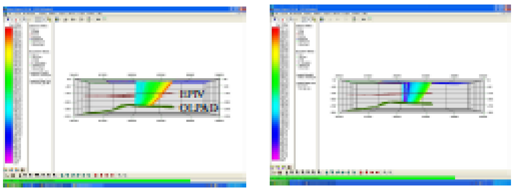

Figure 5: Ray tracing with two different line bearings

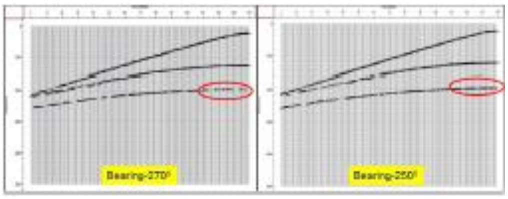

Figure 6: Synthetic shot gathers of two different line bearings.

Synthetic shot gathers (Fig.6) Shows that continuity of the events are better with the line bearing 250^0.

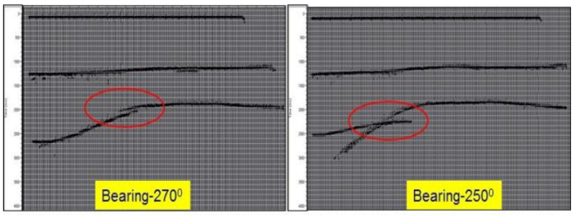

Figure 7: Synthetic seismic section of two different line bearings

Synthetic seismogram (Fig.7) Shows that delineation of fault is better with the line bearing 250^0.

Based on this modeling attributes following acquisition parameters were finalized.

Table.1: Acquisition parameters

Parameters	Earlier	Present
Bin Size	15m x 30m	15m x 15m
Swath Geometry	End-on	End-on
Total active channel/shot	1764 (126x14lines)	1960 (140x14lines)
Spread Length	3750 m	4170 m
Far offset Cross line	4266 m	5036 m
Fold	49 (7 x 7)	49 (7 x 7)
Bearing	270^0	250^0
Aspect ratio	0.67	0.9

c. Data acquisition & Improvement in Data Quality:

Data was acquired with I/O Scorpion digital seismograph. The skillful use of technological developments like 'On-Line Quality Monitoring' using the work station in Scorpion instrument, DDR, Field Processing Unit, actual shot point location measurement after blasting using DGPS survey equipment, use of google maps to see natural obstacles like pond, villages for planning recovery shots, hand held GPS etc. have greatly helped in meeting the objectives. The efforts like analysis of NTG, LMO, Check Shot, Real time measurement of shot point etc. helped a lot in improving data quality. Maximum Frequency content in target zone is up to 52Hz. The data quality as observed from the monitor records (Fig.8) and in Decon stacks (Fig.9a&9b) is very good and shows remarkable improvement in the deeper events. Events in the seismic section are having good correlation with corridor stack of well (Fig. 10).

The data quality as observed from the monitor records and brute stacks is very good. Brute stacks show good amplitude standouts and frequency content of 33-50Hz. In view of the above the data have met the seismo-geological objectives.

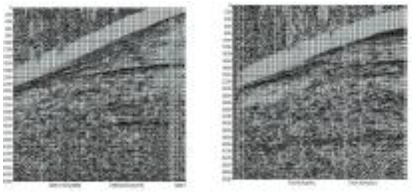

Figure 8: Raw data

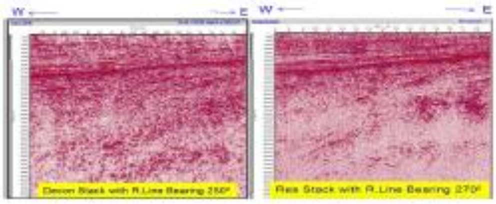

Figure 9a: Comparison with earlier data

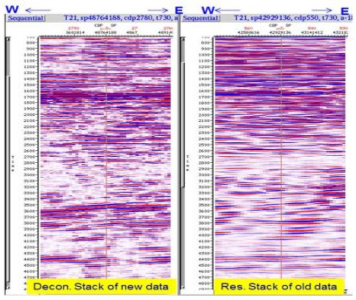

Figure 9b: Comparison with earlier data

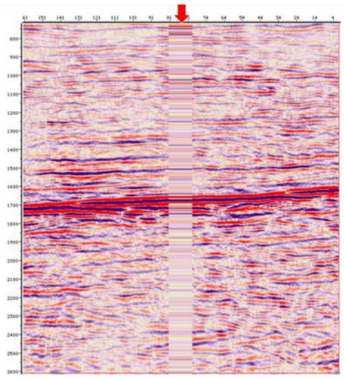

Figure 10: Comparison with Corridor stack

Conclusions

This survey was designed on the basis of clearly identified objectives. Modeling studies successfully established the efficacy of the proposed shooting geometries, direction of shooting, and quality of imaging. 3D modeling studies were crucial and vital to deal with survey design, does guarantee a good signal to noise ratio.

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