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Application of proper imaging tool for structurally complex area: A case history of Cauvery Basin

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Summary

Complex geological structures often are three dimensional. Reservoir mapping with existing 2D data is extremely difficult job even after reprocessing the same data in these areas. Mapping these reservoirs has been a major challenge. The area is revisited for 3D data acquisition with 3D survey geometry. The pre stack imaging in time of the 3D volume have brought out a new play concept and enabled defining the reservoir limits with more confidence because 3-D migration eliminated sideswipes and ambiguities in bringing out blind structures.

Introduction

Cauvery Basin is known as Pericontinental rift basin. Late Cretaceous regression in this passive margin rift basin with horst-graben morphology resulted in a number of deeply incised submarine canyons. Discrete sandstone reservoirs of Paleocene age & younger Eocene fills in these canyons are established hydrocarbon plays of significant potential. Mapping these reservoirs has been a major challenge in the area. Results of some of the step-out wells drilled for the gas pools have established presence of liquid hydrocarbons at the same structural level within the same stratigraphic unit. These fluid anomalies could not be explained with the available structural and reservoir understanding. Pre Stack imaging in time was carried out on some 2D seismic lines over the prospect for better imaging but failed due to limitations of 2D migration. Complex geological structures often are three dimensional. We should not expect 2-D time or depth migration to produce an entirely accurate image of the subsurface in the complex geological provinces (Oz. Yilmaz). The pre stack imaging in time of 3D volume have brought out a new play concept and enabled defining the reservoir limits with more confidence because 3-D migration eliminated sideswipes and ambiguities in bringing out blind structures.

Geology of the area

The Cauvery basin, occupying an area of about 25000 Sq Km in the southeastern part of the Indian peninsula, extends by another 35 000 Sq Km into the offshore (Kumar, 1983) and is considered to be one of the frontier basins in India for oil exploration. On the basis of available geological and geophysical data, it was understood that the basin consists of several depressions separated from one another by subsurface ridges that are extending into the offshore area.

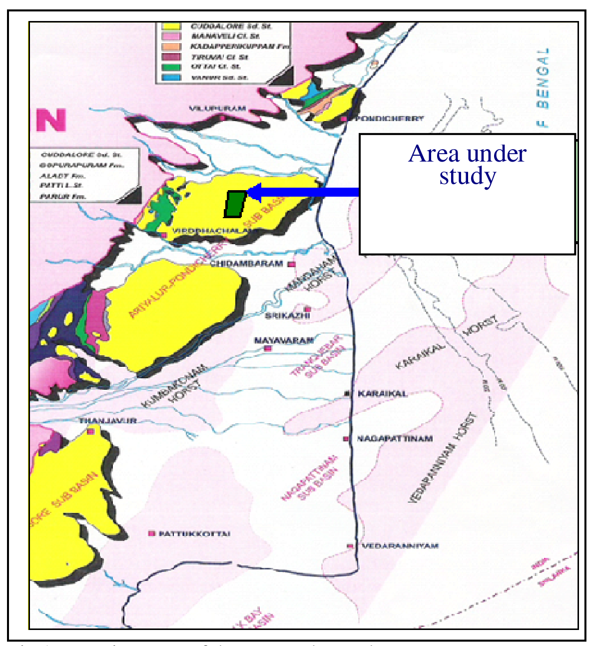


Fig.1: Location Map of the area under study

The sediments filling the basin range in age from Permian to recent and are considered to be as thick as 6000 m. Oil and gas accumulations have been found in fractured basement and in sandstones of Cretaceous to Oligocene age. The sandstone reservoirs within the Andimadam and Bhuvanagiri formations are the main hydrocarbon bearing units within the prospect. The area understudy falls in Ariyalur-Pondichery depression as shown in location map (Fig.:1).

These sandstone reservoirs have been deposited under middle shelf to upper bathyal conditions as slumps and debris flows. The marine transgressive Sattapadi shales overlying the Andimadam formation forms the regional cap rock. The shales within the Andimadam formation in the deeper basinal areas form the main source facies within the area. The geological cross section of basin is shown in Fig.: 3. This geological cross section depicts the complexity in structures across the basin which is consists of several depressions separated from one another by subsurface ridges. The area under study in this paper is shown under red arrow.

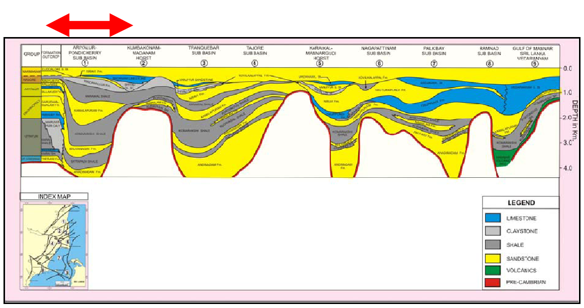


Fig.3: Geological Section

The isochron map at the top of basement of area under study is shown in Fig.:4. The top of basement varies from 500 ms to 3500 ms in the area. The area is dissected by a number of ENE-WSW trending basement controlled normal faults defining elongated fault blocks, which are affected by a NNW-SSE trending transverse faults giving rise to present structural configuration.

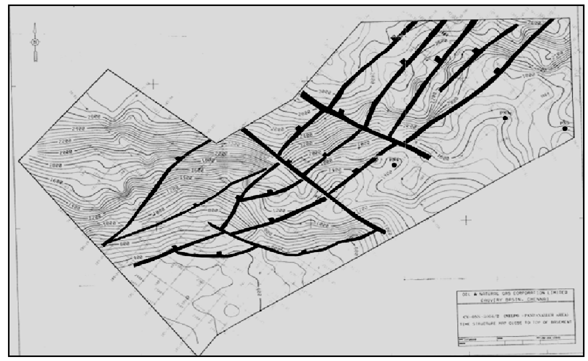


Fig.4: Isochron map (Top of basement)

Problem

The area was earlier surveyed by 2D seismic profiles using 96 channels and 48 fold end-on geometry with maximum offset approx. 2700 mts. The processed output shows poor delineation of basement and structural features. These profiles were again reprocessed to get an improved subsurface image. The comparison shows some improvement as shown in Fig.:5 & Fig.: 6. the improvement in data is mainly due to processing sequence. The earlier processed output follows DMO and post stack migration while in reprocessing of same data, 2D pre stack time migration was performed. But the delineation of structure at basement level is still ambiguous.

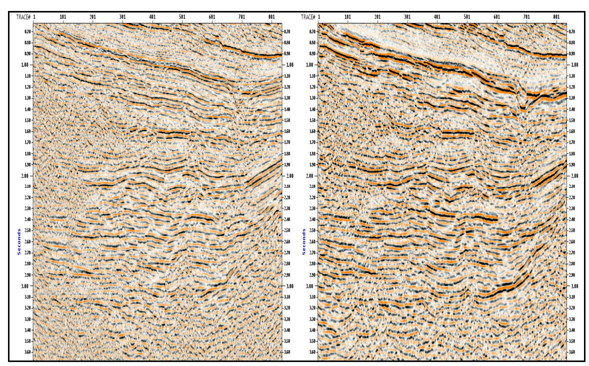
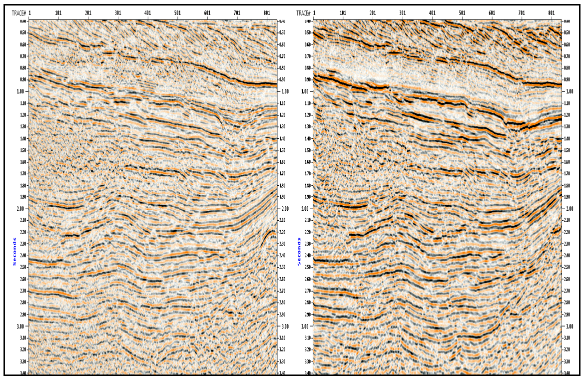


Fig.5: Earlier processed Line A & its reprocessed PSTM output



Earlier Processed   Reprocessed PSTM

Fig.6: Earlier processed Line B & its reprocessed PSTM output

Solution

The area was again surveyed with 3D survey geometry utilizing 2400 channels and 42 fold (6X7) with maximum offset approx. 5500 mts. The area of 3D survey and fold map is shown in Fig. 7 along with two location of 2D profiles. The pre stack time migration of above volume shows a clear delineation and improved structural features at basement (deeper) & shallower levels as shown in Fig.10. The boundary of different levels of deposition has also been clearly defined in processed 3D data. For comparison purpose, two profiles were reconstructed out of 3D volume along earlier shot 2D profiles A & B as shown in 7.

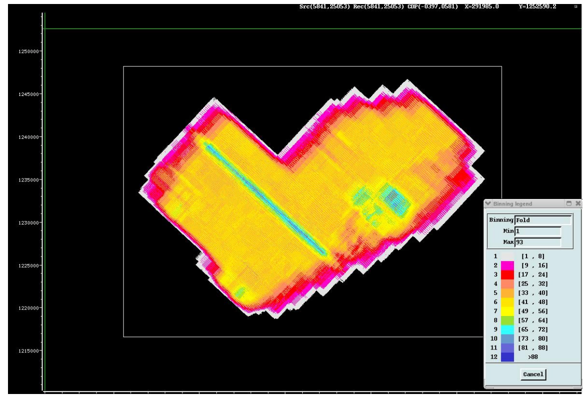
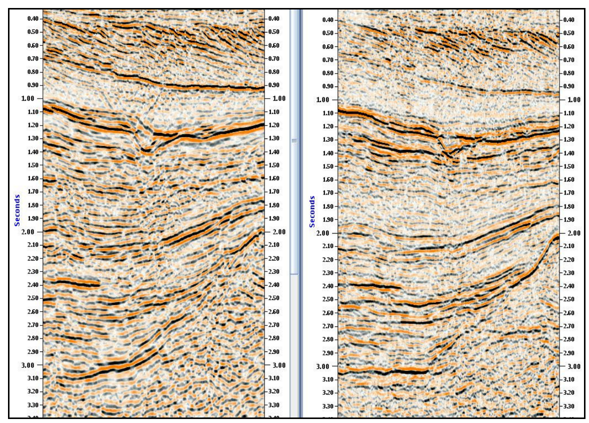
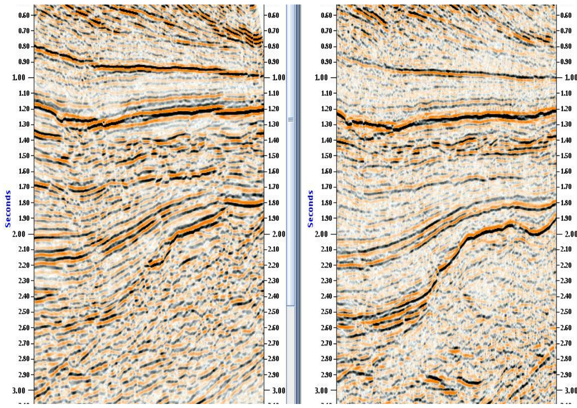


Fig.7: The 3D area showing fold & location of line A & B



2D Line   Reconstructed Line

Fig.8 : Line A & corresponding RC line from 3D data



2D Line Reconstructed Line

Fig.9 : Line B & corresponding RC line from 3D data

The common portions of earlier reprocessed PSTM of 2D profiles and reconstructed profiles from 3D volume are compared in Fig.:8 & Fig.:9. The improvement in reconstructed profiles is considerable. The basement & its structural feature are improved in 3D volume.

Discussion

The improvement is mainly due to change in imaging technology. True structures in the profile plane can be absent in the 2-D raw data due to a component of dip perpendicular to the profile plane (blind structures). For example, no reflected energy from the portion of the fault which lies in the plane of the profile is recorded in the 2D data profile. Conventional 2-D migration of the raw data profile does not eliminate sideswipe events or enhance blind structures. This sideswipe causes an ambiguity in lateral correlation. 2-D migration produced an increase in the background noise too and hence extremely difficult to interpret the data due to diffraction and sideswipe events. Where as in 3-D data volume the 3-D migration eliminated sideswipes and brought out blind structures clearly. The 3-D processed output is shown in Fig. 10 is devoid of any interpretational ambiguities caused by these phenomena. The background noise created by the 3-D migration is similar to that of the 2-D migration and can probably be reduced by use of more sophisticated numerical techniques. More over the migration velocity also plays an important role in delineation of subsurface image correctly.

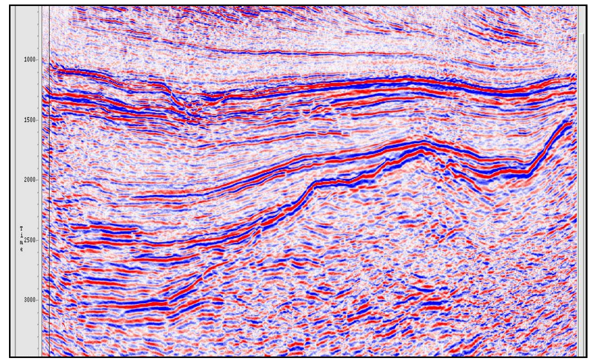


Fig.10: An Inline from 3D Volume

A close grid velocity analysis along the geological formation is necessary because pre stack time migration requires geologically consistent velocity. The velocity model update requires the structural in-line and cross-line dips computed on the PSTM stack.

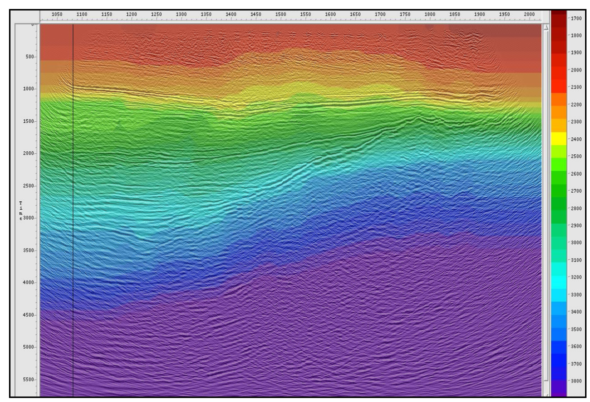


Fig.11: Migration velocity on seismic section

The Fig 11 shows the velocity model superimposed on seismic section used in migration.

Conclusion

The delineation of basement and structural features are brought out clearly after 3D PSTM of newly acquired 3D Volume. The pre stack imaging in time domain have brought out a new play concept and enabled defining the reservoir limits with more confidence. The ambiguities in earlier 2D data could be removed.

Reference

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