

Reservoir and Hydrocarbon entrapment model for MBS pay in Akholjuni area in Cambay-Tarapur Block of Cambay Basin: A case study

Bikram Singh Air
ONGC, E&D Dte.
air_bikram@ongc.co.in

Keywords

Akholjuni, reservoir, entrapment model, anticline, fault closure

Summary

Discovery of yet to find oil in mature basins and in and around well explored fields requires new inputs, either in material (new and advanced data) and/or new ideas. The present study pertains to Akholjuni Area in south-western rising flank of Tarapur Low in Cambay-Tarapur Block of Cambay Basin. Though exploration in and around the study area has been going on for almost last six decades, the Akholjuni Field is relatively new discovery and first oil strike in the field was made in the year 1999. Objective of current study was to develop a comprehensive model for exploration and further delineation of MBS pay in the study. The current study and the proposed reservoir and hydrocarbon entrapment model has resulted in identification of a new prospect south of the established Akholjuni field. Recently a successful exploratory well has been drilled on the prospect. The well has validated the new entrapment model and established presence of commercial hydrocarbons well below earlier established regional OWC.

Introduction

Cambay Basin is a narrow almost NS trending intra-cratonic rift graben. The basin came in existence towards the close of Mesozoic Era as a result of continental rifting along western margin of India. Development of tensional faults along its margins was marked by Deccan Trap activity. The Basin is characterized by several NS and EW trending faults. The EW trending faults have subdivided the basin into five tectonic blocks, viz. Sanchor Patan Block, Ahmedabad Mehsana Block, Tarapur Block, Broach Block and Narmada Block (Figure 1).

The present study pertains to Akholjuni Area in south-western rising flank of Tarapur Low and west of Cambay field in Tarapur Block (Figure 1).

Exploration in the study area started way back in late 1950s. First oil find in the area was established by drilling of the well Cambay-1 (Lunej-1) in 1958 in

the nearby Cambay Field. This was the first oil find by ONGC. Though exploration in and around study area has been going on for almost six decades, and first well in Akholjuni structure was drilled in the year 1962, the Akholjuni Field is relatively new discovery and first oil strike in the field was made in the year 1999.

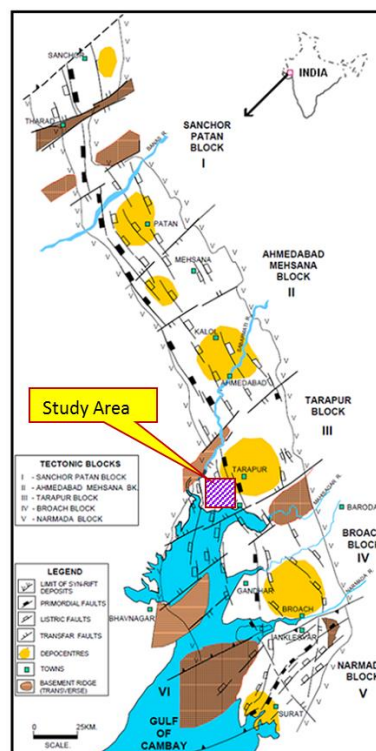


Figure 1: Tectonic map of the Cambay Basin showing study area (after ONGC)

Objective of study

The objective of this study was to revisit reservoir and entrapment model of MBS (Miocene Basal Sand) pays in Akholjuni area in view of recent surprises met in exploratory wells drilled in the area.

Reservoir and Hydrocarbon entrapment model for MBS pay in Akholjuni area in Cambay-Tarapur Block of Cambay Basin: A case study

Established hydrocarbon accumulations

In the study area, hydrocarbon accumulations are mainly contained in MBS (Miocene Basal Sand) Pay belonging to early part of Early Miocene age. The pay sand is developed in the basal part of Babaguru Formation. Besides hydrocarbon occurrences/small accumulations have also been observed in Eocene Pay sands (EP-II & EP-IV). Hydrocarbon shows have also been reported from Olpad Formation of Paleocene age and Late Cretaceous Deccan Trap section.

Reservoir Model for MBS pay

In present study MBS Pay, particularly its well-log motifs, cuttings/core data, lab data, production behaviour and testing/workover data have been analyzed in detail.

Based on well-log motifs, presence of consistent intervening shale layers and production behaviour of drilled wells, MBS unit has been divided in three sub-units namely Unit-A, Unit-B and Unit-C (Figure 2 & 3).

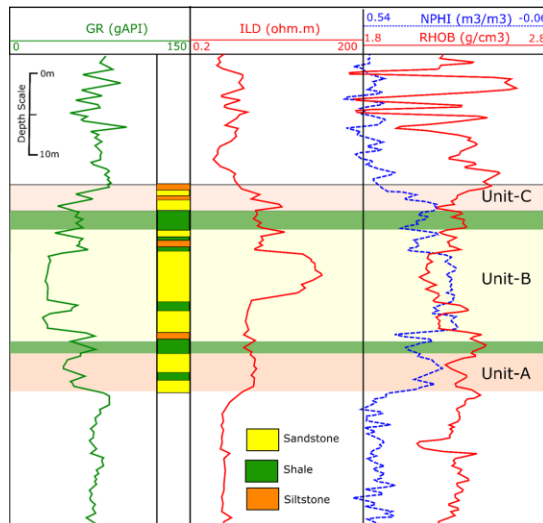


Figure 2: Log motif of MBS section in well-E, showing sub-divisions of MBS pay

The basal sub-unit, Unit-A, is generally a coarsening up sequence with funnel type log signature. This unit is inferred to be deposited as prograding distal delta front silts and fine sands. However at places medium to coarse grained channel/bar facies is also observed, which may be attributed to short term high energy episodes.

The middle subunit, Unit-B, comprises medium to coarse grained sandstone bodies separated at places

by shale layers of limited areal extent. Lower part of the Unit-B is characterized by coarsening up sequence with funnel type log signature inferred to be distributary mouth bars. Whereas upper part of the unit is characterized by blocky to slightly finning up sand bodies with cylinder to bell type log signatures, inferred to be distributary channel sands.

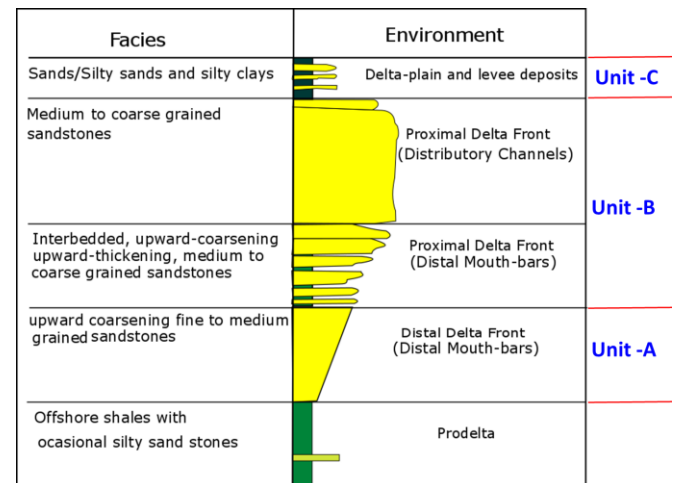


Figure 3: Idealized litho-column showing facies succession in a prograding MBS delta system.

The topmost subunit, Unit-C, is characterized by fine to medium grained sand and silty-sand finning up facies with bell type log signature. The sands have been inferred as fluvial channel sands, however, at places clayey/silty over bank splays are also observed.

To understand facies distribution in the study area and to decipher hydrodynamics affecting oil accumulations Geological cross sections across and along the established field were prepared. Oil Water contacts (OWCs)/ Oil Shale Contacts (OSCs) met in the drilled wells were plotted on these cross sections (Figure 4, 5).

It is observed that in the study area hydrocarbon accumulations are contained only in Unit-B and Unit-C.

Original OWC for Unit-B is observed in logs of Well-D (Figure 4), which subsequently moved up with continuous production from various wells in the block. Current OWC can be inferred on logs of Well-E (Figure 5). Based on SBHP (Shut in Bottom Hole Pressure) recorded in various wells and uniform movement of OWC it has been concluded that within same fault block sand bodies within Unit-B are hydro-dynamically connected with each other.

Reservoir and Hydrocarbon entrapment model for MBS pay in Akholjuni area in Cambay-Tarapur Block of Cambay Basin: A case study

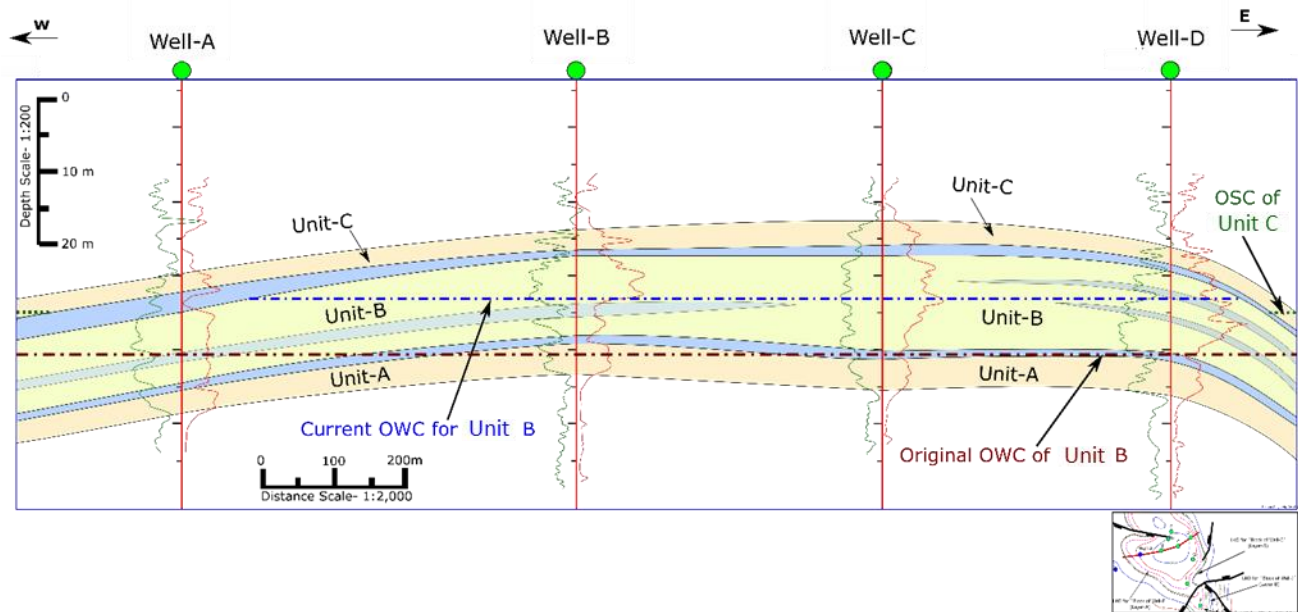


Figure 4: Geological cross section along drilled wells A, B, C and D at MBS level in Study area

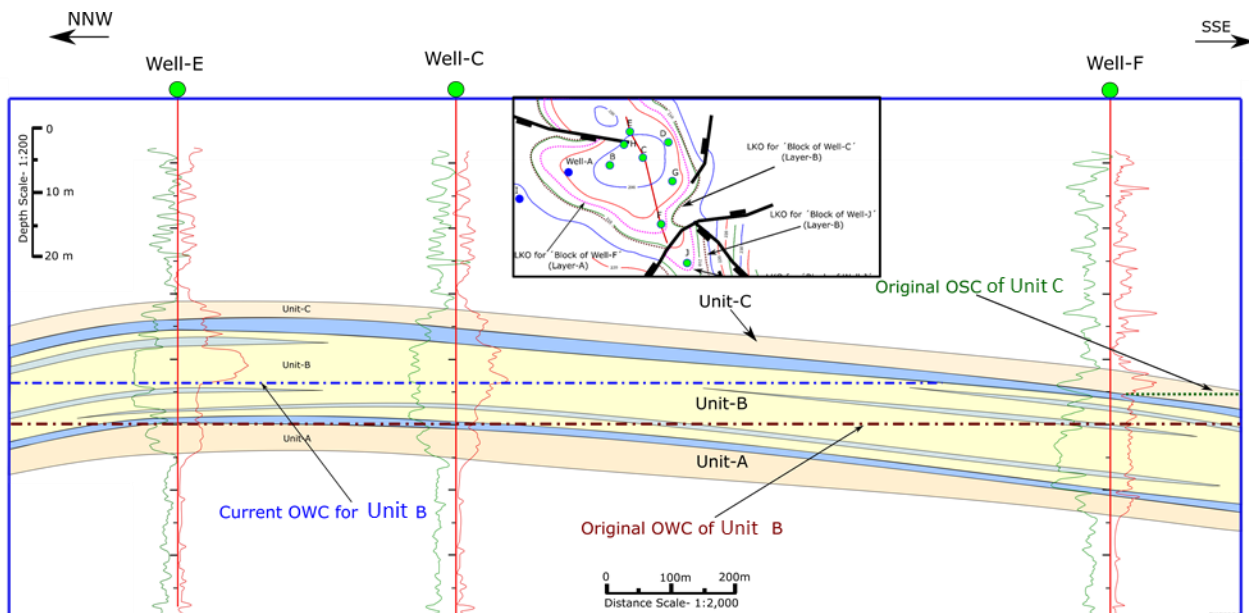


Figure 5: Geological cross section along drilled wells E, C and F at MBS level in Study area

Reservoir and Hydrocarbon entrapment model for MBS pay in Akholjuni area in Cambay-Tarapur Block of Cambay Basin: A case study

In Well-F only Unit-C is hydrocarbon bearing and Unit-B is watered out. This can be attributed to movement of OWC in Unit-B with continuous production from the pay sand. Well-G drilled almost at the same time at structurally higher position (Figure 6) was completed in Unit-B, which was above then current OWC. Further initial SBHP recorded in both of these wells indicated different pressures in Unit-B and Unit-C implying that these are separate reservoirs and not connected hydro-dynamically.

OWCs/OSCs for different fault blocks are plotted on structure map at MBS top (Figure 6) and based on production behaviour in different fault blocks and pressure data recorded in producing wells it is apparent that cross faults are acting as barriers and they are separating different oil pools in the study area.

Structural framework

A prominent seismic horizon close to MBS top was correlated in 3D volume. Coherency slices and other seismic attributes were used for fault mapping in a detailed way (Figure 9). 3D visualization capabilities of modern seismic interpretation software were also used for better visualizing and understanding the structural disposition of MBS pay in the study area (Figure 10).

The present study has brought out a revised structural framework to explain the entrapment model for MBS pay in Akholjuni area. In earlier studies structural model for MBS pay in the area consisted of simple horst-graben blocks (Figure 7 & 8).

However, present study has provided new insights into the structural framework, deformation style in the area has resulted in development of anticlinal highs over two parallel, NS trending basement controlled blocks. (Figure 10 & 11). These Anticlinal highs are dissected by cross faults.

Analysis of the G&G data, Structure/Time maps at MBS top clearly defines locales of hydrocarbon accumulations namely hanging wall anticlinal structures formed against west dipping longitudinal faults. Cross faults have segmented these anticlinal highs into separate culminations, which has resulted

in formation of separate oil pools with distinct OWCs/OSCs (Figure 6).

The study has delineated a very promising hanging wall fault closure prospect (Prospect-Y) in southern part of the study area. Prospect-Y is formed against an arcuate fault of listric nature (Figure 12 & 13).

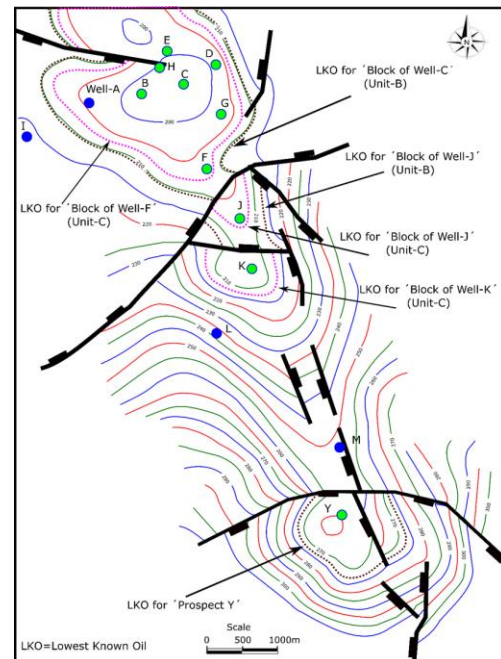


Figure 6: Structure map at MBS Top (from an arbitrary datum), showing composite hydrocarbon distribution in the area.

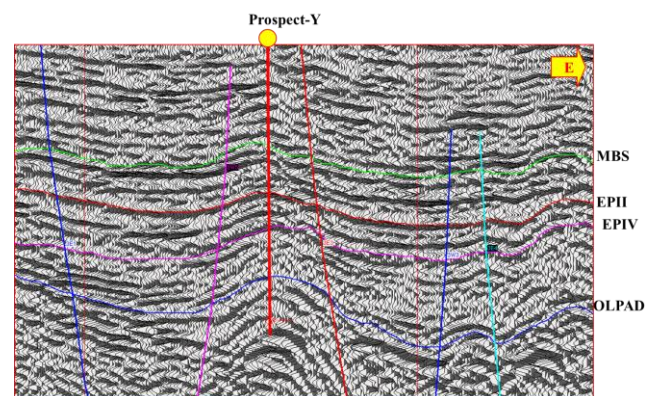


Figure 7: Part of a 2D seismic line passing through Prospect-Y, showing fault placement in earlier perceived horst-graben deformation model for the study area.

Reservoir and Hydrocarbon entrapment model for MBS pay in Akholjuni area in Cambay-Tarapur Block of Cambay Basin: A case study

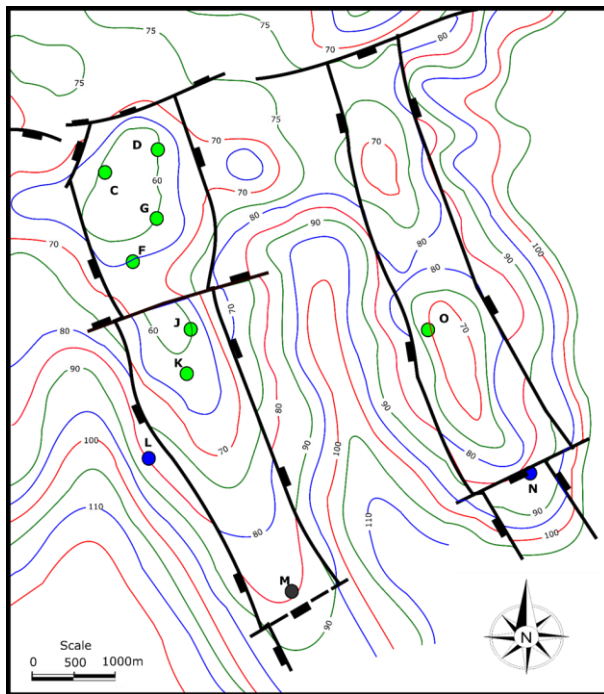


Figure 8: Time structure map close to MBS Top (from an arbitrary datum) showing earlier perceived horst-graben entrapment model for the study area



Figure 9: Coherency Slice showing structural trends close to MBS top

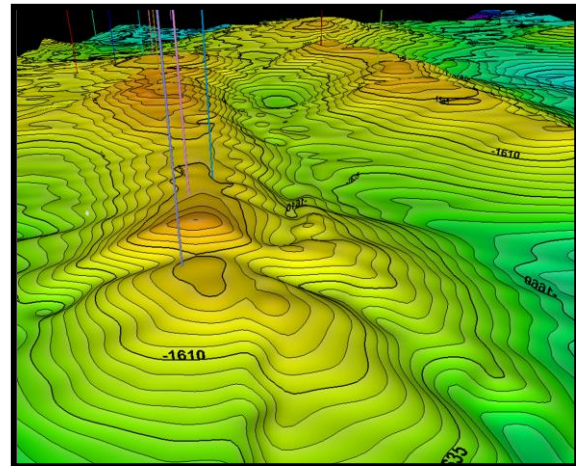


Figure 10: Shaded relief map showing structural trends below MBS top, South Akholjuni field is in the fore-ground.

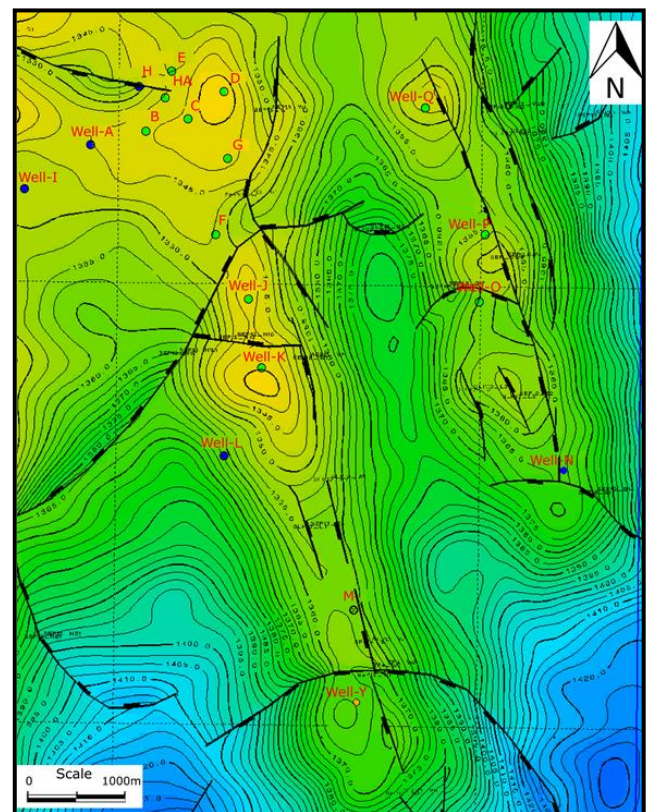


Figure 11: Time structure map close to MBS Top (from an arbitrary datum)

In Prospect-Y MBS top is structurally down with respect to OWC recorded at the Well-K. Further MBS pay is water bearing in Well-L drilled updip of Prospect-Y across the cross fault. However, with

Reservoir and Hydrocarbon entrapment model for MBS pay in Akholjuni area in Cambay-Tarapur Block of Cambay Basin: A case study

sufficient throw at MBS level the cross fault is envisaged to have provided entrapment conditions for accumulation of hydrocarbons and formation of separate oil pool at the prospect.

Well Y has recently been drilled on the prospect and it has proved to be a significant discovery. As expected the oil pool of the well AK-Y has separate OWC and distinct reservoir pressures. In this well all MBS Sub-units are hydrocarbon bearing. The discovery has further validated the reservoir and entrapment model proposed for the study area.

Conclusions

- In Akholjuni area MBS unit can be divided in three sub-units on the basis of the well log-signatures. These sub-units have distinct fluid distribution patterns.
- In the study area two anticlinal highs are developed on two separate but parallel almost North South trending basement controlled blocks. These Anticlinal highs are dissected by cross faults.
- The Cross faults have segmented the anticlines into hydro-dynamically separate culminations and these cross faults play an important role in entrapment of hydrocarbons.
- Proposed entrapment model explains recent surprises met in exploratory wells and model has further been validated by oil find at Prospect-Y

Selected References

- Ajay Kumar Dwivedi (2016) Petroleum Exploration in India - A perspective and Endeavours Proc Indian Natn Sci Acad 82 No. 3 July Spl Issue 2016 pp. 881-903
- D. A. Busch, D. A. Link (1985) Exploration Methods for Sandstone Reservoirs OGCI Publications, Tulsa USA
- Kundu J, Wani M R and Thakur R K (1993) Structural style in south Cambay rift and its control on post rift deltaic sedimentation Proc Second Seminar on Petroliferous Basins of India, Indian Petroleum Pub., Dehradun 2 79-96

Acknowledgements

The author expresses his sincere gratitude to Shri Ajay Kumar Dwivedi, Director (Exploration), for granting permission to publish the work. The author

is also grateful to Shri P. Raja, ED-Chief E&D Dte and Shri R. K. Thakur, GGM, E&D Dte for support, motivation and guidance in writing the paper. Last but not the least all colleagues at E&D Dehradun who have contributed in various means and measures to this work are also gratefully acknowledged.

Views expressed in the paper are Author's opinions and not of the ONGC.

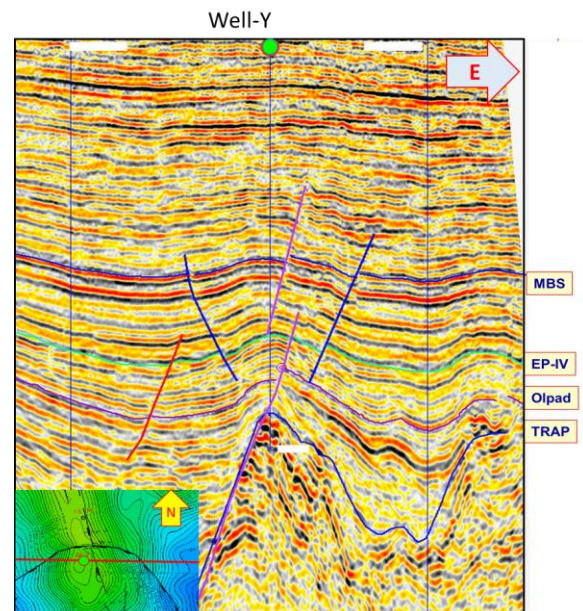


Figure 12: Seismic inline passing through well-Y

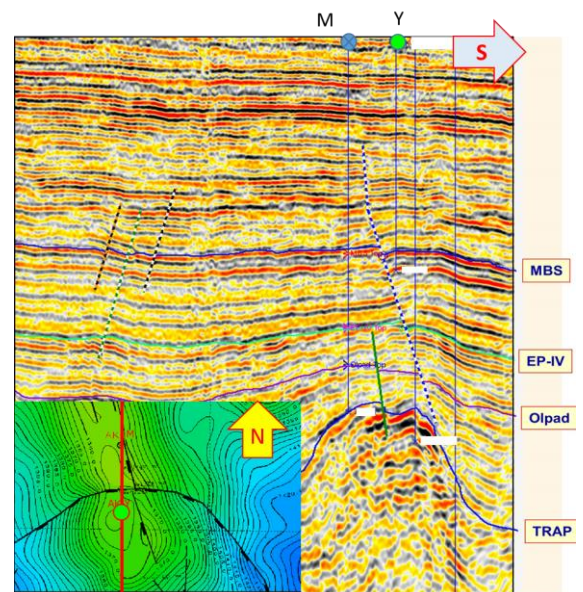


Figure 13: Seismic xline passing through well-Y