Utilization of Geophysical Technologies to Help Deliver Record Beating Oil Production in the Panna Field, Offshore West India

Nick Robb, Rituparna Sarker*, Tata V Santaram
BG Exploration and Production India Ltd.,Midas,Sahar Plaza Complex,
Andheri East, Mumbai

Summary

The success in raising oil production in the Panna oil and gas field to all time highest production records can be attributed to effective planning and implementation of the wells with the aid of latest geophysical, drilling and completion technologies available. Geophysics being one of the main parts of this multidisciplinary jigsaw is discussed here.

Lateral velocity variations, porosity uncertainties, existence of fault and fracture zones and the interference from existing production wells are the major hindrances to planning a new well; the challenge has been to place infill wells optimally, so as to exploit thin oil leg effectively by raising production without coning gas and water.

Introduction

Panna is an oil and gas field about 95 km West of Mumbai, offshore Western India. Panna Field is a broad, low relief, anticlinal trap. The oil column is approximately 20 meters thick and largely is in transition to water. The oil column remains (and has remained during the 20 year production history of the field) 20m thick between 1737 – 1757 m TVDSS. It is situated between a gas cap and a 40 to 60 m water leg. The gas column is typically 50 m thick, but locally exceeds 130 m due to stratigraphic variations. The principal hydrocarbon bearing formations in Panna Field are the Eocene Bassein B limestone and the Early Oligocene Bassein A limestone. The Bassein B Upper reservoir is 50 m thick with excellent reservoir continuity and quality. The Bassein A is roughly 50 meters thick and comprises of tight limestone with thin shale beds, overlain by moderate quality limestone reservoir. The 'tight zone' acts as an important baffle between the gas cap occurring primarily in A Zone, and oil which largely resides in the Bassein B Upper reser voir.

Method

This paper discusses case study of the successful planning and implementation of two infill wells. Usage of multiple geophysical volumes and state of the art technologies has been the key to the success of the drilling campaign.

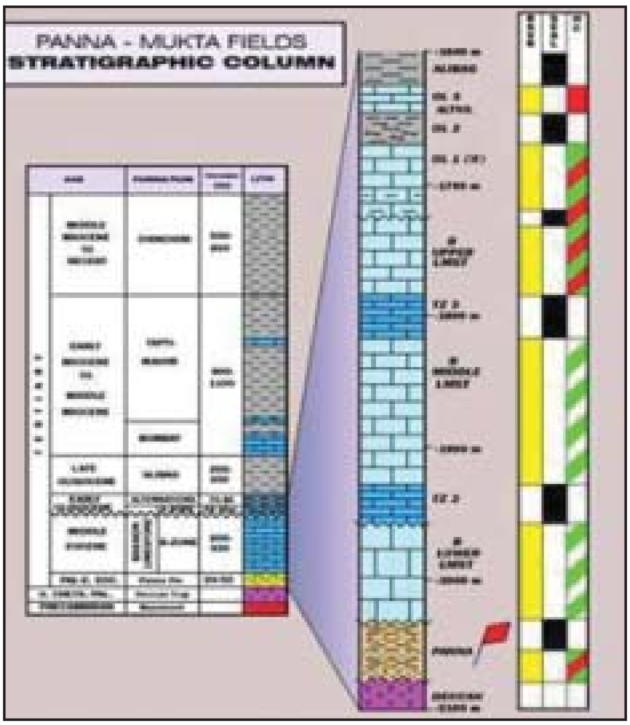

Fig. 1: Panna Stratigraphy

Panna is subjected to significant local velocity anomalies and well placement in flank areas is therefore sensitive to these changes. An Acoustic Impedance Volume provides information on lateral velocity variations across the field.

A total porosity volume was derived from seismic prior to the latest drilling campaign .This PHIT volume is calibrated to a number of wells in the field. This porosity volume allows infill wells to be placed optimally for porosity.

Variance and Instantaneous Frequency volumes allow the wells to be placed optimally with respect to fault/ fracture zones and thus avoiding/predicting mud loss prone zones.

With more than 80 odd wells producing in Panna placement of new wells with respect to nearby producing wells are taken into consideration to prevent production interference.

Case Study 1

In this case study, Well 1 was planned in the eastern flank of the field (Figure 2) intended to target the B Zone which is underlain by an aquifer and capped by gas. The major challenge during planning was to avoid mud loss prone zones (mud losses in Panna are in the order of 400-600 bbls) related to major fault trends whilst placing them within good porosity zones. Variance volumes in conjunction to the seismic A variance slice at the standoff (Figure 3) and instantaneous porosity volume were used to achieve this goal.

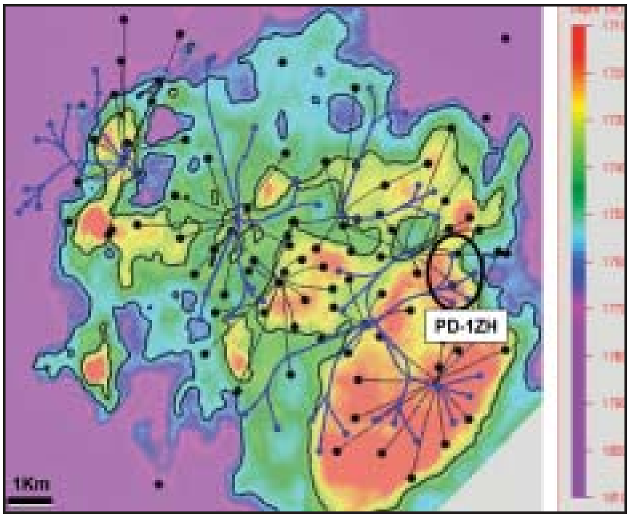

Fig. 2 : Depth structure map on top of Bassein B formation showing location of well 1

A number of well path iterations were investigated and the optimum path was designed so that there was least chance of encountering a fault/fracture zone, while allowing the multilaterals to be widely spaced without compromising oil recovery. were clearly brought out by the variance attribute.

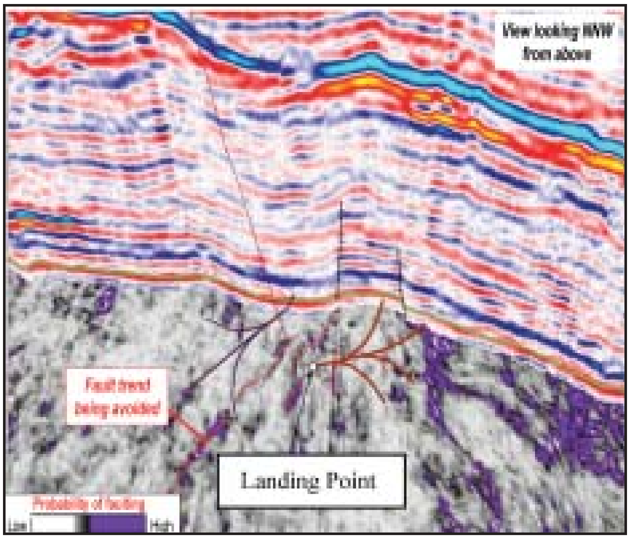

Fig.3 : Variance slice along with seismic section showing presence of faults .

A variance slice at the standoff (Figure 3) and instantaneous frequency volume was used to carefully plan the well by keeping safe distance from the fault and fracture trends that were clearly brought out by the variance attribute. Minor depth uncertainties on either side of the well path are shown as black lines in Figure 4 take into consideration different velocity models.

The final iteration of the mother-bore was placed comfortably within the very good porosity of around 20%+. The result was a 4096m MD drain-hole, longest that has been drilled in Panna.

The major highlights of this success story can be listed as follows:

- Depth control was excellent. Actual top of the reservoir was within 0.7m of prognosis.
- The porosity distribution from the seismic porosity volume(Figure 4) was accurate and is corroborated by an excellent match between porosities inferred from seismic and actual porosities encountered in the well.
- Heavy mud losses could be totally avoided and TD on all laterals was honored.
- The current production from the well is good with a very low water cut.

Case Study 2

This particular well (Well 2) was planned in the steeply dipping western flank of the field intended to target the A Zone (Figure 5). The steep dip and the lack of adequate

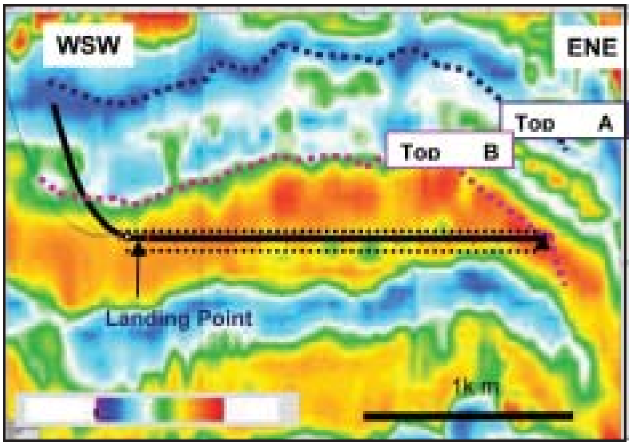

Fig. 4: Porosity section along well path of well 1.

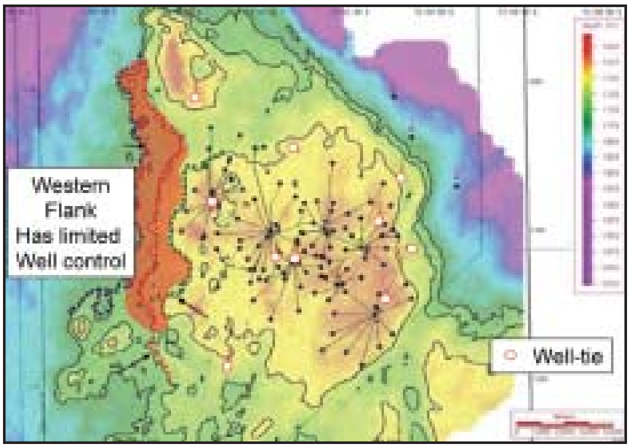

Fig. 5: Depth structure map to top of A-zone showing region where well2 was to be placed in brown.

well control make depth uncertainties higher in this part of the field. Analysis of the seismic porosity volume shows that porosity is well developed in the upper part of the A Zone, unlike B Zone where well developed porosities are encountered uniformly all over (Figure 6). Taking into consideration different velocity models the depth uncertainties were such that the well could either hit the roof of the A Zone or land in low porosity areas at the base of the A-Zone. Figure7 demonstrates the cause of these velocity uncertainties as is brought out by the acoustic impedance section. It shows a laterally varying AI both along A Zone and the alternations which rules out the possibility of extrapolating other well information to the new location. This necessitated the need for a Vertical Incidence Walk Above VSP to be shot in a well in close proximity, the first of its kind to be done in India by any operator. The results were very encouraging. There was an excellent match between VSP stack and the surface seismic. The VSP results

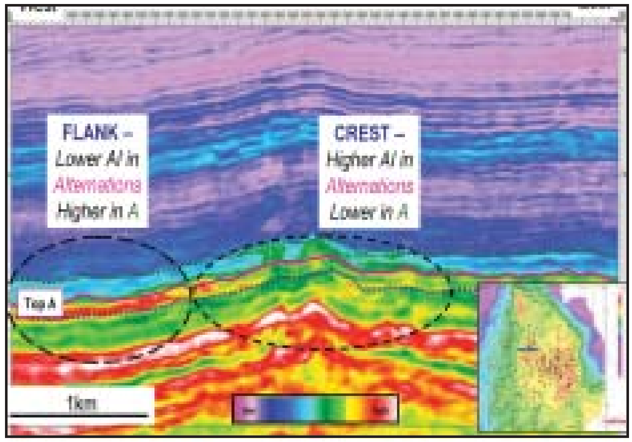

Fig.6 : AI section along a line extending from crest of structure to the flank where the well was to be placed.

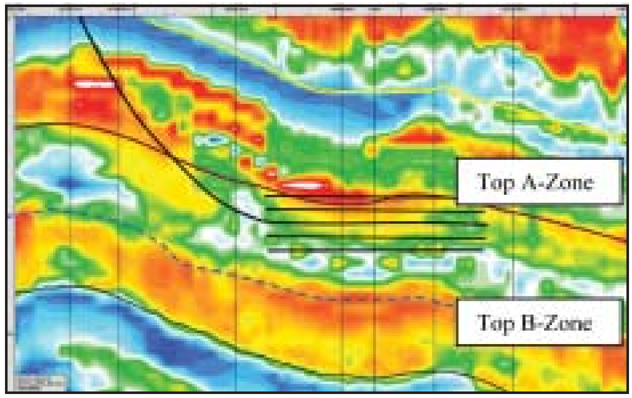

Fig.7: Porosity section along well path of well2, showing porosity uncertainties due to issues with time to depth conversion.

provided the much needed depth control which facilitated the modification of the drain-hole paths to access better porosity zones.

Conclusions

Usage of multiple geophysical data integrated with other subsurface disciplines resulted in optimal placement and excellent recovery from Infill wells. Well planning is iterative and is ongoing as new information is obtained, while drilling and for future wells.

Acknowledgements

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