Delineation of Probable Gas Charged Geo-body within Panna Formation of Western Offshore Basin, India

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Abstract

Commercial hydrocarbon accumulations have been established in Panna formation in various parts of Western Offshore basin (WOB). It is emerged out to be an important exploration target. The recent gas discovery within the study area prompted and motivated us to carry out detailed study in search of sizeable gas play within Panna formation. Multi-stack inversion of seismic data has been carried out to generate P-impedance and Vp/Vs volumes. Rock physics analysis of well log data revealed that the gas bearing sands cannot be discriminated from the rest, even in P-impedanceVp/Vs domain. Therefore Bayesian probabilistic approach has been adopted for the discrimination of most probable gas charged geo-bodies due to considerable overlap in various litho-facies. Sizeable and most probable gas charged geo-body has been extracted in the area. The disposition of the extracted geobody follows the trend of south-east trending lows of Panna formation. This association indicates that it is probably charged due to sand pinch outs / lateral seals.

The probabilistic approach is always associated with certain degrees of uncertainties. Inherent rock physics uncertainties because of various reasons should also be kept in mind while firming up drillable location in the identified prospect

Introduction

The study area covers a part of Heera-Panna-Bassein (HPB) tectonic block (Fig. 1). This block is situated south of Tapti-Daman block and east of Bombay High, west of the Deccan trap out crops and north of Vijaydurg Graben (Fig. 2). The major tectonic elements are the NNE-SSW, NW-SE and WNW-ESE, NE-SW trending faults which dissect the area forming highs and lows. In the eastern part of studied area, almost N-S oriented central graben separares Eastern Homocline to the east from H-P-B plateform to the west. To the south west of Heera-PannaBassein, platform gradually deepens and forms the Murud Low (Fig. 3).

The Panna Formation consisting of mainly clastics of Paleocene to Lower Eocene age unconformably overlies Late Cretaceous Basalt/Basement. Middle to Upper Eocene Bassein Formation, consisting of mainly carbonates, unconformably overlies the Panna formation. Hydrocarbon accumulations in Panna formation have already been established in HPB block of Western offshore Basin. WellA, B, C and D drilled in the area of study encountered gas pay within Panna, but they are thin and appears to be of limited extent. Therefore, the primary motivation of the present work of rock physics modeling, analysis and inversion study is to search for a sizeable gas play within Panna formation.

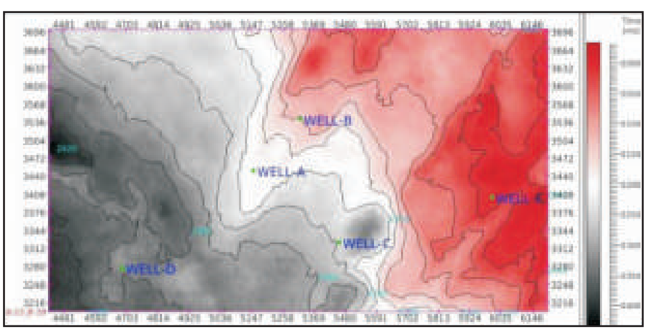

Fig. 1: Basemap of the study area showing well locations and top of Panna formation

Discrimination of pay sand from the rest with the help of P-impedance alone is not possible (Fig. 3) and hence single-stack inversion study is of no practical consequence. Rock Physics analysis with rock physics modeled data clearly indicates that it is difficult to discriminate pay sands exclusively from the rest even with the combination of both P-impedance and Vp/Vs due to considerable overlap for various litho-facies (Fig. 4). To deal with the above difficulties, the effective and prudent option left in the present case is to go for the probabilistic approach to generate probability of occurrence of various litho-facies after generating P-impedance and Vp/Vs volumes through multi-stack inversion of seismic data.

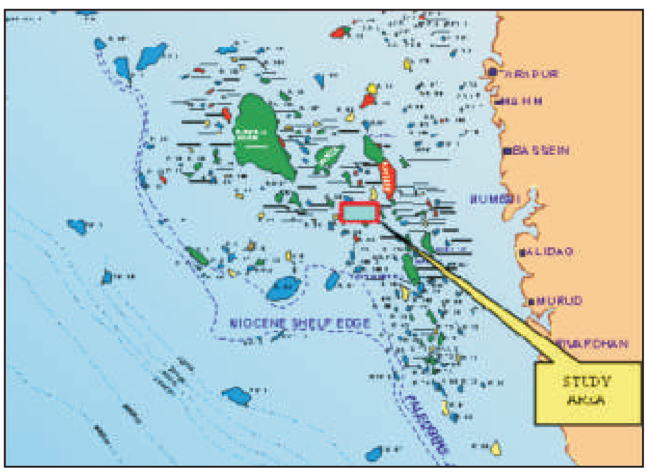

Fig. 2: Location of the study area within Heera-Panna-Bassein block of Western Offshore Basin

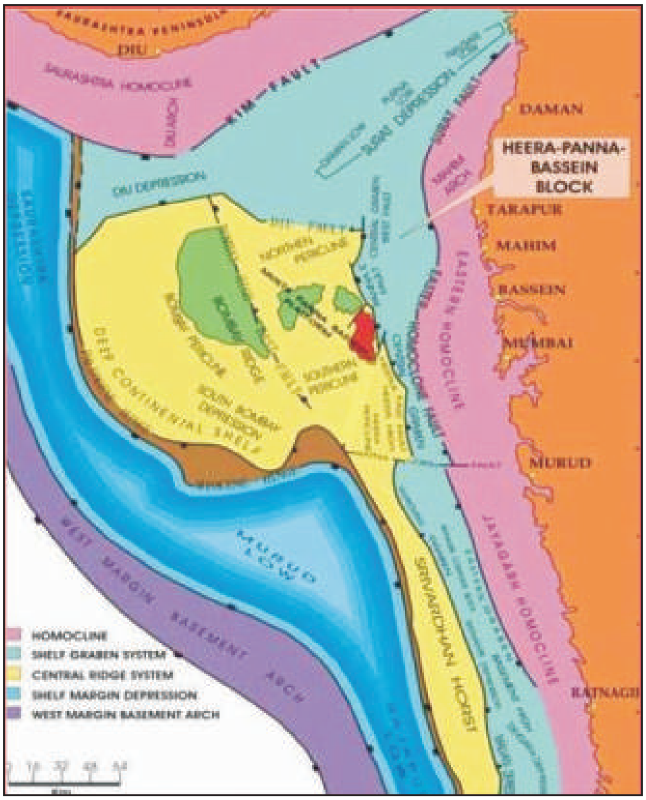

Fig. 3: Tectonic map of Heera-Panna-Bassein block

Shear wave modeling and rock physics analysis

So far, five wells have been drilled in the area of study. Out of which, only two wells (Well-A and Well-B) have recorded shear sonic log. The availability of shear sonic log in all drilled wells is important to understand the rock physics behavior and in particular, building low frequency model for multi-stack inversion. Shear wave modeling has been carried out in wells with shear sonic log using XuWhite approximation and the same model is used to generate shear sonic log in those wells that are devoid of recorded shear sonic log.

As mentioned earlier, it is obvious from the histogram of P-impedance for various litho-facies (Fig. 4) that the discrimination of pay sand from the rest is not possible, thereby discarding the possibility of single-stack inversion for delineation pay sands in the volume. Even, Pimpedance vs Vp/Vs cross-plot (Fig. 5) shows considerable overlap of pay sand with other litho-facies. Therefore unambiguous discrimination of pay sands is not possible even through the result of multi-stack inversion. However, it is possible to talk in terms of probability of occurrence and expected most probable litho-facies by adopting probabilistic approach.

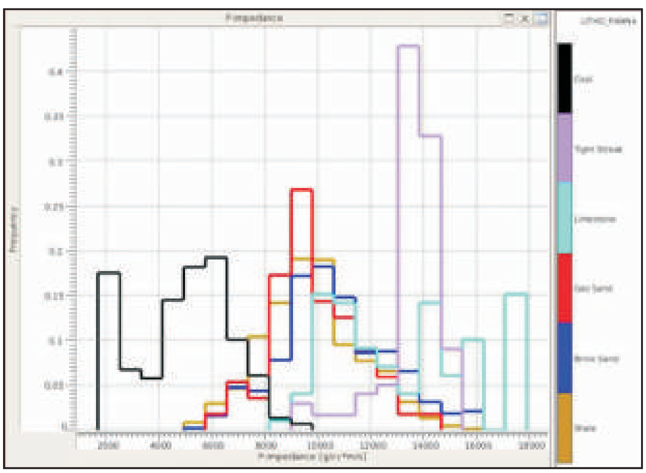

Fig. 4: P-Impedance histogram for identified litho-facies within Panna formation.

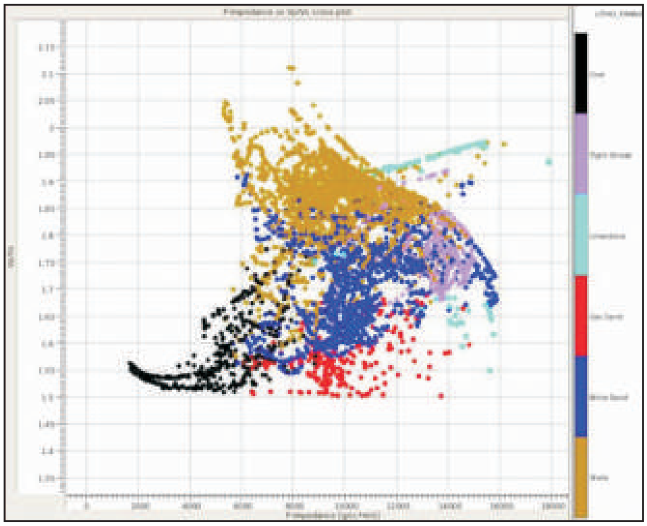

Fig. 5: P-impedance vs Vp/Vs cross-plot. No clear discrimation of gas bearing sands are possible.

Multi-stack Inversion

Angle gather data within the study area indicated that the maximum angle data available at Panna formation level is 32°. To extract shear impedance response, five angle-stacks viz. 5°-12°, 10°-17°, 15°-22°, 20°-27° and 25°-32° (Fig. 6) have been generated.

Multi-stack inversion from five angle stacks is carried out to generate P-impedance and Vp/Vs volumes. This was preceded by Well-to-Seismic tie (Fig. 7) at all the well locations and wavelet extraction. Wavelet is extracted for all the five angle stacks (Fig. 8). Low frequency model for P-

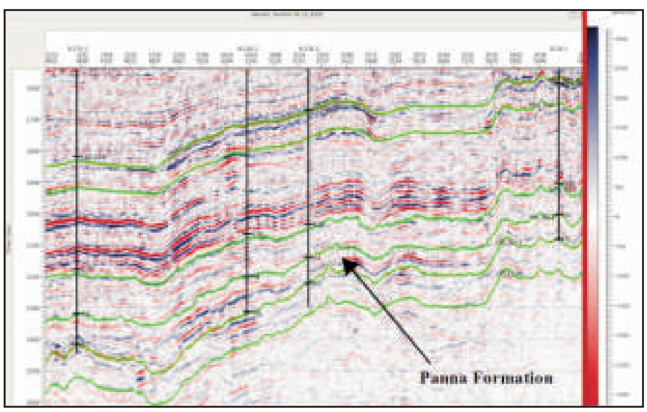

Fig. 6: Seismic section (Angle stack: 5o-12o) through arbitrary line passing through wells

impedance and Vp/Vs are also generated from the rock physics modeled logs. Using all the partial stacks (Angle stacks) and corresponding wavelets as input along with the low frequency models, constrained sparse spike simultaneous angle dependent inversion is run to generate the elastic parameter volumes (Fig. 9).

Comparison of inverted results with actual well logs (filtered to seismic band) show reasonably good match between them confirming the validity of the inversion outputs.

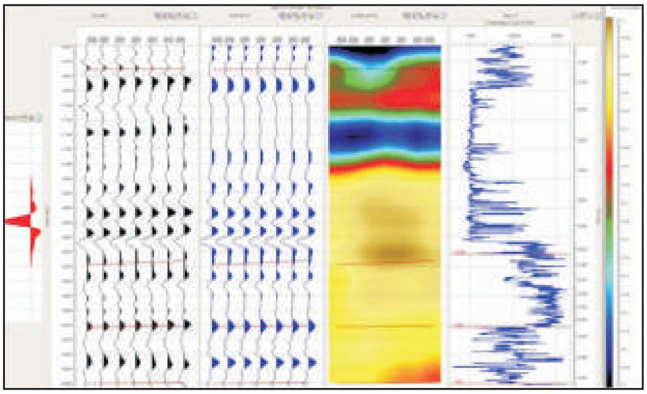

Fig. 7: Well-to-seismic tie of Well-E showing very good correlation in the zone of interest.

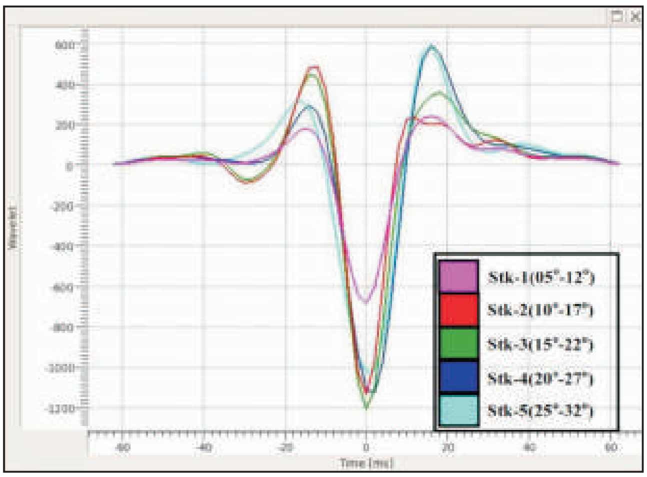

Fig. 8: Estimated composite wavelets for all five stacks.

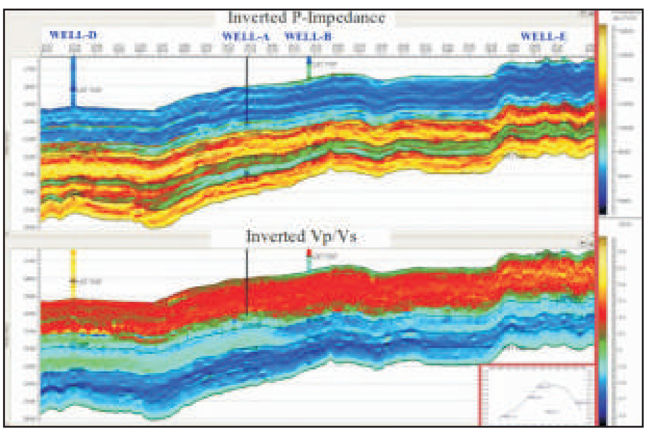

Fig. 9: Inverted P-Impedace and Vp/Vs section through arbitrary line passing through wells

Litho-facies probability volumes

The following workflow has been adopted to estimate litho-facies probability volumes from the result of deterministic multi-stack inversion.

- Cross-plot of P-impedance and Vp/Vs well logs of all five wells colour coded by litho-facies is generated.
- A joint (2D) normal probability density functions (pdfs) are fitted for each litho-facies. Each pdf determines the probability that a particular combination of P-impedance and Vp/Vs ratio represents that litho-facies (Fig. 10).
- The estimation of prior probability i.e. relative proportions of each litho-facies expected within panna formation is calculated by making histogram of lithofacies logs from the wells (Fig. 11).
- Finally, the joint pdfs of litho-facies and the estimated prior probabilities (relative proportions of litho-facies) are combined within a Bayesian inference framework to

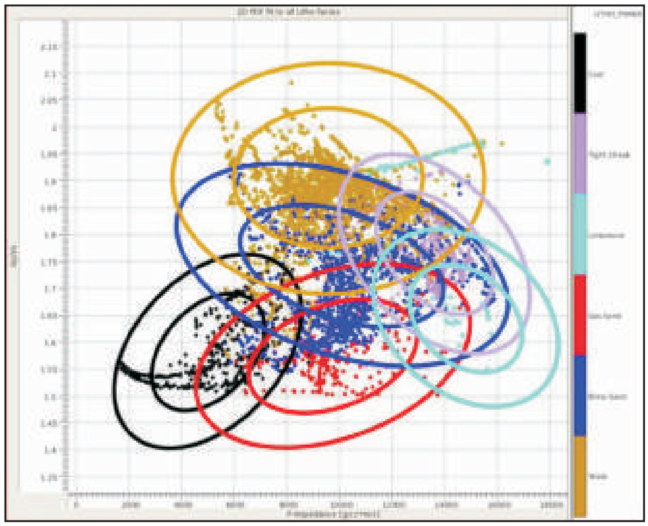

Fig.10: 2D normal probability distribution functions (pdfs) fitted to all identified litho-types within Panna formation in P-impedance vs Vp/Vs cross-plot

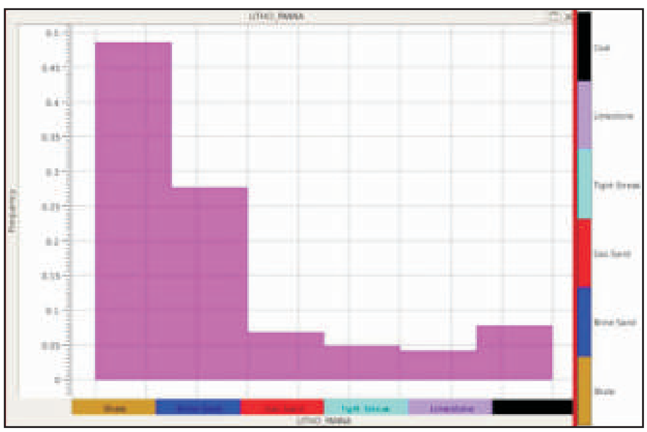

Fig. 11: Histogram of litho-facies proportions within Panna formation derived from wells in the study area

generate litho-facies probability volumes from the inverted P-impedance and Vp/Vs volumes.

Extraction of Geo-body

The probable gas charged geo-body within Panna formation has been extracted from litho-facies probability volume. The disposition of geo-body in 3D space is shown in Fig. 12. The geo-body projected on map has an areal extent of around 8 km^2 (Fig. 13). The alignment of the geobody with south-west trending lows of Panna formation is probably an important geological element in view of the existing petroleum system.

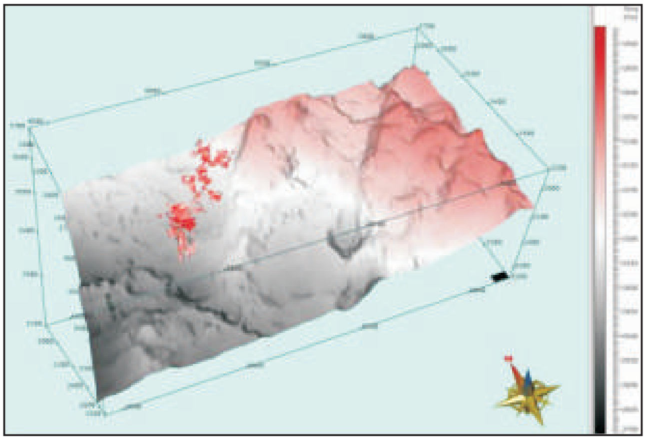

Fig. 12: Disposition of probable gas charged geo-bodies over basement top in 3D space

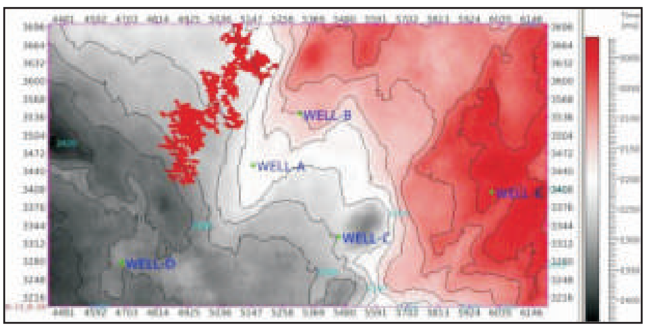

Fig. 13: Map view of probable gas charged geo-body superimposed on Panna top horizon

Conclusions

Sizeable probable gas charged geo-body has been extracted in the study area. The geo-body appears to be associated with south-west trending lows of Panna formation and probably charged due to sand pinch outs and lateral seals. The results of the study show that the area has good exploration/development potential.

Probabilistic approach has been adopted for the discrimination of gas charged geo-bodies due to overlap in various litho-facies type in P-impedanceVp/Vs domain. The probabilistic approach is always associated with certain degrees of uncertainties.

The estimated prior probabilities (litho-facies proportions) may not be true representative of the whole area. Since, posterior probability is dependent on prior probability, any error in prior will be mapped in the final outcome.

Inherent rock physics uncertainties because of various reasons should also be considered while firming up any prospect. Moreover, regular interpretation work needs to be combined with this study before finalizing the drillable location.

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The views expressed in this paper are solely those of the authors and need not necessarily be that of ONGC.

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