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An Insight into the Prospects of Low Resistive Complex Panna Pay Sands Through High-Tech Logs and Core data, Heera Field - An Electrofacies Based Approach

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Abstract

This study pertains to Panna Formation of Heera Field, located in western offshore basin of India. Unlike other prolific carbonate reservoirs in this basin, this reservoir is clastic in nature with complex petrophysical characteristics. As a consequence at places it is difficult to identify the reservoir facies and hence productive hydrocarbon bearing layers are missed. The conventional approach of identifying the reservoir quality from logs does not apply in this reservoir due to complexity involved. This challenge is addressed by adopting an innovative approach using conventional logs, High-tech logs, PLT along with production and core data.

In this study high-resolution synthetic resistivity curves (SRES) were generated and used to reveal and establish the presence of thinly bedded nature of Panna clastics, validating with core data. Broadly, three types of electrofacies have been identified i.e. Massive sand, Massive shale and Thinly bedded electrofacies. Massive sand & Massive shale electrofacies consist of dominant sand & shale lithology without laminations respectively.

However, thinly bedded electrofacies, based on sand counts have been further subdivided into Sand Rich, Moderate and Shale Rich electrofacies. The Sand Rich electrofacies consists of thin sand/shale interbeds with high sand counts. This type of facies can be interpreted by set of conventional logs because shale interbeds are very few in numbers. Whereas Moderate and Shale Rich electrofacies contain lesser numbers of sand inter beds embedded within shale and therefore has larger adverse effect on conventional logs (due to lower vertical resolution). As a consequence these electro-facies depict more shaly behavior and the presence of thin sand inter-beds are nearly ignored and therefore productive thin bedded reservoirs remains unrevealed. This challenge is met by integration of conventional logs with high resolution synthetic resistivity curves generated by FMI data. This approach led to identification of Shale Rich & Moderate type of electro-facies reservoir, which may otherwise hide the productive zones. The findings of the study were validated and firmed up using CMR, PLT core and production data.

Based on this approach, new promising zones were identified for perforation and re-testing. One such recommended promising zone has already contributed in significant oil gain and testing of remaining zones is likely to accrete reserves and enhance oil production.

Introduction

Heera field lies 140 km south east of Mumbai High field (Figure 1). The average water depth is 50 m. The field proved to be second largest hydrocarbon find of ONGC. Hydrocarbons were established in Heera, Mukta, Bassein, Panna and Basement formations. Free gas has been encountered in shallow Miocene Bandra formation. The field was put on production from Oct 1984.

General stratigraphy

The Panna Formation (Basal Clastic) overlies the Basement (H5). The top of the Panna Formation is an erosional unconformity and seismically marked as H4 marker. The onset of Panna sedimentation is marked by the deposition of trap wash and sediments derived from granite erosion during Paleocene. This pay is hydrocarbon bearing in Heera and South Heera Fields but commercially exploited in HB, HY, HSA, HZ and HV platform areas. Panna Formation is overlain by Bassein, Mukta, Bombay, Bandra and Chinchini Formations. The general stratigraphy is shown in Figure 2.

Methodology and Discussion

Revealing presence of thin beds using FMI data and validation by core data

As per conventional log data perforated interval 1502-1519 m in well No. A (Fig. 3) shows low Resistivity (<10 ohm m), high Gamma Ray(except at the bottom part) & high Rhob-Phin separation, indicating towards non-productive nature (shaly) of this reservoir. However on testing this interval flowed oil @ 278 bopd .To understand this contradiction with the perspective of thin bed, synthetic resistivity curve (generated thru FMI data) have been plotted in linear scale (Fig. 3, track 4). A shale resistivity cut off distinguishes low resistivity shale layer from productive high resistivity sand/limestone layers. Further, due to the high resolution (3 cm) of synthetic resistivity (also called shallow FMI resistivity) curve it is able to reveal the presence of hidden thin beds. These thin beds are not seen by the conventional logs due to their poor vertical resolution.

This brings out the thinly bedded characteristics of the Panna formation and such behaviour have been observed in many other wells in the field. This inference is very well supported by the available core data of well No. B (Figs 4, 5 & 6).

Identification of electro-facies with in Panna Formation

Based on the generated synthetic curves (SRES) three type of electrofacies have been identified i.e. Massive sand electrofacies, Massive shale electrofacies and Thinly bedded electrofacies.

Massive sand & Massive shale electrofacies consist of dominant sand & shale lithology without laminations. The petrophysical interpretation of such electrofacies is straightforward, even with conventional logs.

Based on sand counts, Thinly bedded electrofacies have been further subdivided into Sand Rich, Moderate and Shale Rich electrofacies (Fig. 7).

Sand Rich electrofacies consists of thin sand/shale interbeds with high sand counts. This type of facies is easier to be interpreted on conventional logs because shale interbeds are very few in numbers and therefore, suppression of resistivity value is not significant and porosity & Gamma Ray logs are also not much effected.

Moderate and Shale Rich electrofacies are characterized by lesser numbers of sand inter beds embedded within shale and therefore has larger adverse effect on conventional logs (due to lower vertical resolution). As a consequence these electro-facies depict more shaly behavior and the presence of thin sand inter-beds are nearly ignored and therefore may mask the productive thin bedded reservoirs. These type of electrofacies are difficult to be identified with conventional logs only.

This problem was resolved to some extent by integration of conventional logs with high resolution synthetic resistivity curves generated by FMI data. This process led to the identification of Shale Rich & Moderate type of electro-facies reservoir, which may otherwise hide the productive zones. Further integration was done with CMR, PLT and production data to firm up the findings.

Identification of promising zones

Based on this integrated approach many new promising zones were identified and recommended for perforation and re-testing. Some of these promising zones consisting of Sand Rich, Moderate and Shale Rich electrofacies are shown in Fig. No. 8, 9, 10 & 11.

Fig. No. 8 shows one of the recommended zone for re-perforation (Interval 1489-1495 m). Actually this zone shows a number of thin sand beds imbedded within shale (SRES curve) and due to this petrophysical properties are subdued. This zone on re-perforation gave an oil gain @ 50 bopd.

Conclusions and Recommendations

High resolution Synthetic Resistivity Curves, clearly brings out the thinly bedded characteristics of the Panna Formation and is well supported by the available core data.

Based on the generated Synthetic Resistivity Curves three types of electrofacies have been identified i.e. Massive sand, Massive shale and Thinly bedded electrofacies.

Thinly bedded electrofacies consists of thin sand/ shale interbeds. Because of the poor vertical resolution of the conventional logs these thinly bedded hydrocarbon bearings layers often yield an average lower Resistivity value along with average porosity and Gamma Ray value, therefore sometimes masking the hydrocarbon productive layers.

This problem was resolved by integration of conventional logs with Synthetic Resistivity Curves generated by FMI data. Further integration was also done with CMR, PLT and production data to firm up the findings.

Based on this approach, many new promising zones were identified for perforation and re-testing.
and are likely to accrete the reserves and increase the production of the field. One of the recommended promising zone has already contributed in significant oil gain.

References

1. Sedimentological and petrophysical studies on conventional cores of well HI-9 (Heera Structure), RGL, Panvel, Navi Mumbai, 2012 (Unpublished Report)

2. Quantitative mineralogical analysis of CC-1 & CC-2 cores of well HZ-9, RGL, Panvel, Navi Mumbai, 2012 (Unpublished Report)

3. Petrophysical Evaluation of Hydrocarbon Pore-Thickness in Thinly Bedded Clastic Reservoirs, AAPG Archie Series No.1 by Q.R. Passey et.al., 2005.

4. Dipmeter and Borehole Image Log Technology, AAPG Memoir 92, Edited by M. Poppelreiter et.al., 2010.

Acknowledgement

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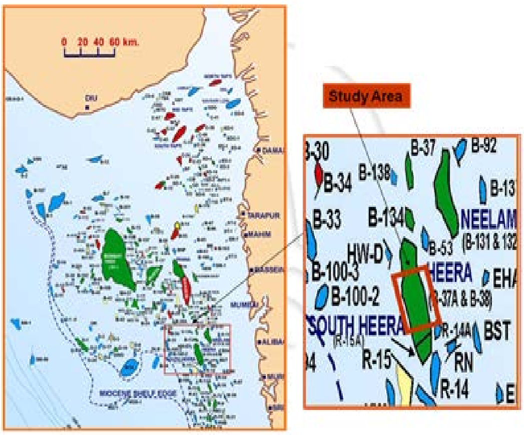
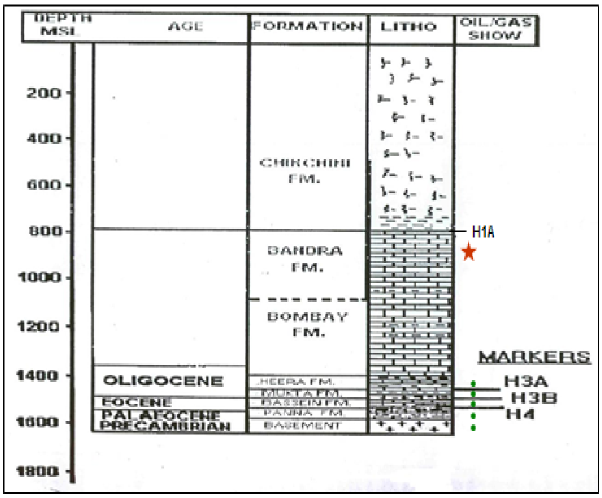
Location Map of Heera Field

Fig-1



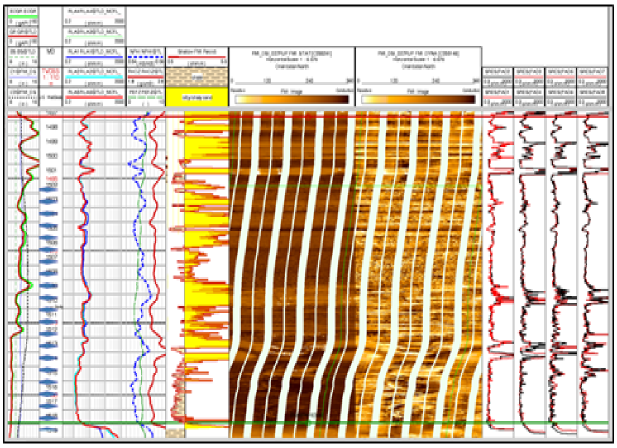
Stratigraphy of Heera Field

Fig-2



FMI Image & SRES Array Revealing Thinly Bedded Nature of Panna Fm (Well-A)

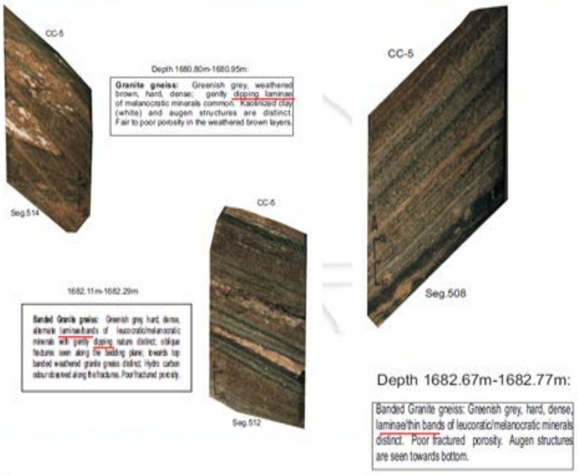
Fig-3



1502-19 m:Flowed oil @ 278 bopd

Lithofacies and Diagenetic Imprints of CC-5 (Well-B)

Fig-4



Depth 1680.80m-1680.95m:

Granite gneiss: Greenish grey, weathered brown, hard, dense; gently dipping laminae of melanocratic minerals common. Kaolinized clay (white) and augen structures are distinct. Fair to poor porosity in the weathered brown layers.

1682.11m-1682.29m

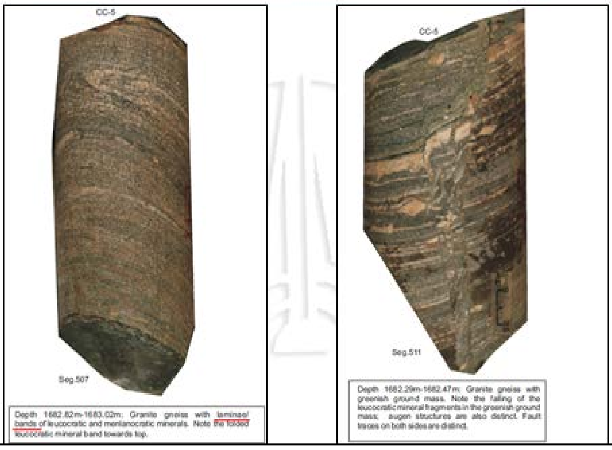
Banded Granite gneiss: Greenish grey hard, dense, alternate laminae/bands of leucocratic/melanocratic minerals with gently dipping nature distinct; oblique fractures seen along the bedding plane; towards top banded weathered granite gneiss distinct. Hydro carbon odour observed along the fractures. Poor fractured porosity.

Depth 1682.67m-1682.77m:

Banded Granite gneiss: Greenish grey, hard, dense, laminae/thin bands of leucocratic/melanocratic minerals distinct. Poor fractured porosity. Augen structures are seen towards bottom.

Special Core Segments Studies of CC-5 (Well-B)

Fig-5

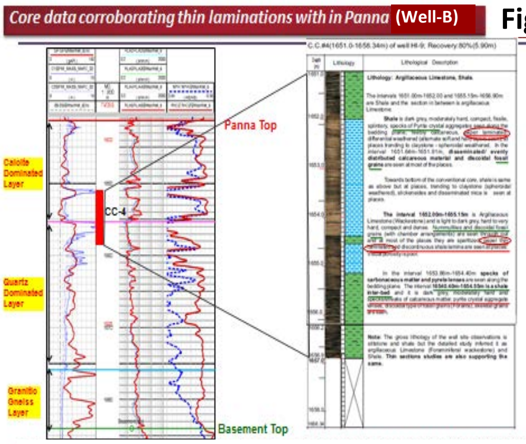


Depth 1682.82m-1683.02m: Granite gneiss with laminae/bands of leucocratic and menlanocratic minerals. Note the folded leucocratic mineral band towards top.

Depth 1682.29m-1682.47m: Granite gneiss with greenish ground mass. Note the falling of the leucocratic mineral fragments in the greenish ground mass; augen structures are also distinct. Fault traces on both sides are disting.

Core data corroborating thin laminations with in Panna (Well-B)

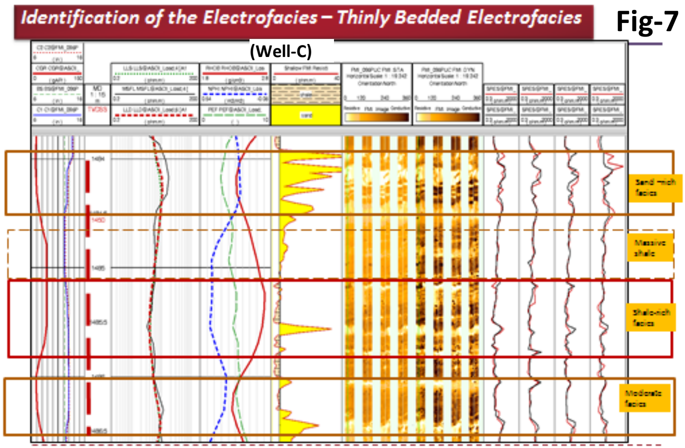
Fig-6



Identification of the Electrofacies – Thinly Bedded Electrofacies

Fig-7

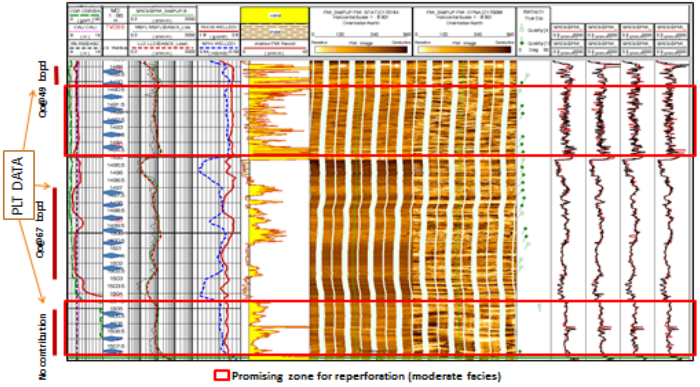
(Well-C)



26 Qo@799 bopd, completed in Panna

Promising Zones for Reperforation (Well-D)

Fig-8



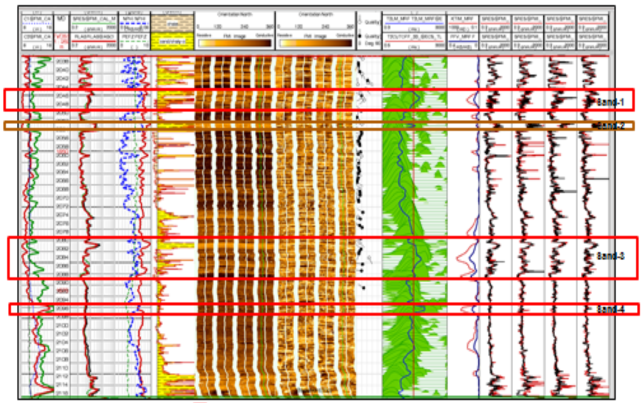
🟥 Promising zone for reperforation (moderate facies)

Reperforated, interval 1489-1495 m, after the study: oil gain =50bopd

No PLT done after reperforation job

Integration wiith CMR & Identification of Promising Zones (Well-E)

Fig-9

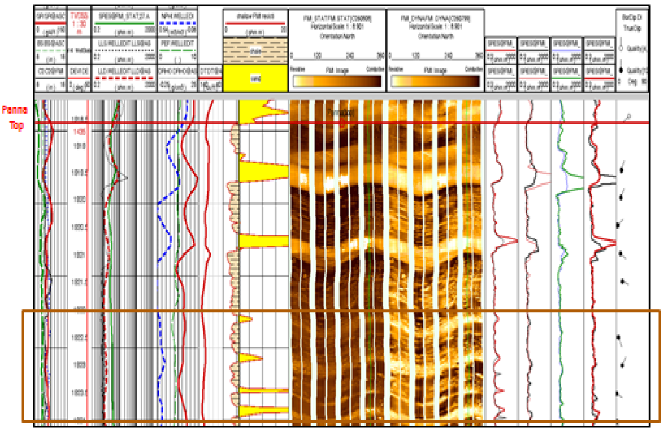


☐ Promising zone (moderate facies)

☐ Promising zone (sand-rich facies)

Identification of Promising Zones (Well-F)

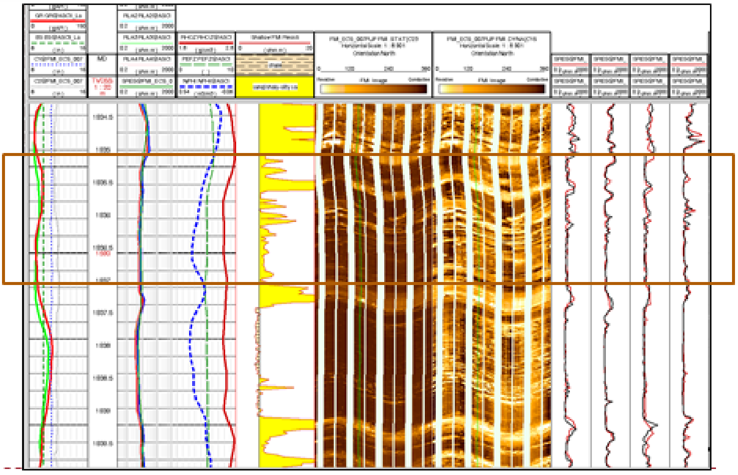
Fig-10



☐ Promising zone (shale-rich facies)

Identification of Promising Zones (Well-G)

Fig-11



☐ Promising zone (shale-rich facies)