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Identification of Low Resistivity Pays in Tapti Daman Field: An Integrated Petrophysical Evaluation Using Image and Spectroscopy Log

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Summary

Tapti Daman field hosts prolific gas in Mumbai Offshore. However, identifying the low resistivity pay sand from the conventional openhole log poses immense challenges. High resolution image log proved to extremely helpful in addressing this issue. Image texture clearly reveals presence of thin beds in the formation. Spectroscopy log indicates presence of clay and pyrite within the reservoir, which most likely the cause of anomalous resistivity profile with in pay zones. Presence of montmorillonite and chlorite clay detected in the reservoir zone, from natural gamma ray cross plot. An integrated approach was taken to identify the causes of ambiguous resistivity in the reservoirs. A detail volumetric analysis was performed to delineate the reservoir sands, based on the open hole log and high resolution image logs.

***Keywords**: Low Resistivity Pay, Thin Beds, Conductive Minerals, Image log, Spectroscopy Log*

Introduction

Mahuva and Daman formations are the most important gas producers in Tapti Daman field. The field is producing from different blocky and finning up sand bodies of Upper Oligocene to Miocene sand. The hydrocarbon bearing sand is elusive in nature due to their varying resistivity profile. In some place the resistivity value exhibits fair range between 40-100 ohm.m which along with density neutron profile indicates hydrocarbon bearing zone .However, majority of the zone with in reservoir represents quite a low resistivity values ranges between 0.5-10 ohm.m.

The present study focused on the integrated approach for determining the reasons for low resistivity within the pay sands. High resolution image log and spectroscopy logs were used to detect the presence of shale laminae and conductive minerals in the reservoir. The finding from the high resolution logs were then subsequently incorporated into volumetric analysis. The result shows fairly good match with the production data from the adjacent well.

Background Geology

Tapti-Daman fields lie within the Surat Depression, a broad depocenter of Tertiary age clasitic sedimentation in the North-eastern portion of the Bombay Offshore Basin. The Tapti-Daman block (fig.1) is a predominantly clastic sub-basin of the Bombay Offshore basin. The basin is moderately well explored up to the Oligocene level. Most of the discoveries are predominantly gas. The Tapti – Daman block consists of Tertiary clastics from Palaeocene to Recent. The depositional lows contain in excess of 5000m of sediments.

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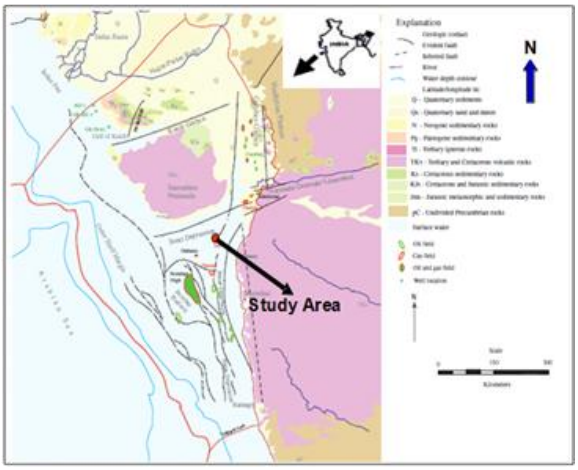


Figure 1: Location of the study area (Tapti-Daman)

AGE	Formation	Lithology
Mid Miocene to Recent	Tapti & Chinchini	Claystone, Shale
Lr Miocene	Mahim	Shale & siltstone
Up Oligocene	Daman	Shale & siltstone
Lr Oligocene	Mahuva	Shale, siltstone & sandstone
Mid-Up Eocene	Diu	Shale with limestone streak
	Belapur	
Paleocene –Lr Eocene	Panna	Shale with sandstone streaks
Cretaceous	Deccan Trap	Basalt

Figure 2: General stratigraphy of Tapti Daman

The Cenozoic basin is floored by Late Cretaceous to Palaeocene Deccan Trap Basalts which erupted as a consequence of the rifting of the Indian plate in the Late Jurassic-Early Cretaceous time. The lower part of the Panna Formation filled the emerging lows with clastics and trap derived detritus during the Palaeocene times. The Middle Eocene Belapur and Diu formations are predominantly marine shale with minor limestone and occasional thin sandstone bands. The Lower Oligocene is represented by the Mahuva Formation (fig.2) which can be subdivided into a lower shale unit and an upper unit with lenticular sands and thin limestone bands. This formation is a major target for exploration and a number of gas and occasionally oil bearing plays have been probed. The Upper Oligocene is represented by the Daman formation (Zutshi et.al,1993) which has been deposited in a delta front environment. The Miocene basal sands are fluviatile sands in the northern part of the basin and are the shallowest targets.

Methodology

A unique methodology was very much required to establish the low resistivity pay sands in the Tapti Daman field. Volumetric analysis using the integrated log results is the key to understand the ambiguous resistivity profile in the well bore.

Total production from the clastic reservoir is often higher than predicted from the conventional openhole log. Therefore, a refinement of the existing volumetric model was needed to establish the pay zones in the reservoir. Detail image and spectroscopy log processing was performed to identify different elements for better volumetric analysis.

Borehole image provides high resolution electrical image of the formation around the borehole from multiple electrode measurement. Image log was dynamically normalized to enhance the colour resolution. High resolution image log was used to identify different geological and mineralogical aspects of the formation. Spectrolith results were utilized to calculate dry weight mineralogy based on element capture spectroscopy. The Spectrolith approach uses a technique whereby the elements silicon, calcium, iron and sulfur can be used to produce as accurate an estimation of clay, pyrite, siderite etc. A general algorithm for predicting minerals from these different elements is at the heart of this technique.

Mud cutting data was also corroborated with the existing high resolution data set to validate the mineralogical model. All the information derived from the high resolution logs were integrated to get the best possible picture for pay zone determination.

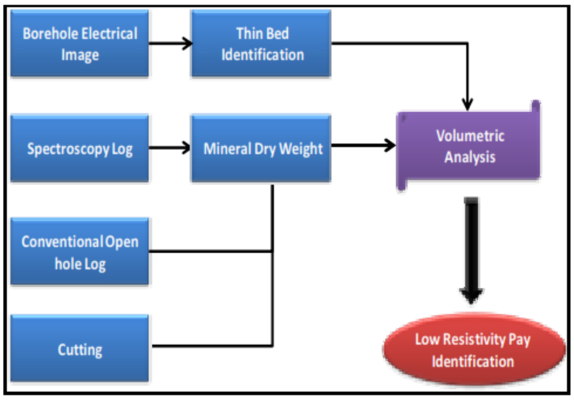


Figure 3: Integrated Workflow

Results

Four major sand units (namely Sand-A, Sand-B, Sand-C & Sand-D) were identified as based on the conventional openhole log. Spectroscopy results indicate presence of pyrite and clay in the three of the sand units (Sand-B, Sand-C & Sand-D; fig.5); however, very low amount of pyrite and clay detected in Sand-A (fig.4).

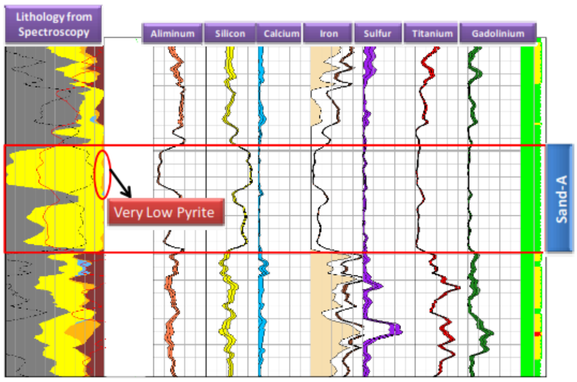
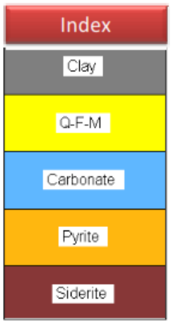


Figure 4: Spectroscopy result for Sand-A



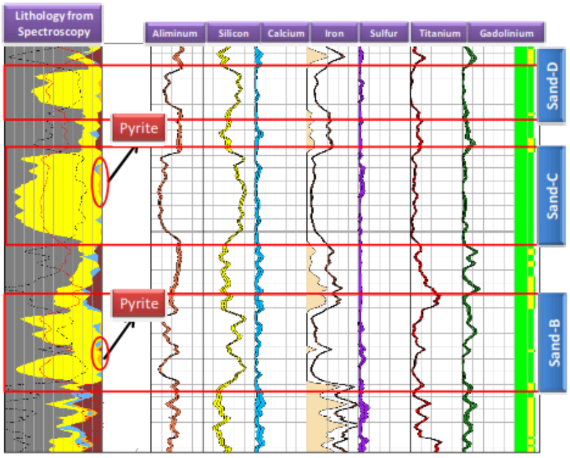


Figure 5: Spectroscopy result for Sand-B, Sand-C & Sand-D

Clay lamination (fig.6) and conductive mineral detected on the borehole image in Sand-B. Spectroscopy result validates the conductive mineral is pyrite. However, only a few clay lamination observed in Sand-A (fig.7).

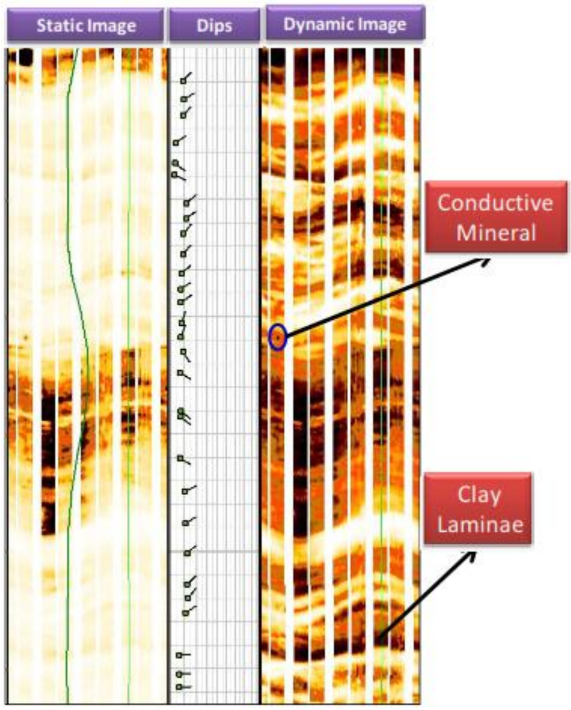


Figure 6: Image example showing clay layer and conductive mineral in Sand-B

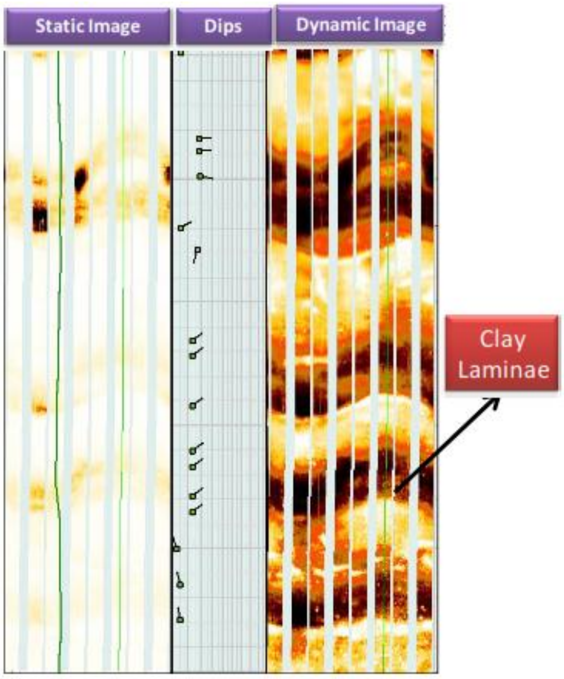


Figure 7: Image example showing clay layer and conductive minerals in Sand-A

An approach was taken to understand the clay types in the reservoir sand. Potassium (K) and Thorium (Th) cross plot from natural gamma ray log indicates presence of montmorillonite and chlorite clay in sand units (fig.7 & fig.8). Clay typing provides very good idea about the different clay distribution in the reservoir and thus indicates their role in controlling the reservoir property.

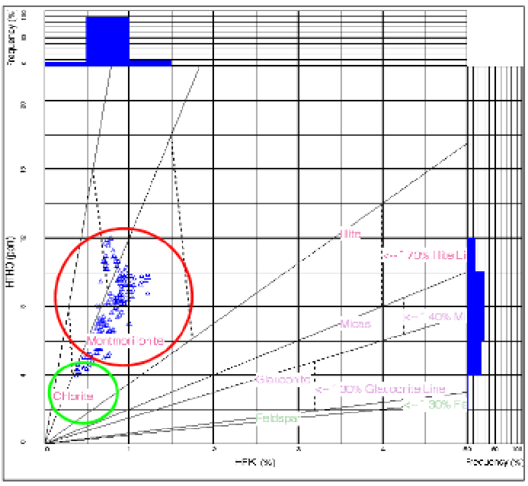


Figure 8: Potassium (K) versus Thorium (Th) cross plot showing presence of montmorillonite and chlorite in Sand-C

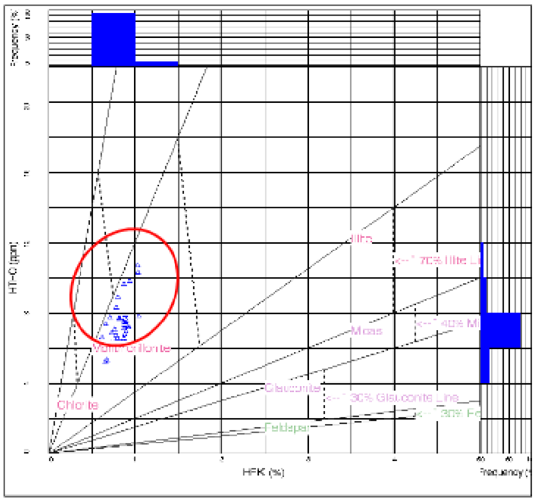


Figure 9: Potassium (K) versus Thorium (Th) cross plot showing presence of montmorillonite in Sand-D

Volumetric analysis was performed based on the conventional open whole logs and the high resolution logs.. Advanced volumetric result reveals absence of pyrite in Sand-A (fig. 10), which shows high resistivity (100 ohm.m) profile. Whereas Sand-B, Sand-C and Sand-D (fig.11) shows low resistivity profile (6-10 ohm.m), at the same time presence of pyrite is detected on the volumetric result. All the sand unit shows good hydrocarbon potential.

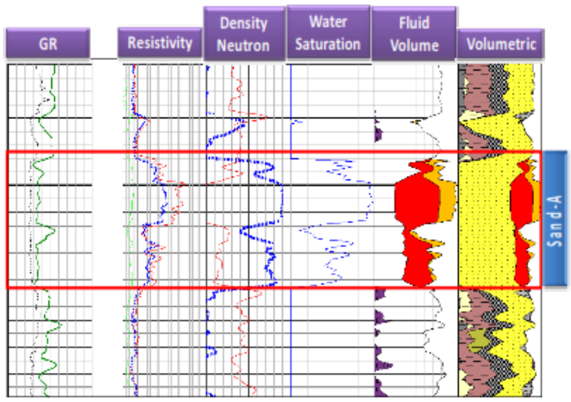


Figure 10: Volumetric result of Sand-A

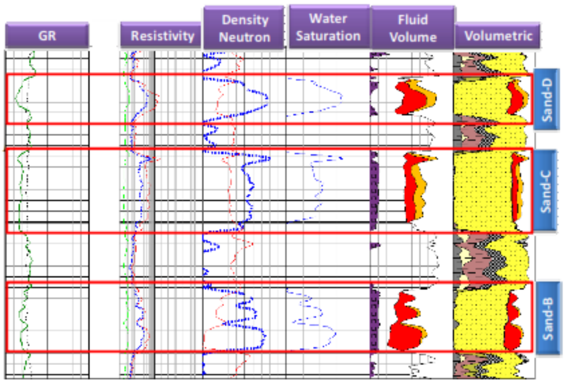
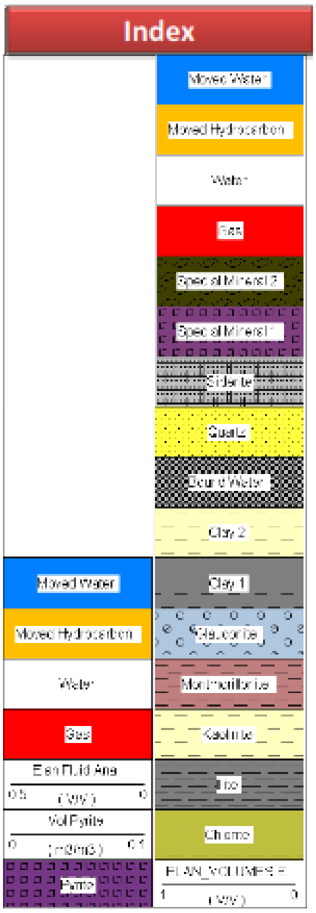


Figure 11: Volumetric result of Sand-B, Sand-C & sand-D



Conclusion

Openhole log alone is not distinctive for low resistivity pay characterization.

Image log texture is immensely helpful in finding thin beds and conductive mineral in the reservoir.

Spectrolith log provides very good idea about the elemental assemblage which leads to the estimation of mineral distribution within the pay zone.

Presence of montmorillonite clay along with pyrite in the reservoir most probably has helped to reduce the reservoir resistivity to a great extent; due to its high cation exchange capacity.

Integrated log analysis along with the volumetric results clearly depicts all the pay zones in the formation.

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