

## Value addition through Hi-Tech Logs and Realistic Formation Evaluation towards the discovery of hydrocarbon in Bengal Basin.

Abul Basar\*, Ramesh Ghosh, Anushree Pandit, Rahul Singh, Dilip Ghosh; ONGC, Kolkata  
\*basar\_ab@ymail.com

### Keywords

Value addition, Hydrocarbon, discovery, multi-mineral, processing, Well Logs, Hi-Tech.

### Summary

Finding hydrocarbon from well logs is extremely difficult when log signature exhibits vague and complex in nature. Recently, in Bengal On-land Basin, oil and gas has been discovered in a well whose log characters appeared to be not promising. There was no hydrocarbon show during drilling and not so encouraging basic log motif as well. Despite this, careful and optimistic log evaluation coupled with some Hi-Tech logs, e.g., XMAC, RCI and STAR helped in finding hydrocarbon in this well. All the recorded log data were processed analyzed and interpreted to predict and recommend the hydrocarbon bearing interval. The well was tested with TCP perforation and produced gas in Object-I @ 1.08 lakh m<sup>3</sup>/day with 8 mm bean size whereas the object-II produced oil @ 10 m<sup>3</sup>/day with 6 mm bean. This paper highlights the overall log interpretation strategy integrated with few Hi-Tech tools such as RCI, XMAC and STAR which directly contributed towards the discovery of hydrocarbon in Bengal Basin.

### Introduction

Exploration efforts in Bengal Basin are not new though it has not seen any success for around six decades despite heavy sustained investment in terms of money, technology and time. A very recently drilled well in Bengal On-land Basin showed a ray of hope which produced oil and gas in considerable rate thereby leading to discovery of hydrocarbon in Bengal Basin after six decades of exploratory efforts.

In the present well, (Well-X) no appreciable hydrocarbon show was reported during drilling. Basic open hole log motif was not very encouraging either.

### Methodology

### 1. Basic log study:

First, basic log suits e.g., Resistivity, density, porosity etc., have been carefully studied and analyzed in order to find interesting interval, if any, from hydrocarbon point of view. But overall the basic log did not give any promising indication of hydrocarbon. However, at least two of the layers captured imagination because of their depositional set up - thick cleaner water bearing sand layers at bottom overlain by silty sand layers having moderate resistivity/ porosity/ permeability with thick tight shale layers as cap. The low contrast between silty/shaly and shale layers in terms of density/porosity and reverse order in resistivity made them difficult to be identified. Though, gamma ray and neutron porosity logs gave clue that they are likely to be silty layers, SP log indicated moderate permeability and above all processed full wave sonic log data indicated the possibility of presence of hydrocarbon.

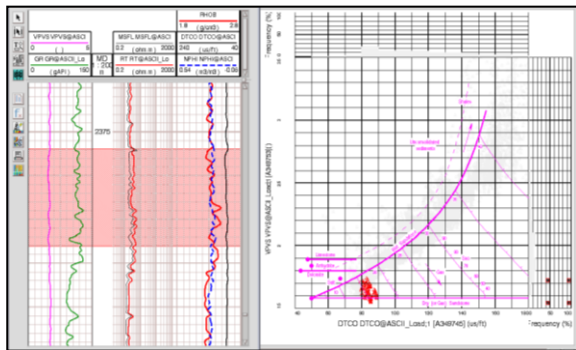


Figure-1: Location map of Well-X.

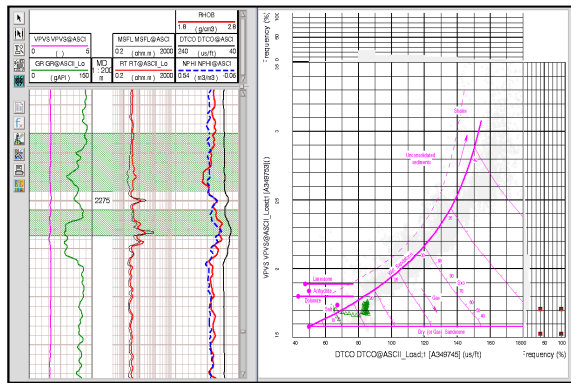
**Value addition through Hi-Tech Logs and Realistic Formation Evaluation towards the discovery of hydrocarbon in Bengal Basin.**

**2. Shear-Sonic (XMAC) log study:**

The shear Sonic ((XMAC) log data was analyzed to identify light oil and gas bearing reservoirs. For gas, Vp/Vs value observed to be around 1.58-1.6 or less and for water and shales it varies with degree of compaction and effective stress besides other factors. Vp/Vs versus DTC cross plots were generated and it was found that the intervals X377-88 m and X268-74 m & X276-78.5 m are interesting from hydrocarbon point of view. For the interval XX77-88 m all the points fall on the line having Vp/Vs value of about 1.58-1.6, indicating the presence of gas. Value of Vp/Vs ratio little higher than 1.6 indicates the presence of light oil, which may be the case for the intervals XX68-74 m & XX76-78.5 m.



**Figure-2:** Vp/Vs Vs. DTC cross plot for interval X377-88m.



**Fig.-3:** Vp/Vs Vs. DTC cross plot for interval X268-74m & X276-78.5m.

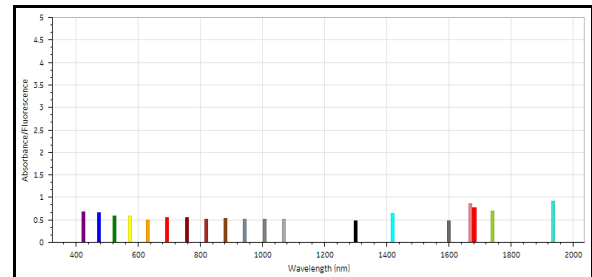
**3. Formation resistivity Imager (STAR) study:**

Formation resistivity image log (STAR) has been used to identify thin sand-shale lamination, silty-sand and bedding with gentle dip, which is beyond the resolution of conventional resistivity log.

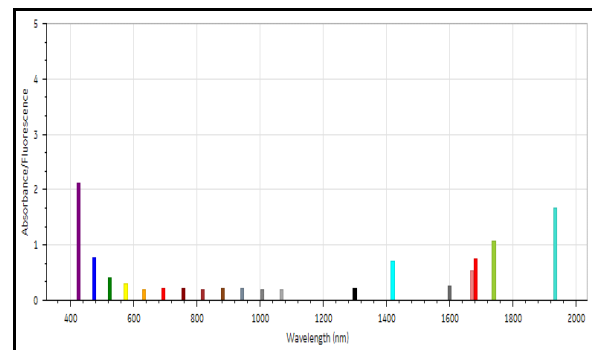
**4. RCI study:**

To prove the presence of hydrocarbon it was decided to record RCI log. Accordingly 14 pressure data, in situ fluid analysis for 4 depth points followed by 2 samples were collected from the interval 2200-2610 m. Presence of gas at X387.2 m and presence of oil at X272 m were confirmed through in situ fluid analysis and physical testing of collected samples at the laboratory.

The optical absorbance spectrum at X387.2 m recorded during sampling indicates low absorbance across the first 12 channels indicating a transparent fluid. There is a minimal presence of liquid hydrocarbon and water since Channel 14-13 ~0.15 and Channel 16-15 ~0.2 respectively. Hence it can be confirmed that formation fluid is gas. There is a prominent presence of methane which further confirms the presence of gas (Fig.4).



**Fig.-4:** Optical Absorbance Spectrum at X387.2m.



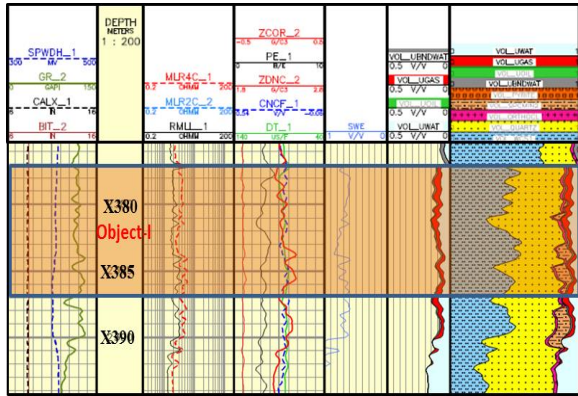
**Fig.-5:** Optical Absorbance Spectrum at X272m.

**Value addition through Hi-Tech Logs and Realistic Formation Evaluation towards the discovery of hydrocarbon in Bengal Basin.**

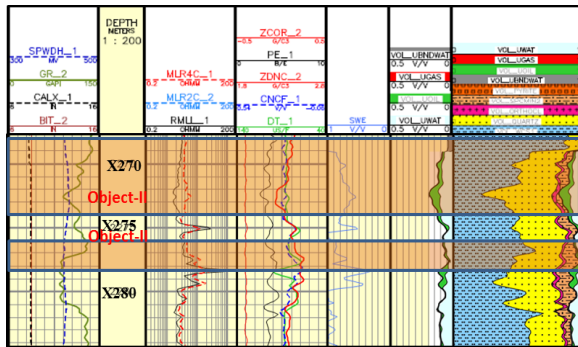
The optical absorbance spectrum at X272m (Fig.-5) shows a dropping trend across the first 12 channels which typically corresponds to an oil spectrum. The optical absorbance at the time of sampling confirms presence of formation oil (Channel 16-15~0.8) with some contamination from WBM filtrate (Channel 14-13~0.5).

**5. Multiminerall Processing:**

A suitable multi-mineral petrophysical model has been developed that best suits the log behavior, formation testing data. Processing result showed that Object-I was shaly-silty sand in nature and interpreted as gas bearing. The average effective porosity and water saturation are 15% and 64% respectively. GWC can be taken at X390 m.



**Fig.-6:** Elan processed output (Obj-I).



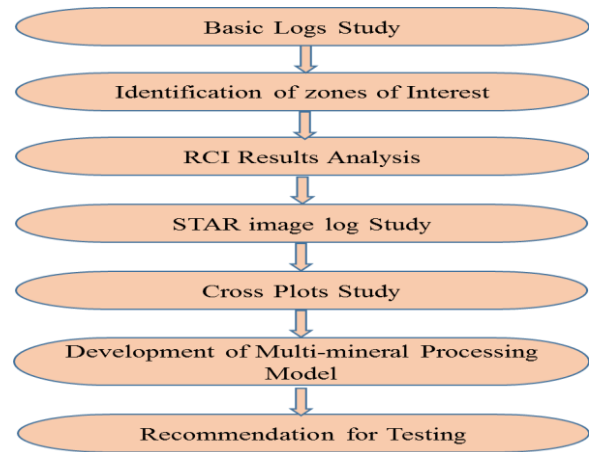
**Fig.-6:** Elan processed output (Obj-II).

The multi-mineral processing result for the interval X269-81 m shows that the interval has effective porosity in the range of 7-17% and water saturation of about 64%. 1565 - 2280 m were studied in petrophysical and sedimentological laboratories to

Petrophysical Lab studies on core samples revealed the mineralogical assemblage, porosity, permeability, grain density etc. The dominant minerals found to be present in the core samples are Kaolinite, Illite, Feldspar and little trace of Pyrite and Quartz as matrix. Porosity derived from lab has been found to be in the range of 4% to 13%.

Two objects in the intervals X377-88 m (Object-I) and X268-73 m (Object-II) were recommended for testing. Object- I flowed gas @ 1.05 lakh m<sup>3</sup>/day with 8 mm bean during testing through TCP and Object-II flowed oil @ 10-20 m<sup>3</sup>/day with minor gas & less than 10% water cut. This lead to the commercial hydrocarbon discovery in on-land Bengal Basin, for the first time in its six decades of exploration history.

The entire methodology has been depicted below:



**Fig.-7:** Methodology of the study

**Conclusion**

Despite no hydrocarbon show during drilling and not so encouraging basic log motif, Hi-Tech log data such as XMAC, STAR and RCI have been of tremendous help in identifying hydrocarbon bearing layers both oil and gas in the well. Compressional and shear sonic data(XMAC) indicated the presence of gas and light oil; formation resistivity image log (STAR) helped in identifying thin sand-shale lamination, silty-sand and bedding with gentle dip in most of the image section, which is beyond the



## **Value addition through Hi-Tech Logs and Realistic Formation Evaluation towards the discovery of hydrocarbon in Bengal Basin.**

resolution of conventional resistivity log. But it is worth mentioning that the tool that proved the presence of hydrocarbon was RCI during in situ analysis and by collecting oil and gas samples from Object-1 and Object-2. So, induction of high-tech tool combined with realistic formation evaluation may lead to the new discovery as in the case of the present case.

### **Reference**

1. Stacy Lynn Reeder, Robert L. Kleinberg, Badarinadh Vissapragada, Malka Machlus, Michael M. Herron, Alan Burnham, and Pierre Allix., A Multimeasurement Core-Log Integration for Advanced Formation Evaluation of Oil Shale Formations: A Green River Formation Case Study.
2. Robert C.L. Klenner, Jason R. Braunberger, James A. Sorensen, Kurt E. Eylands, Alexander Azenkeng, Steven A. Smith, A Formation Evaluation of the Middle Bakken Member Using a Multimineral Petrophysical Approach.
3. Muhammad Nur Ali Akbar, Junita Trivianty Musu, An Extensive Petrophysical Evaluation for Determining Sweet Spot Intervals in the Ultra-Tight Organic-Rich Shale: A Case Study of the North Sumatra Basin, University of Miskolc, Hungary.
4. Pavel Kulyapin1, Tatiana F. Sokolova, A Case Study about Formation Evaluation and Rock Physics Modeling of the Bazhenov Shale.

### **Acknowledgements**

The authors express their sincere gratitude to Shri K.R. Durga Prasad, GGM-Basin Manager and Shri S,K das former ED-Basin manager for providing necessary infrastructure, continuous support and guidance.

Authors are grateful to Shri A. K. Ashta, Chief Logging Services, Mumbai, for his constant motivation.

Authors are grateful to Field Engineers and Scientists of M/s Baker Hughes for their hard work and supports towards these findings.

\*\*\*\*\*