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Author **S.S.Pabla , ONGC , India**

Co-Authors **Sanjeev Lakhera, Debashish Saha**

Technology-An aid to tackle challenges in Logistically and Geologically complex Reservoirs: A case study from Assam

Abstract:

This paper deals with the complications encountered in log data acquisition and challenges faced in evaluation of Pre-barail (Eocene) prospects in the fields of Assam Asset. Over last 45 years the main focus of development activities was on Tipams and Barails although hydrocarbon has been discovered in Basal sandstone of Lakwa in 1995 through exploratory well L-452. Now the focus has again shifted to deeper prospects (pre-barails) to explore alternative opportunities available in the matured fields. The discrete nature of the sands, mineralogical complexity, loss of porosities due to depth of burial and diagenetic processes make formation evaluation, reservoir characterisation and geological modelling a daunting task. The fact that drilling these sections takes considerably more time thereby exposing the formations to drilling fluids adds to evaluation uncertainties. For the same reasons, establishing HC potential during initial testing also becomes difficult and sometimes inconclusive.

Onland exploration in the Northeast is further mired by many logistic challenges in addition to the geological ones. The monsoon season is extended (June to October) and even pre-monsoon spells are sometimes long. Many of the well locations may fall in low lying areas and access to the sites becomes constrained.

This case study from Lakwa field depicts the success story of an exploratory well in deeper prospects which came on self despite facing severe well complications and logistic challenges during drilling and log data acquisition. Advance planning, meticulous workflow and diligent field study adopted by logging services during the course of drilling of this well made it possible to take the well to final completion and flowing stage. Every possible step was taken to make the evaluation possible and with efforts to make effective use of new state of art logging technologies available, this well started flowing on self in Upper Tura which otherwise is considered very tight.

Introduction:

Assam and Assam Arakan basin is a polyhistory basin situated in the North East India with distinct episodes of tectono-sedimentary evolution. It is essentially an amalgamated basin with phases of superposing tectonics presenting a complex picture. From depositional point of view the area of study is a shelf regime and whole pile of sediments rests over weathered metamorphic basement of Precambrian age. The sediments are of fluvial to marginal marine environment deposits. Total 14 pays are developed in the field from Middle Eocene to Pliocene. Pays at the stratigraphically top position are of Miocene to Pliocene age and are of fluvial origin comprising dominantly sandstone with clays with in it. These pays are followed by pays of late Eocene to Oligocene age and are Deltaic deposit comprising coal shale and sand sequences. The bottom most pays are of Middle to Lower Eocene age and deposition environment varies from open marine-Platformal to distal alluvial fan and braided river (Deshpande, et al. 1993). The field was discovered in 1963 and situated in shelf part of A & AA Basin. In this field majority of the reserves is calculated in Oligocene (Barails) and Miocene (Tipam) prospects. Handful of wells has been drilled for Pre-barails (Eocene) prospects and PS category reserves calculated.

The well L#X was directionally drilled up to depth of about 5000 m as an exploratory well in Lakwa field with the objective of exploring Kopili and Tura and deepened down to Basement. Drilling of the well was completed in five phases: 26", 17½", 12¼", 8½" and 6"sections. Several logging complications arose while logging in 8½" section of this well. The final logging in this section couldn't be initiated for around a month due to flooding of the wellsite. The petrophysical evaluation of this well therefore was a big challenge as open hole logs in 8½" section could not be recorded.

Data available & logging complications:

Open hole logs comprising PEX-HRLA-DSI-SP-HCAL-GR were recorded on TLC in the 12¼" section covering Tipams & Barails. An extensive MDT-LFA campaign with 84 points was also carried out.

Only one core of about 2.5 m could be cut with poor recovery (14.16 %) in Kopili Section. However, even the 35.4 cm of core so obtained provided important insight and established presence of hydrocarbons in the Kopili section.

While the 8½" section was drilled well within time, an unprecedented rainy spell and flooding lead to destabilisation of the civil work carried out at the wellsite. It became impossible to move any vehicle including logging units near the Catwalk. Efforts to strengthen and facilitate access for logging failed and the logging could not be carried out for over a month. For the first time, a new solution in the form of PORTADECK was adopted which allowed movement of heavy vehicles at the wellsite.

Having got access to the Catwalk after a month, the next set of challenges arose. After the held up observed in one wireline attempt, severe stuckups leading to de-latching in two of the three pipe conveyed logging attempts, only partial down log of RTEX-DAL-GR could be recorded. The lower part of Tura could not be covered. At this stage due to many complications, open hole logging had to be called off.

7" liner was lowered keeping shoe at 4887m with hanger top at 4050m and later tied back to surface. This tie back was done first time in Assam Asset & would enable to test the object behind 9 ⅝"casing.

After lowering the casing a full set of logging including FMI and DSI were carried out in the 6" section of the basement. Hitech tools CHFR-CHFD-CHFP were mobilised and attempts were made to carry out logging in the 7" casing for covering the data gaps in 8 ½" section. However due to resistivity range encountered in Tura were in excess of 100 ohm-m and much above the CHFR tool limitations, the tool malfunctioned due to overheating after recording around 93 m.

Formation Evaluation and Analysis:

The 12¼" section comprised of Tipams, BCS and LBS sands. On the basis of log evaluation, Oligocene sands (BCS) in the interval 3544-3548m have been interpreted as hydrocarbon bearing (Fig-1).

The interpretation is substantiated with MDT pretest pressure plot in this interval (Fig-2) showing Gas gradient. ***This is a discovery object*** in this field though it will fall behind 9 ⅝"casing. LBS-VI & V sands have also been interpreted to be hydrocarbon bearing (Fig-7 & 8).

Due to so many well complications during logging in the 8½" section of this well and non-availability of resistivity and porosity logs, the down log consisting of Resistivity-Sonic-GR recorded on PCL was conditioned, calibrated and validated with few available CHFR data points and was used to evaluate Kopili, Sylhet and Tura alongwith CHFP-CHFD recorded in casing.

Sands in the Kopili formation are interpreted to be hydrocarbon bearing (Fig-5). The presence of HC in Kopili formation is also substantiated by hydrocarbon shows observed in drill cuttings.

Only one plug could be cut from the available conventional core (Fig-3A) in this section & presence of hydrocarbons was also confirmed by oil extraction from the plug (Fig -3B).

The NMR study was also carried out on this sample at CEWELL which revealed conventional T2 cut off values both for the sand (32 ms) and shale (2.7 ms) (Fig-4A & 4B).This is a very important deduction for the purpose of log evaluation and further reservoir characterisation using NMR in the area.

While the Lower Tura shows presence of volcano-clastics and tuff to a large extent in the area, the Upper Tura unit contains mainly clastics (sandstone, siltstone and shale) minor carbonate and some thin inter-beds of volcano-clastics. Interval 4747-4751m in Upper Tura has been interpreted as hydrocarbon bearing (Fig-6). These sands are normally tight with low porosity/ permeability values. Except for one of the wells in Lakwa, activation problems were encountered during initial testing in other exploratory wells.

The basement was drilled as a 6" hole. The FMI and DSI output reveal the gneissic nature of the basement. Data quality was affected by large washouts below the 7" casing shoe as well as near TD. However indications of open fractures could be inferred from the logs (Fig-9).

Discussion:

Open hole log data combined with MDT results gave good indication of new sand development in BCS which will provide new leads in this area. Sample collected in this sand clearly indicated presence of oil. Apart from testing the basement barefoot, the most relevant object was found to be in Upper Tura in the interval 4747-4751m having effective porosities in the range 8- 10 p.u. and estimated water saturation (S_w) values in the range 55-60%.

Since, the object falls in 7" casing, to make the perforation effective in the bigger diameter hole, 4½" guns were planned to be used and mobilised as they were not available departmentally. Also, Tura being tight with low porosity & permeability values, STIM gun was planned in advance to create additional fractures. The formation was pre-modelled to see the efficacy of using the STIM gun technology. Based on the modelling results, optimum sleeve length was used which proved effective and the well flowed @19m^3/d oil during activation.

Conclusions:

The case study shows how a decent log data set was created despite severe complications in the well. However, with meticulous planning this well could be saved and has been logged, evaluated and interpreted making best use of the technology and available data. Integration of all available information finally resulted in identification of two new prospective sands.

Tura being low permeable/ low porous and in 7"casing, it needed deep penetration charges with some stimulation to make it flow. Use of the higher diameter deep penetrating charges and STIM gun technology helped to create additional fractures resulting in the well coming on self.

Acknowledgements:

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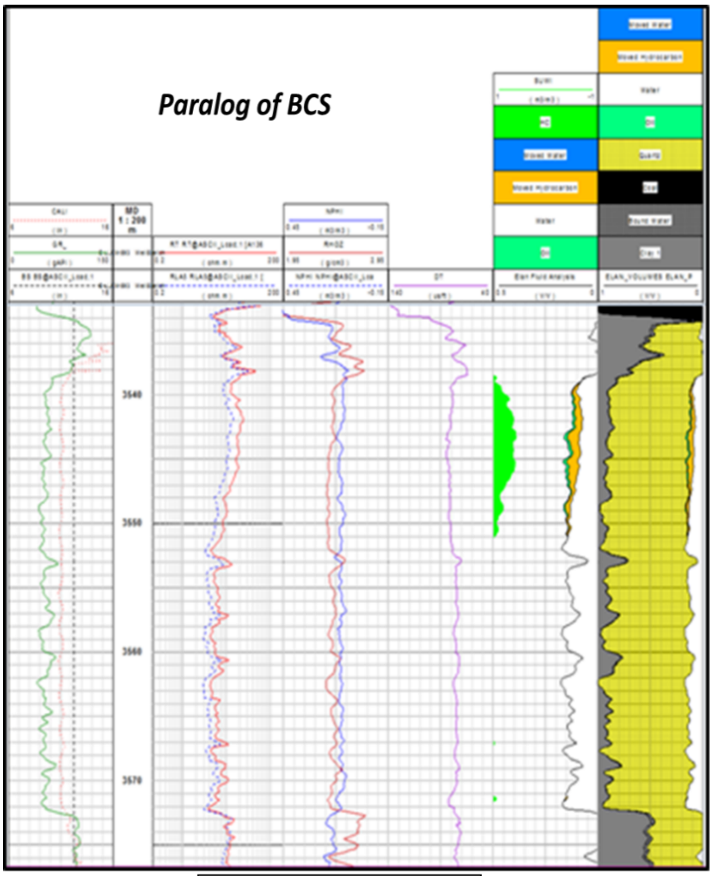


Fig-1: Paralog of BCS discovery sand

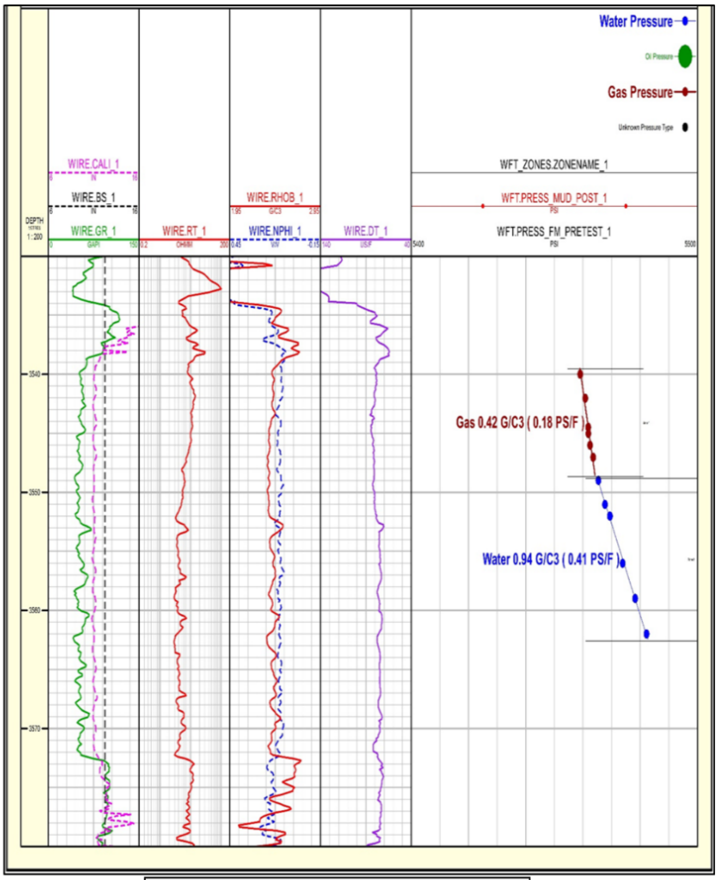


Fig-2: MDT Gradient plot in BCS discovery sand of well L#X

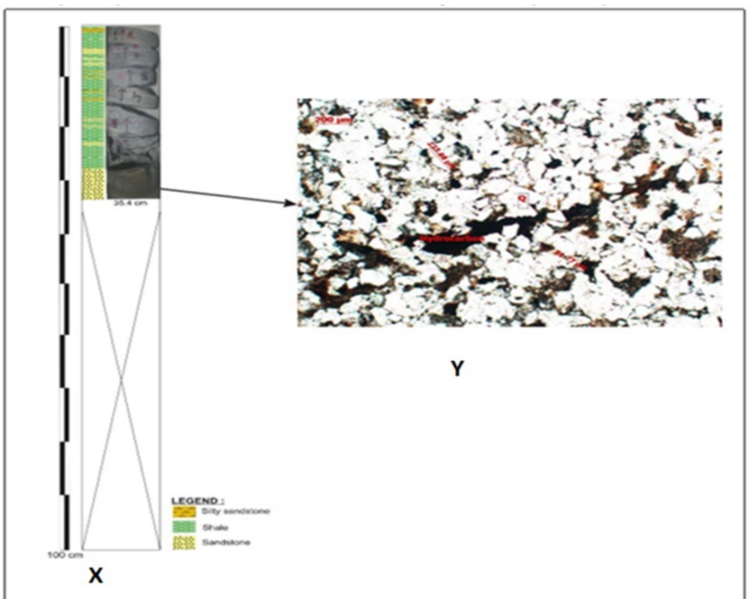


Fig X : The core photograph depict that the gross lithology comprises of shale and sandstone. The shales are grey, hard and at places thinly laminated with fine grained sandstone. The sand is fine grained with discontinuous carbonaceous lenses and shows golden **yellow fluorescence and strong positive cut.**

Fig Y : The petrographic studies revealed Quartz Arenite. Quartz grains are fine grained. The grains have mainly point contact. The primary intergranular porosity and secondary fracture porosity within the detrital quartz grains are well developed. The porous spaces are filled with hydrocarbons. The Arenite shows good reservoir properties.

Fig-3A: Kopili Core description in well L#X

Fig-3B: Oil sample extracted from core

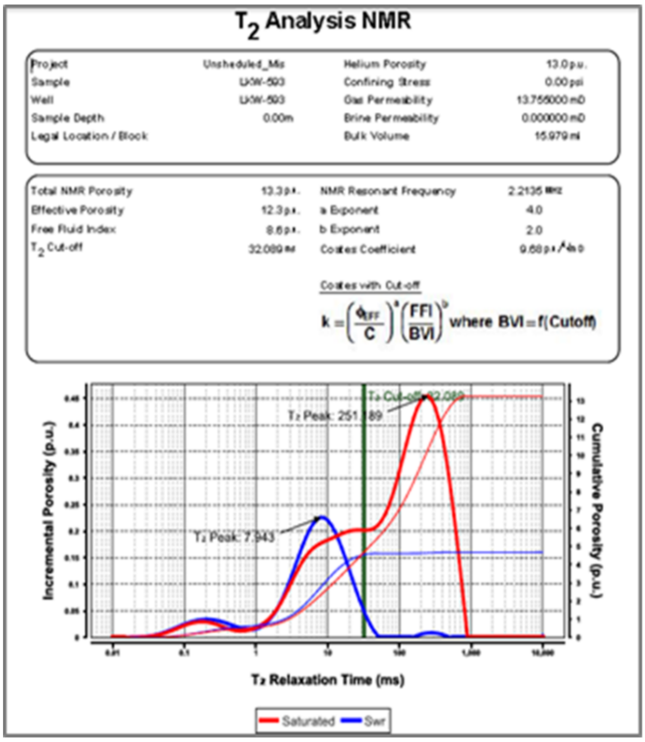


Fig 4A: T2 cut-off estimated: 32.089 ms

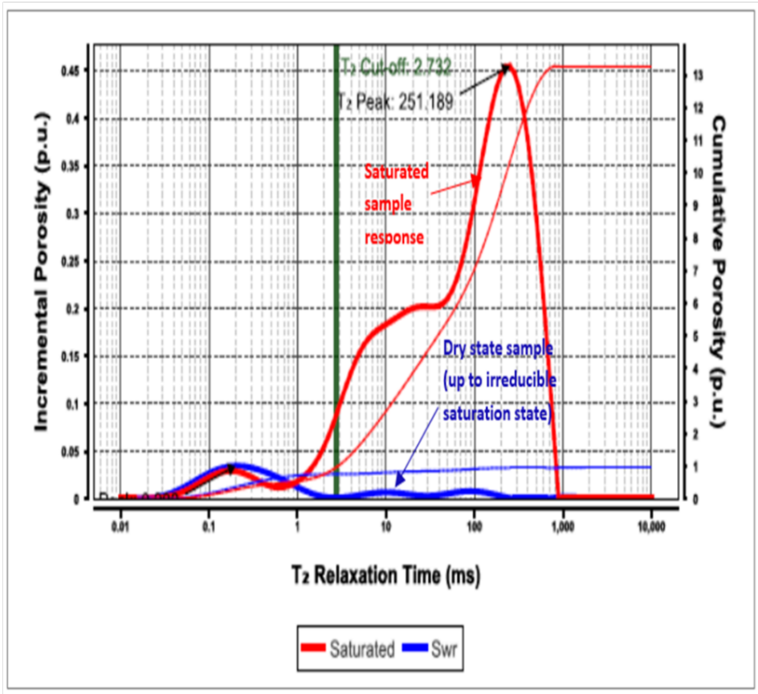


Fig-4B: T2 clay cut-off estimated: 2.73 ms

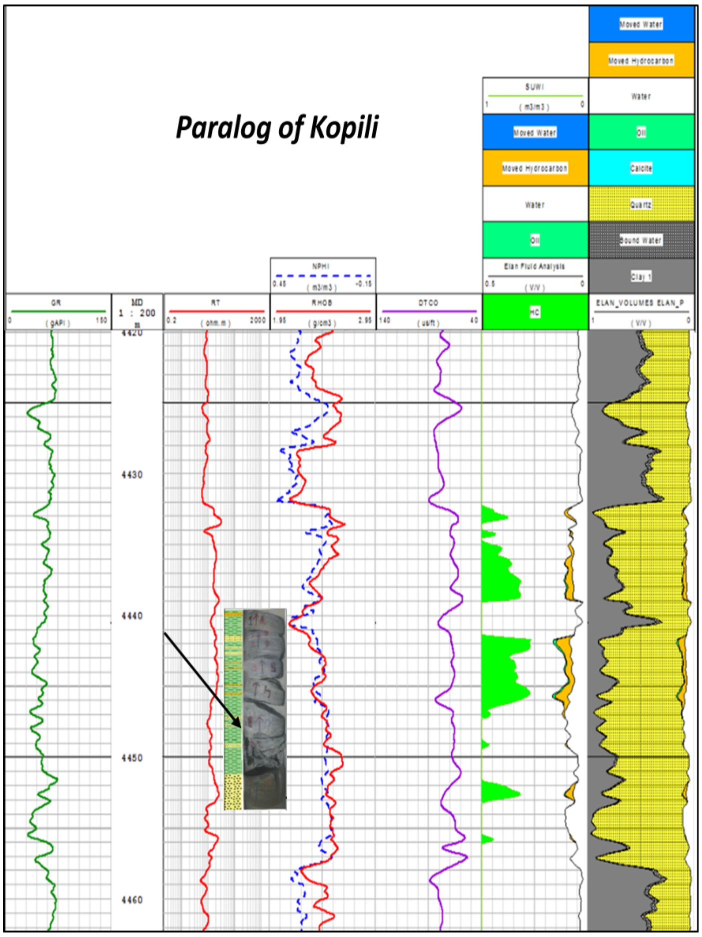


Fig-5: Paralog of Kopili & Conventional Core

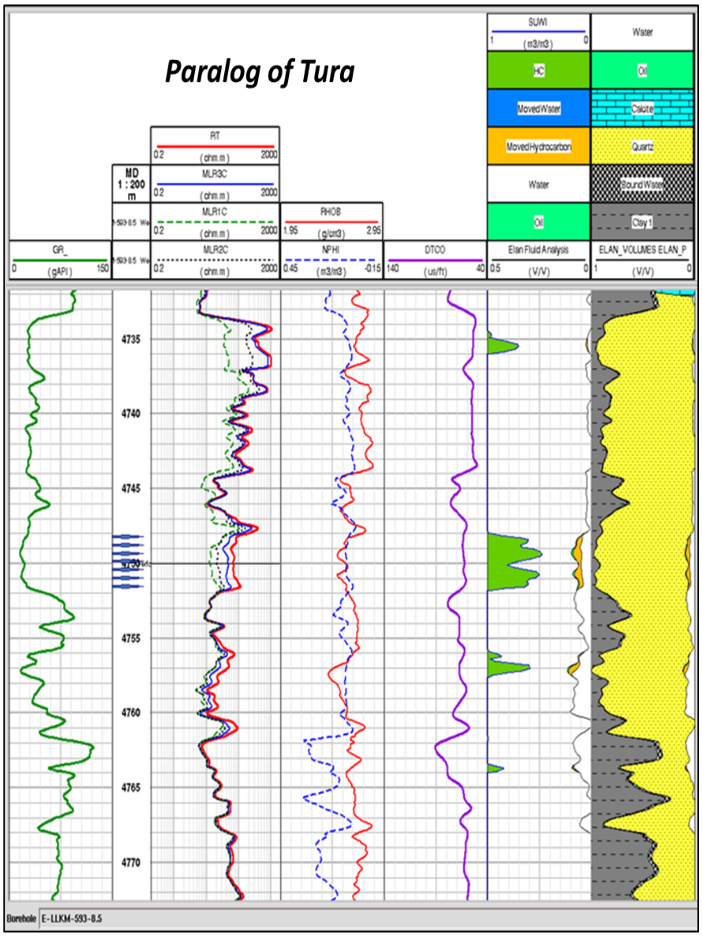


Fig-6: Paralog of Tura. Blue marked perforated with STIMGUN

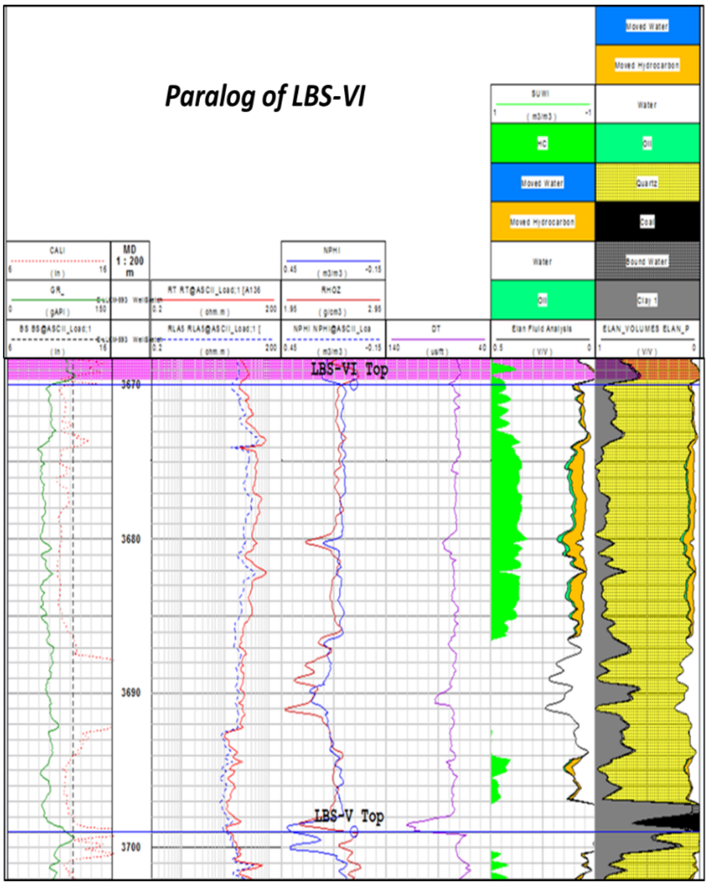


Fig-7: Paralog LBS-VI sand of Well: L#X

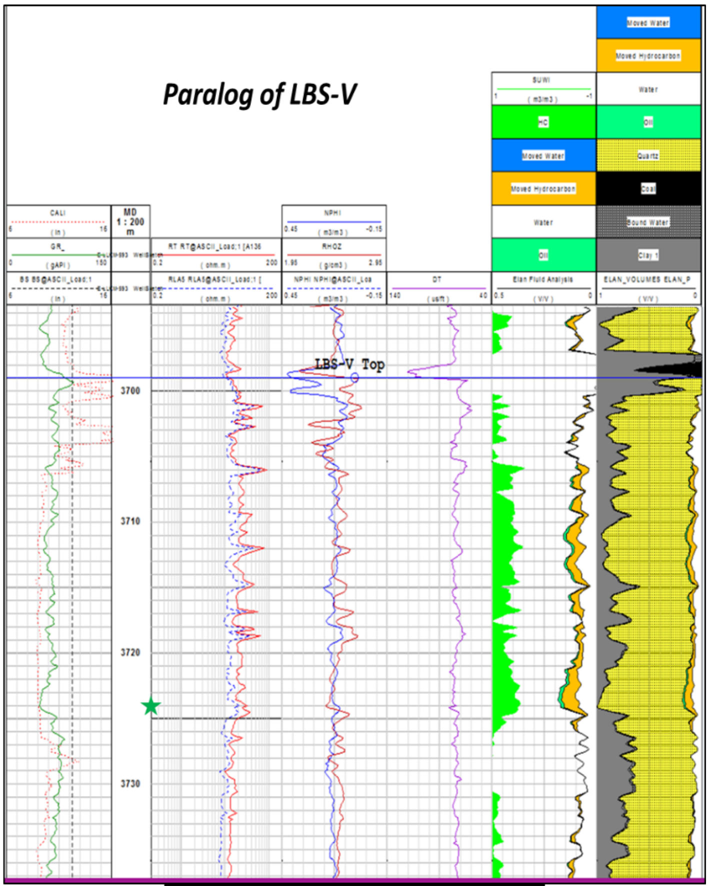
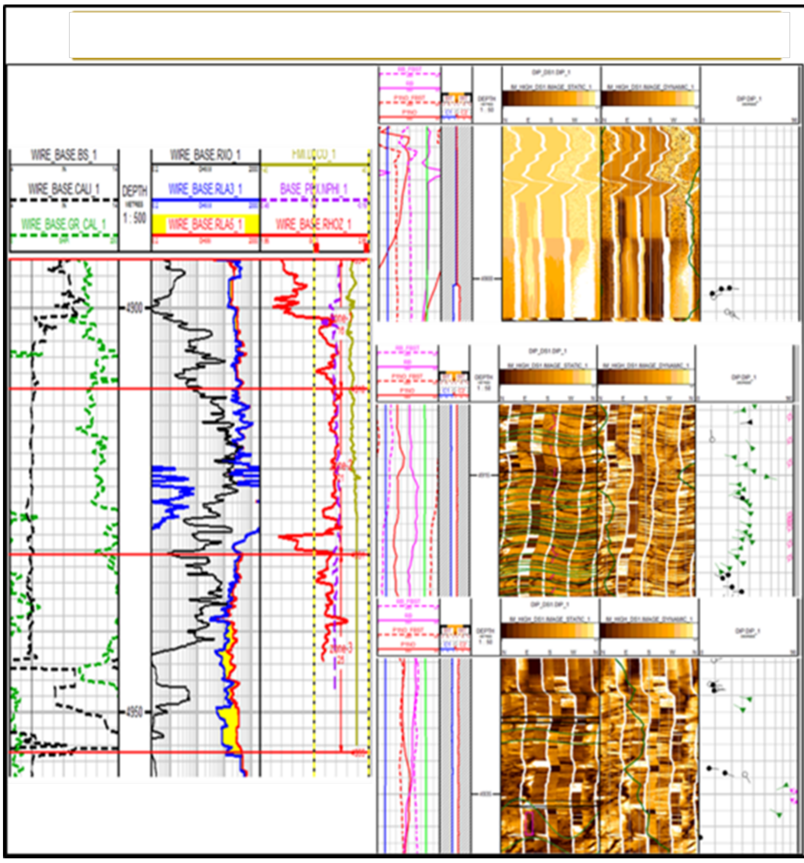


Fig-8: MDT Gradient plot in LBS-V sand of well L#X



4894-4910m: FMI and other data are affected due to hole enlargement. Non planer discontinuities crisscrossed by drilling induced fractures are seen on FMI. Some well-defined fractures can also be inferred. Stonely data show good degree of openness and series of chevron pattern in top part (up to 4903m).

4910-4930.5m: Deep and medium resistivity track each other (indicating lack of fractures). Lot of planer features having dips between 30 - 40 degrees in NW and N directions are observed. These are inferred as foliation planes supported less openness and absence of chevron patterns in Stoneley reflection data.

4930.5-4960m: Sonic data is not present. FMI data is severely affected by borehole conditions. Few fractures can be inferred in FMI. Resistivity data show good separation between deep and medium resistivity indicating presence of probable fractures.

Fig-9: Integrated observation of FMI data in Basement