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Identification and determination of gross thickness of hydrocarbon bearing zone of Habiganj gas field.

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ABSTRACT : *Formation evaluation is a very important stage in prospecting for reservoir characterization and hydrocarbon bearing zone identification. The study has been carried out by qualitative and quantitative analysis. The logging data studied comprises of gamma ray, dual induction micro spherical focused log, borehole compensated sonic log, spectral density dual spaced neutron log. The gamma ray log is used to determine lithology, reservoir and non reservoir rocks, facies and depositional environment. Dual induction micro spherical focused log calculates the resistivity of the flushed zone as well as medium and deep resistivity of the invaded and uninvaded zone. Borehole compensated sonic log measures travel time through the formation and thus porosity. It analyzes fluid rock type such as hydrocarbon or formation water. Porosity is calculated by both density and neutron log. Neutron log is used to identify hydrocarbon bearing zone as well as fluid type.*
In well#10, Habiganj Gas Field, the hydrocarbon bearing zone is found between the depth ranging1311m to1505m and gross thickness is 194m.In well#11, two gas zones upper gas sand(UGS) & lower gas sand (LGS), have been detected and they are prevailed in the depth ranging from 1373m to 1485m and 3076 m to 3081m .

KEYWORDS: *Formation Evaluation, porosity, resistivity, fluid type, gross thickness.*

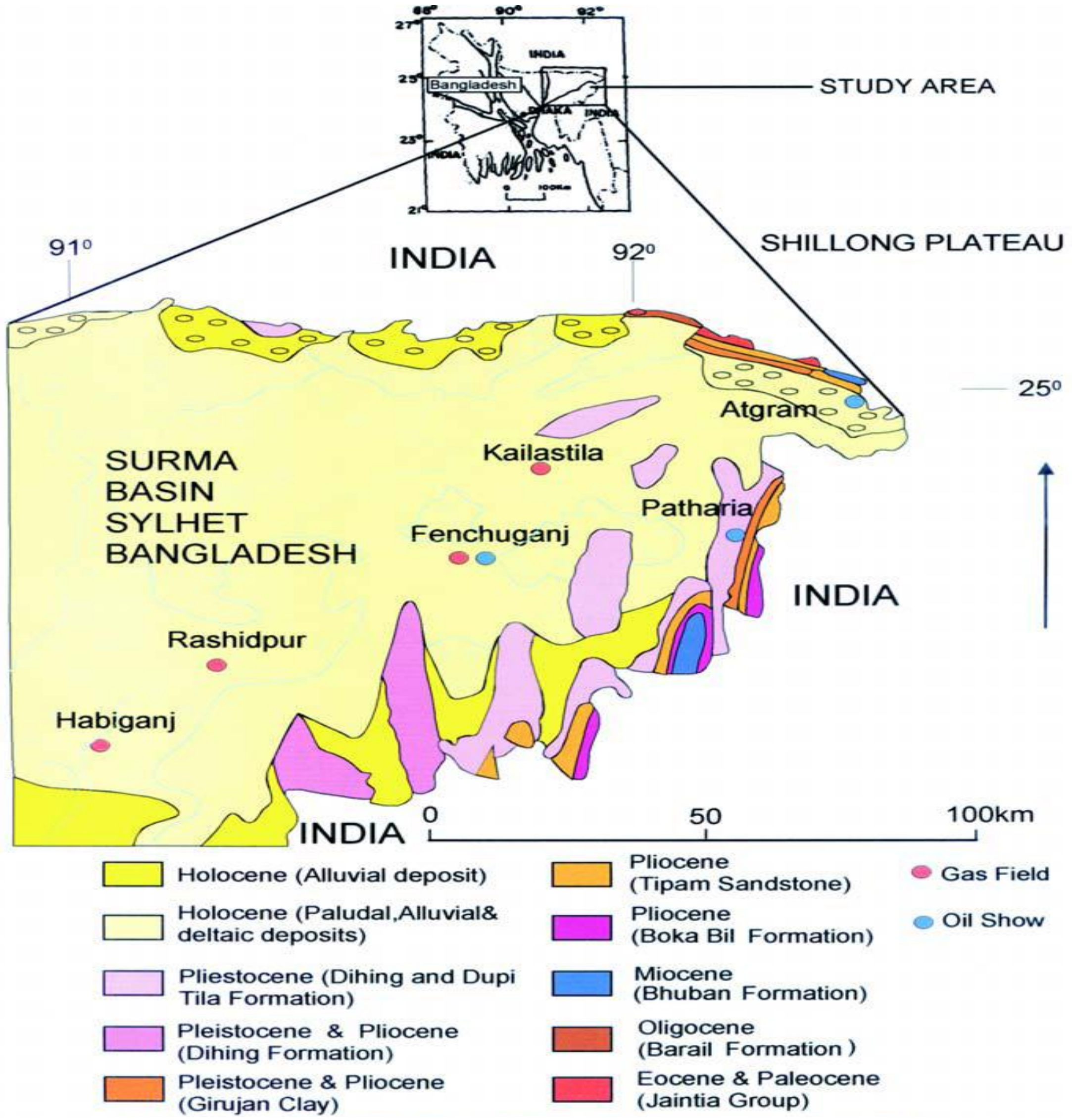
I. INTRODUCTION

Formation evaluation, a sub discipline of petroleum engineering, specializes in the gathering of data and the quantification of parameters needed for the practice of the other three major sub disciplines: drilling, production and reservoir engineering. Formation evaluation methods include rock-and fluid-sample analysis, well logging, and pressure and production testing. A combination of these methods usually is required for a complete and thorough evaluation. [1]

Well-logging technology embraces three distinct areas. The first area consists of the definition of mathematical and empirical models that relate a formation property of interest to the property measured with the logging tool. The second area consists of the log measurement itself and encompasses tool design and calibration. The third area is analysis and interpretation. [2]

Different types of methods were applied to acquire data to evaluate the hydrocarbon bearing zone of Habiganj Gas Field. The data that were obtained from the well no. 10 & 11 of Habiganj Gas Field were provided by Bangladesh Gas Field Company Limited (BGFCL). Resistivity log, Neutron log, Density log and sonic log were used to detect hydrocarbon zone.[3]

Figure 1: Location map of the study area (Surma Basin, Sylhet, Bangladesh). (After alam MK et al. 1990)[7]



Porosity logs (density, neutron, and sonic) have relatively shallow radii of investigation. Gas saturation near the wellbore in all types of formations causes an increase in density log porosity and a decrease in neutron log porosity. The presence of gas results in an appreciable increase in sonic log porosity only in poorly compacted sands, which is the case of most shallow sands and some abnormally pressured formations. Using density or sonic log porosity values uncorrected for gas effect usually results in a low apparent value of the formation factor, *F*. This, in turn, results in a low apparent R_0 value. Consequently, clean gas formations will be identified easily as hydrocarbon zones by use of an interpretation technique, such as the apparent water resistivity, R_{wa}, and porosity resistivity cross plots. The hydrocarbon saturation estimated under these conditions usually will be exaggerated. Use of uncorrected neutron log porosity produces the opposite effect. A low apparent porosity results in a high F, which, in turn, results in a high estimated R_0 value. Subsequently, a gas zone can pass undetected. [4,5]

Several interpretation techniques have been used to detect hydrocarbon-bearing zones and to estimate their porosities and fluid saturations. The optimum interpretation technique for analyzing a formation of interest depends on the quantity and the quality of the data available to the log analyst.
Log analysts are faced with four main questions.

- Does a specific formation or zone contain hydrocarbons?
- Which hydrocarbon is present, oil, gas or both?
- Is the hydrocarbon saturation high enough to indicate sufficient effective permeability to hydrocarbons?
- Is the hydrocarbon accumulation large enough to warrant the completion of the well?

If the log analyst can answer all four questions conclusively and positively, the well is completed in the zone of interest. If the answers are conclusively negative, the formation is abandoned. More frequently, especially in exploration, the role of well log is limited by the complexity of the problem to identify the relatively high potential zones. These zones will undergo additional testing, before the final decision to complete or abandon the well is made. Under certain circumstances, however, the additional tests cannot be performed or are inconclusive. In such cases, the decision is based on well-log interpretation. [2, 6]

II. METHODS AND MATERIALS

Determination of Rw:

Water Resistivity (R_w) can be obtained from water bearing formation. [12, 13]

$$R_w = \frac{R_{mf} * R_t}{R_{xo}} \qquad -------------- (1)$$

Where,

R_w = water Resistivity in uninvaded zone
R_{mf} = Resistivity of mud filtrate (1.5 ohm-m @ 124F BHT)
R_t = True Resistivity (Deep Induction)
R_{xo} = water Resistivity in flushed zone (MSFL)

Using the above equation, Rw is calculated and all the findings are tabulated in Appendix.

Bulk Porosity (By Neutron Log & Density Log)

Bulk porosity includes both primary porosity (intergranular void space) and secondary porosity (vugs and fractures). It can be measured by both Neutron log and Density log. [14-17]

Neutron log shows comparatively higher porosity in the formation. But in the gas zone Density log reads greater value than Neutron log. Finally the bulk porosity is calculated as root-mean-square (rms) porosity and given by
$\Phi = \sqrt{[\{(\text{Neutron } \Phi)^2 + (\text{Density } \Phi)^2\}/2]}$ ……………………………. (2)
Using Eq^n (2) the bulk porosity is calculated for every 5 meter interval ranging 1180m to 1540m depth.(Appendix)

Calculating Porosity Using Litho density

Bulk density is a function of the amount of matrix and the amount of fluid in the formation, as well as their respective densities. [18-20]

$$\emptyset = \frac{\rho_{matrix} - \rho_{bulk}}{\rho_{matrix} - \rho_{fluid}} \qquad -------------- (3)$$

The density log reads the bulk density fairly well. Errors in calculated porosity appear, however, because the grain density and fluid density are often not measured and erroneous values of their magnitude are assumed. Using the equation stated above, the bulk porosity of well #11 is calculated for every 5 meter interval ranging 1200m to 1900m dept and 1920m to 3190m. Matrix porosity and fluid porosity are assumed to be 2.65 g/cc(sandstone) and .2g/cc(gas).(Appendix)

Analysis Based on Resistivity Log

There are two general types of resistivity tools. Electrode forces a current through the rock and measures resistivity. Electrode logs need a conductor in the well bore so they don't work with fresh water and oil based mud, or air. Electrode tools over the past 40 years are able to focus the current to control the depth of measurement in the borehole environment. The flushed zone resistivity is normally measured with an electrode log (MSFL). Induction uses a fluctuating electro-magnetic field to induce electrical currents in the rock; it measures conductivity which is converted to resistivity. Induction tools do not need a conductor in the bore hole and can be used with fresh water and oil based mud and air. They are designed to read intermediate and deep resistivities and are labeled ILm and ILd respectively.

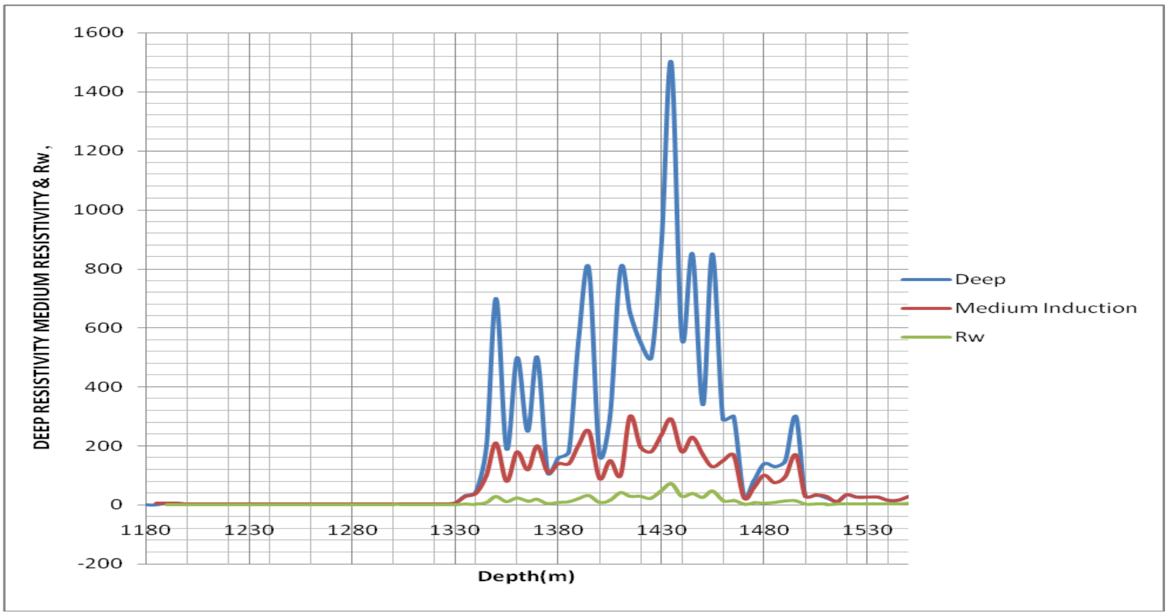


Figure 2: Depth Vs Deep Resistivity Medium Resistivity & Rw of Well#10(Step 1)

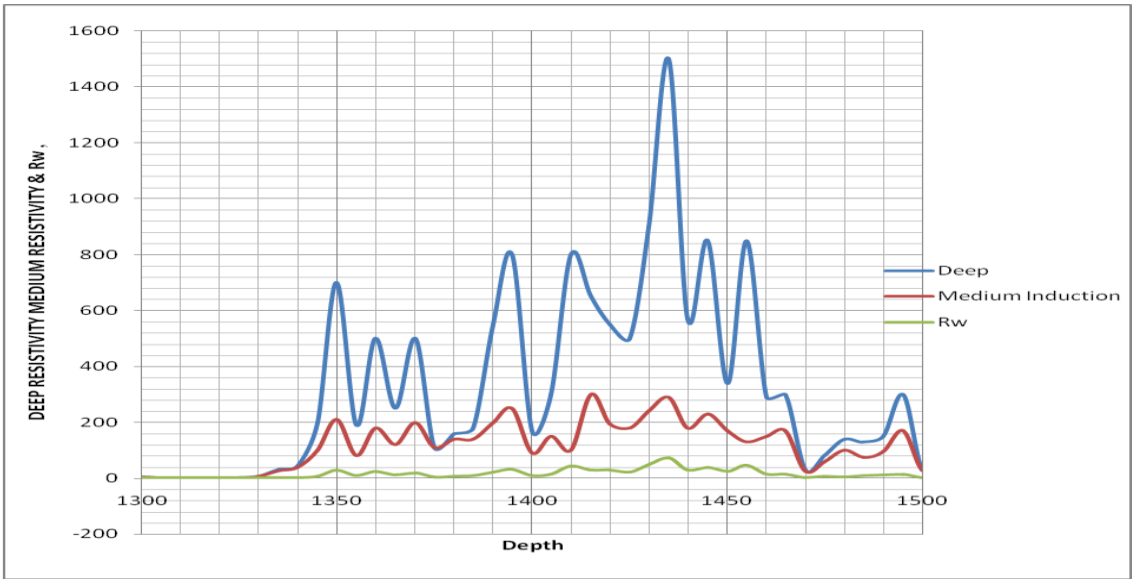


Figure 3: Depth Vs Deep Resistivity Medium Resistivity & Rw of Well# 10(Step 2)

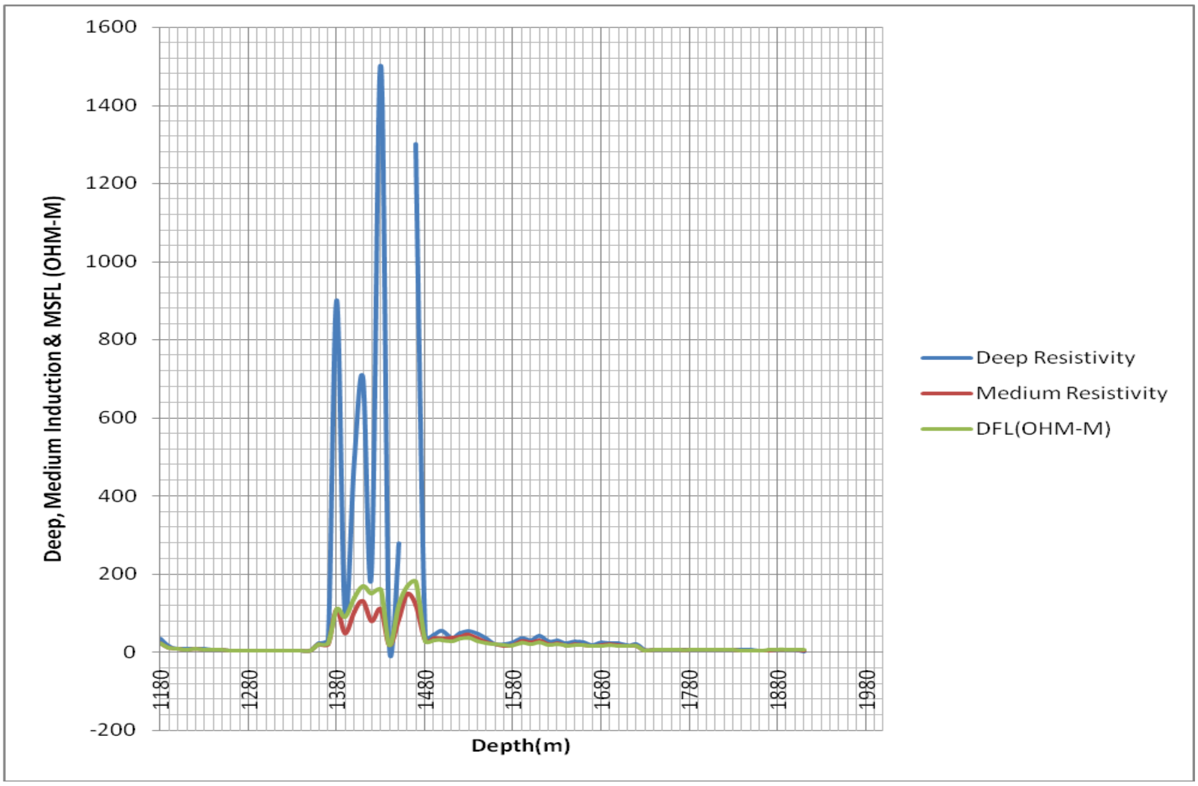


Figure 4: Depth VS Deep Resistivity Medium Resistivity & DFL of well#11(UGS)

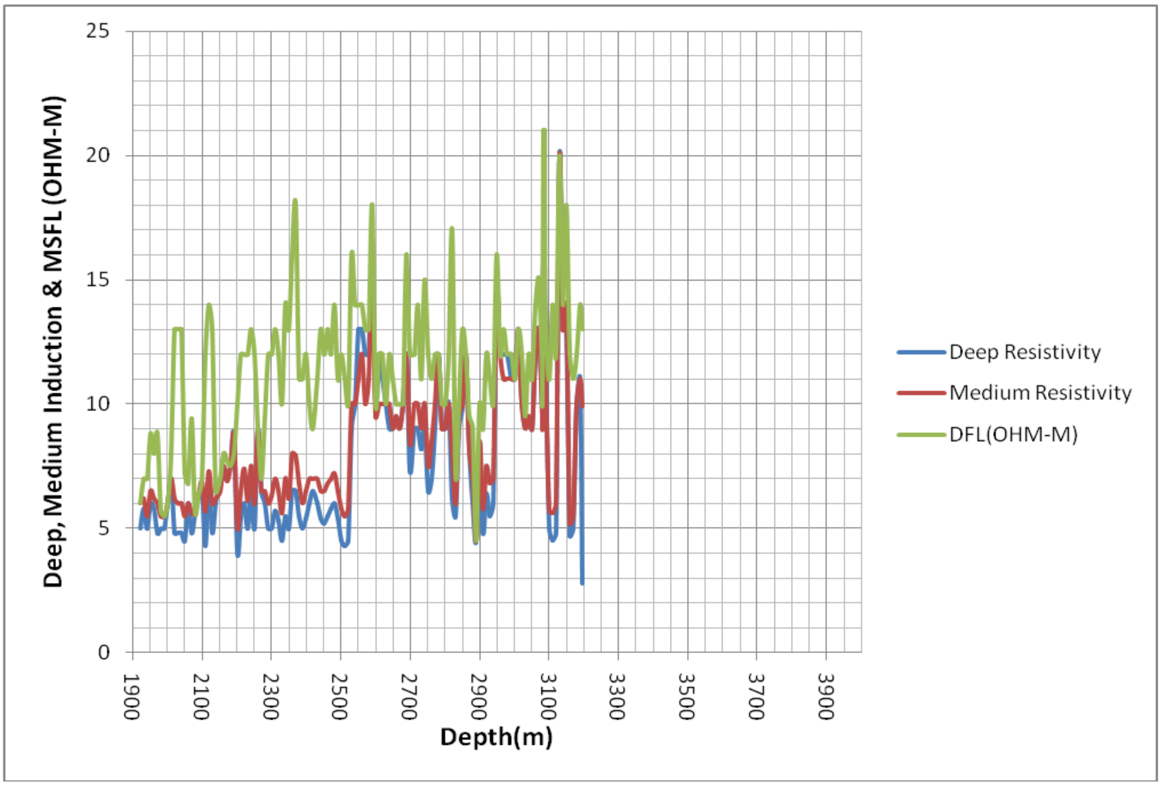


Figure 5: Depth VS Deep Resistivity Medium Resistivity & DFL of well# 11(LGS)

Induction tools do not work well in formations with low conductivity (high resistivity) because only weak currents will be induced in the rock and are hard to measure. High resistivity indicates the potentiality of hydrocarbons (absence of free electron) that is the true resistivity (R_t) of the formation is greater than that of the resistivity (R_w) of the formation water. Such occurrence is prevailed in the figure 2, 3 & 4 except figure 5. The results are tabulated bellow.

Table 1: resistivity log result

Well No.	Year	TD (mSS)	Type	UGS (mSS)	UGS GWC (mSS)	LGS (mSS)	LGS GWC (mSS)
well#10	1999	1531	Vertical	1345-1495	1500		
well#11	2008	3200	Vertical	1370-1480	1490		

Sonic Log Analysis

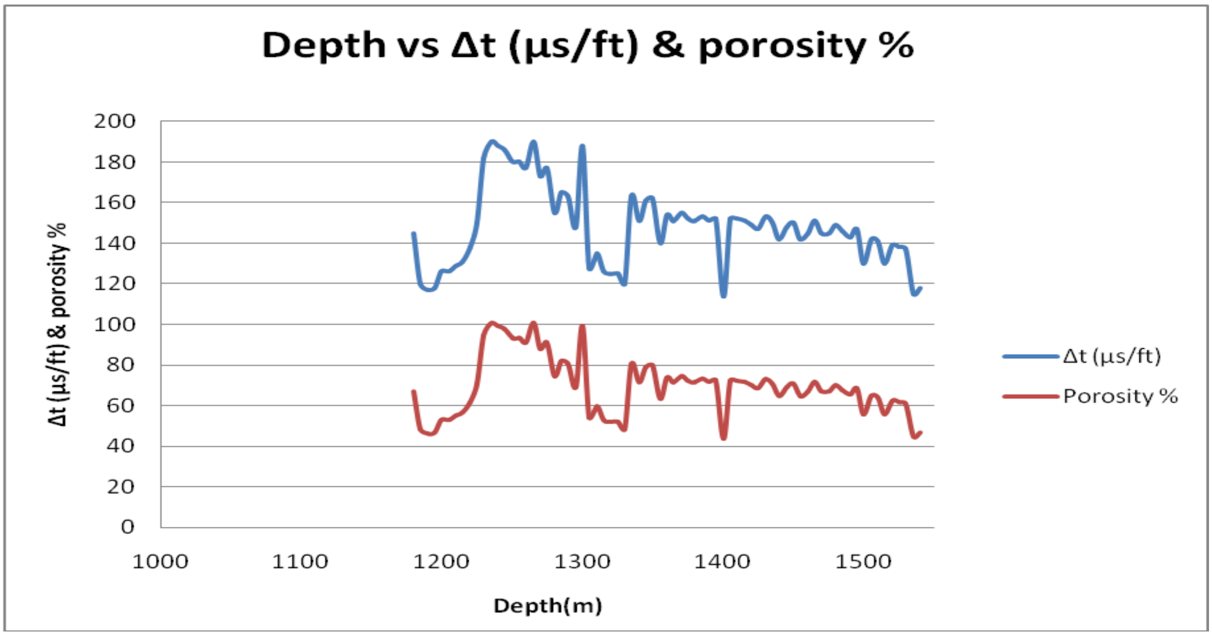


Figure 6: Depth VS Δt (µs/ft) & Porosity % well#10

In figure 6, due to dampening of first arrival at far receiver of the sonic log sonic curve shows spiking or abrupt changes towards a higher travel time. Greater travel time in porous media filled with gas(as acoustic wave takes less time in solid medium than that of lighter zone). There are unconsolidated formations (particularly gas bearing) or fractured formations.

Table 2: result from sonic log

Well No.	Year	TD (mSS)	Type	UGS (mSS)	LGS (mSS)
well# 10	1999	1531	Vertical	1255-1520	

Neutron Log Analysis

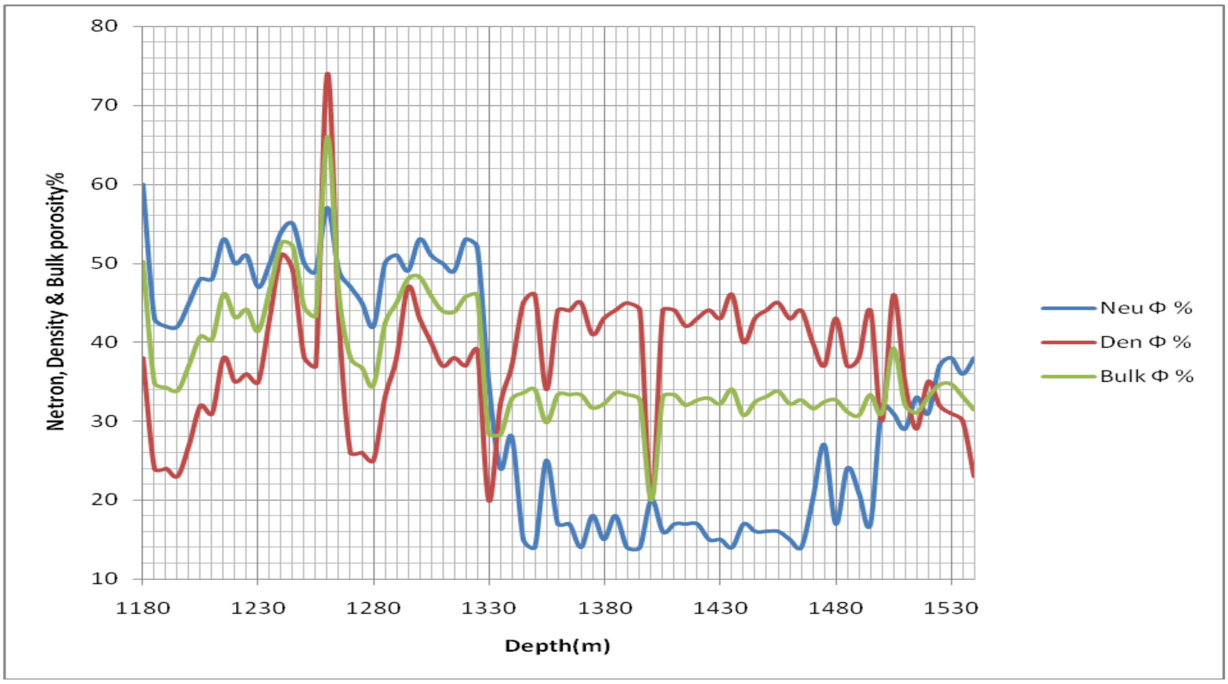


Figure 7: Depth VS Neutron, Density & Bulk Porosity % of well#10(step1)

The Neutron Log is primarily used to evaluate formation porosity, but the fact that it is really just a hydrogen detector should always be kept in mind. Most oils have a hydrogen index close to one, except light oils and gas; they have lower values due to lower hydrogen content. Consequently, the log estimates too low of porosity in zones containing gas or light oil .Gas zones are more easily picked when the neutron and density porosities are plotted on the same scale

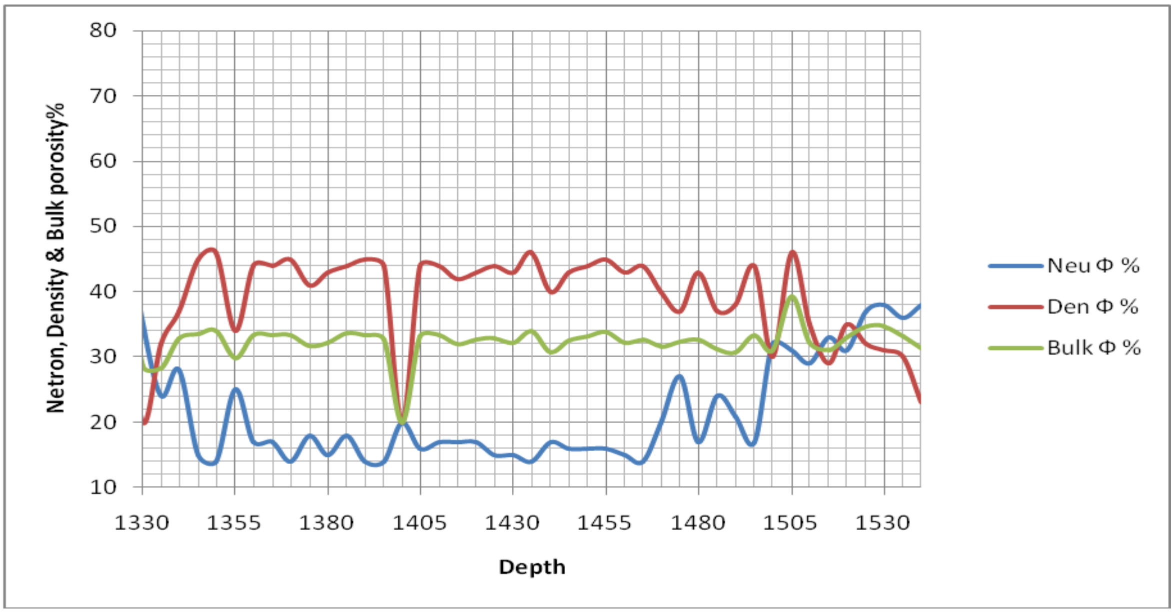


Figure 8: Depth VS Neutron, Density & Bulk Porosity % of well#10(step2)

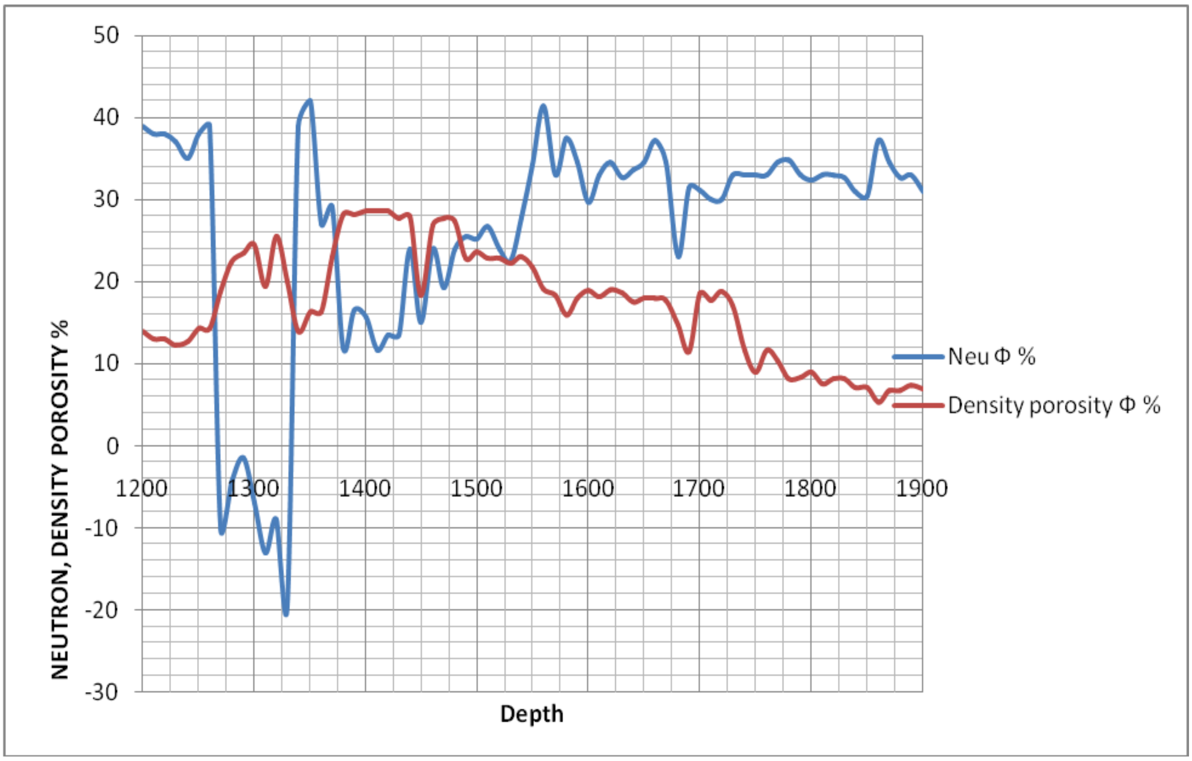


Figure 9: Depth VS Neutron, Density Porosity % of well#11(UGS)(step1)

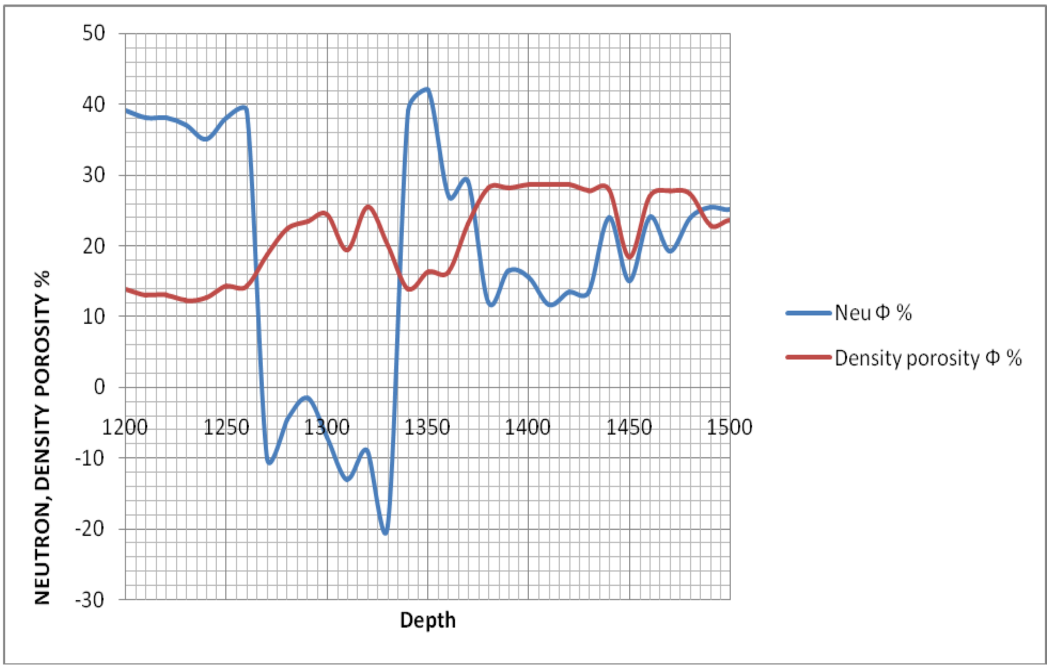


Figure 10: Depth VS Neutron, Density Porosity % of well#11(UGS)(step2)

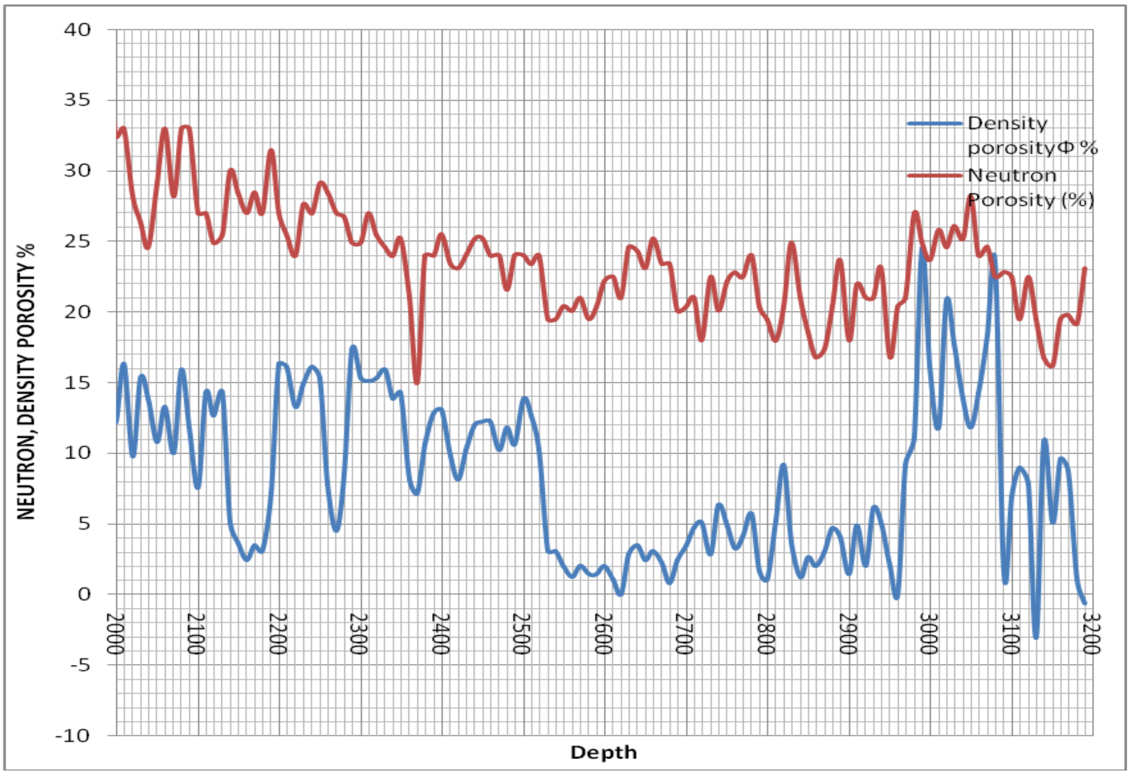


Figure 11: Depth VS Neutron, Density Porosity % of well#11(LGS) (Step1)

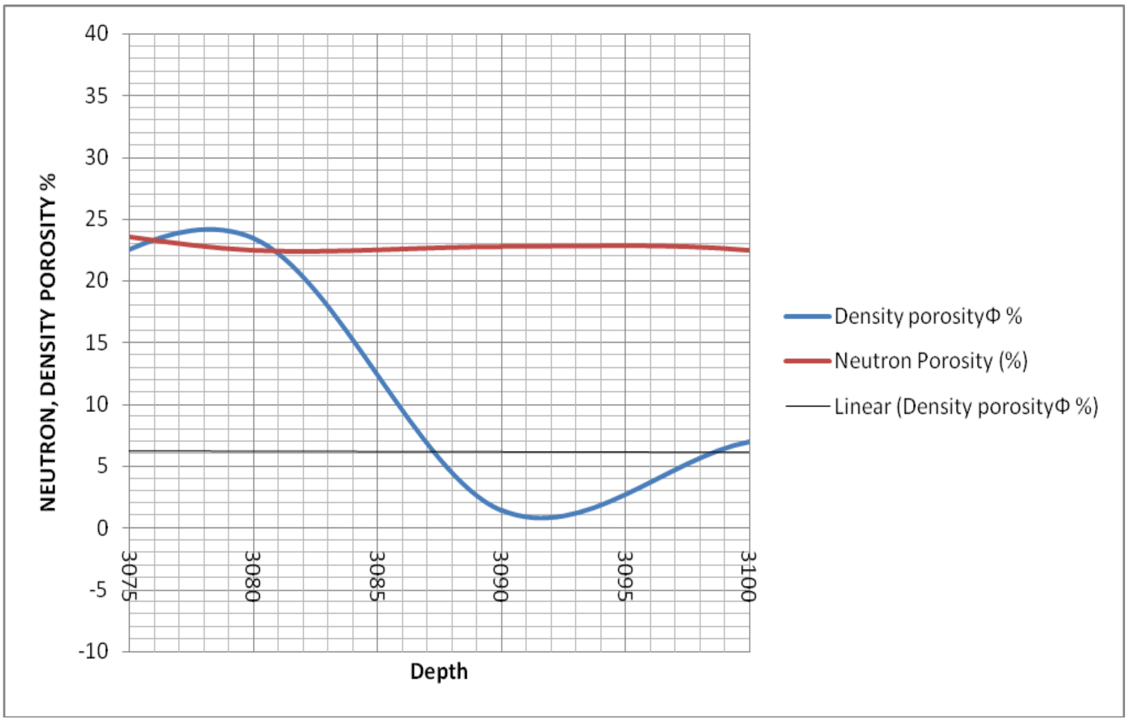


Figure 12: Depth VS Neutron, Density Porosity % of well#11(LGS)(Step2)

The computed density porosity will read high in gas zones (a fluid density assumption that is too high would be used) and the neutron log will read low, therefore, a cross-over will occur. The density porosity will track to the left and the neutron porosity will shift to the right. Based on the principal stated above, we have concluded the result tabulated below.

Table 3: result from neutron log

Well No.	Year	TD (mSS)	Type	UGS (mSS)	UGS GWC (mSS)	LGS (mSS)	LGS GWC (mSS)
well#10	1999	1531	Vertical	1335-1500	1515		
well#11	2008	3200	Vertical	1375-1490	1500	3076-3081	

III. RESULT AND DISCUSSION

In this study, I have strived to find out hydrocarbon bearing zone, the gross thickness of the pay zone and the fluid type of well#10 and well#11. Finally I have come out with the results varying for different logging tools. Actually the geological structure is the great factor to trap hydrocarbon in the underground. On the other hand, the results are not measured rather than estimated. So in well#10, Habiganj Gas Field, the hydrocarbon bearing zone is found between the depth ranging1311m to1505m and gross thickness is 194m.In well#11, two gas zones UGS &LGS, have been detected and they are prevailed in the depth ranging from 1373m to 1485m and 3076 m to 3081m .From the previous study it has been found that the hydrocarbon zone of well#10 is exists in the depth between 1297m-1464m using all Log data and all stratigraphic data. The total thickness of the gas zone is 167m. In well#11, the upper gas zone prevails in the depth between 1357m – 1474m and the lower gas zone is in the range of 3084m-3087m and 3144m-3147m. For detecting hydrocarbon zone, the accuracy of log data is too much important. If the collected log data is authentic, the result also is reliable. For collecting authentic data, we must use the sophisticated method and tools. There are a lot of methods for well logging but we used some selective method. So the result is not completely right. Even there is a continuous debate about the reserve of the gas field of Bangladesh due to method selection for reserve estimation. So I think, there are a lot of drawbacks in my method selection. If I used all of the logging data, then my result would be more reliable. But logging is very expensive. Sometimes it requires millions of money for one type of logging. For a good result of a study, tools and instruments used in the field should be well designed and sophisticated. Since the logging tools are also very expensive, may be the tools used in the logging was obsolete. The result can also vary due to the obsolescence of the tools and instruments.

IV. CONCLUSION

Determination of clay or shale volume, porosity, resistivity and water saturation is very important in the formation evaluation. Sonic curve shows spiking or an abrupt change towards a higher porosity. The porosity values are strongly affected by clay volume but less influenced by hydrocarbon fluids content. The increasing of clay volume will result in decreasing porosity. The resistivity log is strongly affected by the water saturation. Increasing of resistivity will result in decreasing water saturation. The result of this study and the actual result have not matched. That is, there are some limitations in this study. I have come across the study that the accuracy of log data is too much important. If the collected log data is authentic, the result is reliable. For collecting authentic data, we must use the sophisticated method and tools. There are a lot of methods for well logging but we have used some selective method. Besides, sufficient data were not available. Lab facilities were not worth mentioning. Some values for several parameters have been assumed. On the other hand, the result from log interpretation is estimated rather than measured. That is why, drawbacks may have occurred.

From the study it is clear that, the Habiganj gas field is very prospective area in Bangladesh. It is especially clear from the result of well # 11. Total two hydrocarbon bearing zones were found though the thicknesses of lower gas zone were small. But this zone is the indicator of the presence of huge amount of gas in Surma Basin.

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