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Research paper

Petro physical properties analysis of beani bazar gas field, Bangladesh using wireline log interpretation

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Abstract

The study on analysis of petro physical properties which are done into two well such as BB-1 and BB-2 of Beani Bazar Gas Field using wire line log data. In BB-1, Upper Gas Sand (UGS), Lower Gas Sand (LGS), Sand-1 and Bellow Lower Gas Sand (BLGS) zones and in BB-2, UGS and LGS are identified through high gamma ray log, high resistivity, low neutron and low density log response. The thickness of UGS, LGS, Sand-1, BLGS of BB-1 and UGS, LGS of BB-2 are respectively 47.69m, 14.326m, 17.526m, 17.526m and 26.37m, 21.03m. The Shale volumes of UGS, LGS, Sand-1 and BLGS of BB-1 are respectively 14.87%, 21.58%, 11.69% and 21.28% and UGS and LGS of BB-2 are respectively 17.91% and 29.33%, which are measured through Schlumberger Clavier method. The average porosity of UGS, LGS, Sand-1 and BLGS of BB-1 are respectively 17.55%, 16.60%, 18.07% and 31.10% and UGS and LGS of BB-2 are respectively 13.19% and 11.29%, which are very effective for hydrocarbon prospect by using neutron-density combination method. The average water saturations of UGS, LGS, Sand-1 and BLGS of BB-1 are respectively 24.97%, 23.78%, 80.18% and 19.85% which revised to hydrocarbon saturations as respectively 75.03%, 76.22%, 19.82% and 80.15% and UGS and LGS of BB-2 are respectively 41.20% and 69.50% which revised to hydrocarbon saturations as respectively 58.80% and 30.50% that are followed by Simandoux method. By analysis of petro physical properties of those zones, the UGS and LGS are very effective hydrocarbon bearing zones where production is running at the present time, the Sand-1 zone is water bearing zone. This study impose high important on BLGS. This zone is satisfied all criteria for hydrocarbon prospect. This study recommends that more study is needed for BLGS, and it may be commercially economical viable in a future.

Keywords: *Hydrocarbon Saturation; Beani Bazar Gas Field; Petro physical Properties; Hydrocarbon Prospect and Wireline Log Data.*

1. Introduction

Wireline logging is the practice of making a detailed record of the geologic formations penetrated by the well. Petro physical properties are the properties of a reservoir such as thickness, lithology, shale volume, porosity, water saturation and hydrocarbon saturation of the gas field (Ajisafe & Ako, 2013). Different types of gamma ray (GR), spontaneous potential (SP), resistivity, neutron and density log are determined to the petro physical characteristics of the reservoirs such as porosity, hydrocarbon saturation and water saturation (Asquith & Gibson, 1982).The proposed study aims at interpretation of well log data and quantitative evaluation of petro physical properties such as water saturation, shale volume, sand thickness, porosity, water resistivity, geothermal gradient, formation temperature etc. in a Beani Bazar gas field, well-1 and well-2. Beani Bazar Gas Field Well-1 (BB-1) was discovered by Parker Drilling Company (PDC), Germany at 1979. This well was spudded in on 20th November 1980, and the drilling was completed on 12th may 1981. The total depth (TD) reached at 13480 feet (4108.70m).Beani Bazar Well-2 (BB-2) was drilled under the second Gas Development Project (SGDP). The well was spudded in on 21st March 1988, and the drilling was completed on 16th July1988 at a total depth (TD) reached at 13,480 feet (4108.70m). The study area is a Beani Bazar gas field (Fig. 1) which is located in Beani Bazar upazila of Sylhet District in the division of Sylhet, Bangladesh. The well Beanibazar-1 is located at 92º10′18″ N and 24º97′33″ E and Beanibazar-2 is located at 92º10′9.99″ N and 24º48′24.99″ E. The main objectives of this research of well log analysis are to measure the petro physical properties of the Beani Bazar Gas field to detect prospective hydrocarbon zone.

2. Geological structure of beani bazar gas field

Beani Bazar structure is situated within the folded flank of the Bengal fore deep. The structure lies on the Western margin of the Chittagong-Tripura folded belt in the south-central part of the Surma Basin. On the surface, the structure has a north south extension of about 12 km and 7 km wide. The dips of the flanks are symmetrical, and the amplitude is gradually decreasing with an increase of depth. In the upper horizon, dips are low (2^0-3^0) but in the deeper horizon this increases slightly and amounts to (8^0-11^0). The northern pitch is steeper than the south. The top of the upper pay zone was delineated by a contour line of 3200 m and the crest is found about 500m NNW of well no.1.The dimension of the structure on top of the upper pay zone is 11 km × 5 km (within closed contour 3400 m), and the amplitude is about 200 m. The dimension of the structure on top of the lower pay zone does not change much. But the crest of the lower zone is slightly shifted towards SSE, and the well is almost on the top. No faults were observed from the 2D seismic data over the Beani Bazar structure, or it's about. This is probably due to the low resolution of the variable quality 2D seismic data and probably more faults can be expected to be seen in a higher resolution 3D seismic data set.

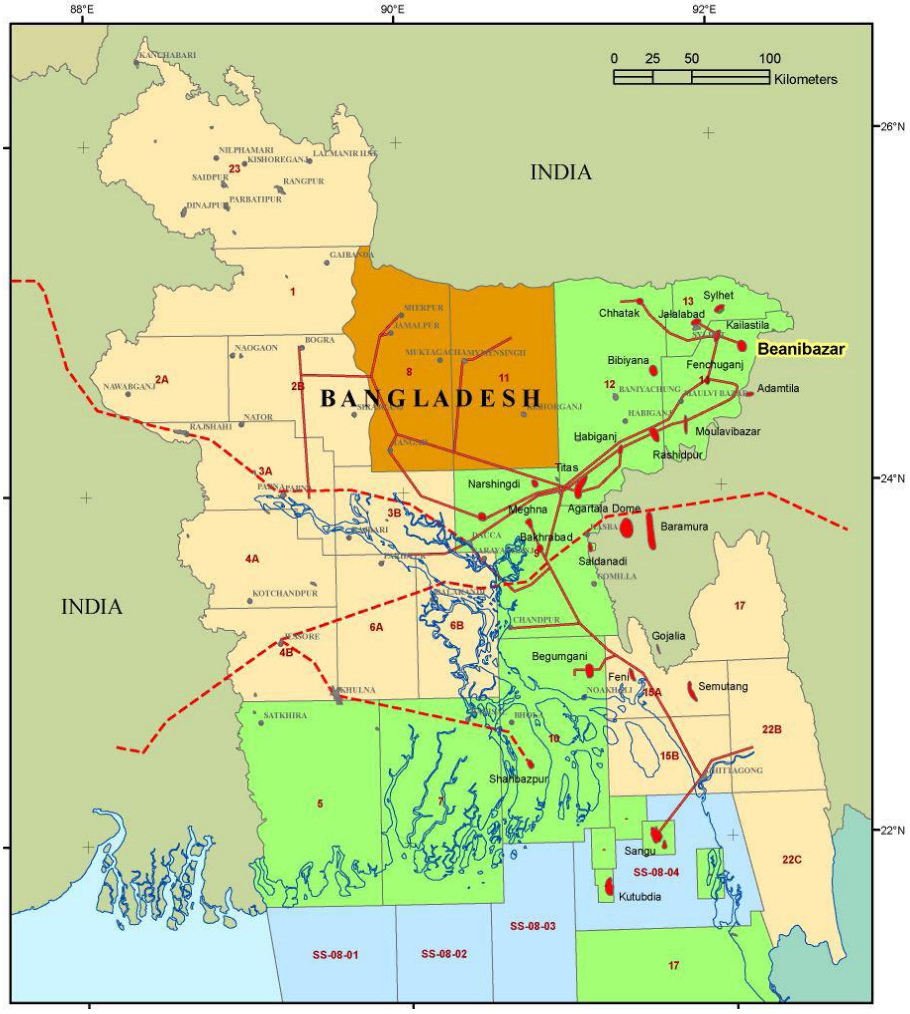

Fig.1: Location Map of Beani Bazar Gas Field (Source: RPS Energy Report, Petrobangla).

3. Methodology

The study is mainly based on the petro physical properties of Beani Bazar gas field well no. 1 and 2. The value of the wire-line log data is plotted continuously against depth in the well. Wireline log data is the most consistent source of information for determining the presence of hydrocarbon. For this research purposes, Resistivity (R) log, Gamma ray (GR) log, Neutron log and Density log are used to determine the petro physical properties of Beani Bazar gas field. The steps for determination of petro physical properties of the Beani Bazar gas field are as follows:

3.1. Lithology identification

The natural radioactivity of the formations in the borehole on the gamma ray (GR) log is identifying lithology (Hasan et al. 2013). High GR value indicates shale due to the presence of potassium ions in the lattice structure of clay mineral and low GR value exhibit reservoir rock (sandstone) due to the absence of potassium ions in the lattice structure of minerals (Asquith & Gibson, 1982).

3.2. Shale volume calculation

At initial situation, through gamma ray log value, shale volume can be calculated by using gamma ray index (I_{GR}) for tertiary rocks (Schlumberger, 1972).

That's given bellow:

$$I_{GR} = \left[\left(GR_{\log} - GR_{\min} \right) / \left(GR_{\max} - GR_{\min} \right) \right] \tag{1}$$

Where, I_{GR} = Gamma ray index, $GR_{\log}$ = Gamma ray response in the zone of interest, $GR_{\min}$ = Minimum gamma ray response in clean, shale free formation and $GR_{\max}$ = Maximum gamma ray response in shale zone.

Various formulas are used to modify the linearly derived shale volume to obtain a more satisfying answer. The Dresser Atlas's equation (Atlas, 1979) is used for measuring shale volume. This equation given bellow:

$$V_{sh} = 0.083 \left[2^{3.7 \times I_{GR}} - 1.0 \right] \tag{2}$$

3.3. Porosity calculation

After determining the volume of shale, porosity is calculated from density-neutron logs (Schlumberger, 1979). The porosity equation (Atlas, 1979) from density log consists of matrix density, fluid density, bulk density. This Equation is given bellow:

$$\phi_d = \left(\frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} \right) - V_{sh} \left(\frac{\rho_{ma} - \rho_{sh}}{\rho_{ma} - \rho_f} \right) \tag{3}$$

Where, ϕ_d = The density porosity, ρ_{ma} = Matrix density (gm/cc), ρ_b = Bulk density, ρ_f = Fluid density and ρ_{sh} = Shale density.

The porosity is measured by neutron log through following equation (Atlas, 1979), the clay corrected Neutron porosity,

$$\phi_{n-corr} = NPHI - \left(V_{sh} * NPHI_{sh} \right) + Litholog\,yCorrection \tag{4}$$

Where, $NPHI =$ Neutron logs value of zone of interest, $NPHI_{sh} =$ Average neutron log value of shale volume and Lithology correction $= 0.04$.

It is always best to read porosities directly from the logs where the lithological units match the formation lithology. To obtain correct porosities from density-neutron logs using Schlumberger (Schlumberger, 1979) when the two logs record different porosities for a zone, use one of the methods given bellow:

$$\phi = \sqrt{\left(\phi_n^2 + \phi_d^2\right)/2} \tag{5}$$

Where, $\phi =$ The percent of porosity, $\phi_n =$ Neutron porosity and $\phi_d =$ Density porosity.

3.4. Water saturation calculation

The water saturation determined after the log-derived porosity had corrected for shale. The saturation is known as the total water saturation if the pore space is the total porosity, but is known as effective water saturation if the pore space is the effective porosity. In this research water saturation will be shown through Simandoux method. According to Simandoux method, the water saturation equation (Simandoux, 1963) given bellow:

$$S_w = \left(\frac{0.4 \times R_w}{\phi^2}\right)\left[\frac{V_{sh}}{R_{sh}}\sqrt{\left(\frac{V_{sh}}{R_{sh}}\right)^2 + \frac{5\phi^2}{R_t \times R_w}}\right] \tag{6}$$

Where, $S_w =$ Water saturation, $R_w =$ Formation water resistivity, $\phi =$ Porosity, $V_{sh} =$ Shale volume, $R_{sh} =$ Resistivity of shale volume and $R_t =$ True resistivity.

3.4. Hydrocarbon saturation calculation

The percentage of total volume in a formation held by hydrocarbon is known as hydrocarbon saturation (Ahammod et al. 2014). It can be determined by the following equation:

$$S_{hc} = 100 - S_w \tag{7}$$

4. Result

Data are collected from log sheet which is provided by Petrobangla. Data are collected in two steps. Average log values are collected in first step where depth is in range such as 3230 m to 3277 m provides a single log value of different type of log (Fig. 2 and Fig. 3).

4.1. Lithology and thickness identification

From Wireline log observation, hydrocarbon prospective zones for Beani Bazar Gas Field BB-1 and BB-2 with respect to depth are shown on table 1 given bellow:

Table 1: Hydrocarbon Prospective Zones of Beani Bazar Gas Field.

Well	Lithology	Depth (m)		Thickness (m)
		Top	Base	
BB-1	UGS	3230.118	3277.81	47.69
	LGS	3451.098	3465.424	14.326
	Sand-1	3572.561	3590.087	17.526
	BLGS	3768.242	3781.806	13.56
BB-2	UGS	3286.96	3313.328	26.37
	LGS	3496.056	3517.087	21.03

4.2. Shale volume evaluation

Shale volume (V_{sh}) has been estimated from gamma ray log. Using those equations (1 and 2), the study can show shale volume content in selective zones of Beani Bazar gas field is given below as:

Table 2: Shale Volume of Beani Bazar Gas Field.

Zones	Depth (m)	Average V_{sh} (fraction)	Average V_{sh} (%)
BB-1			
UGS	3230-3278	0.1487	14.87
LGS	3452-3466	0.2158	21.58
Sand-1	3573-3590	0.1169	11.69
BLGS	3768-3782	0.2128	21.28
BB-2			
UGS	3287-3313	0.1791	17.91
LGS	3496-3517	0.2933	29.33

4.3. Porosity distribution

Porosity determination is a very important for analyzing the petro physical properties of any gas field (Ruhovets, 1990). Using equations (3, 4 and 5), calculate the average porosity of Beani Bazar Gas field both well. Those are given bellow:

Table 3: Porosity of Beani Bazar Gas Field.

Zones	Depth (m)	Ø-Average (fraction)	Ø-Average (%)
BB-1			
UGS	3230-3278	0.1755	17.55
LGS	3452-3466	0.1660	16.60
Sand-1	3573-3590	0.1807	18.07
BLGS	3768-3782	0.3110	31.10
BB-2			
UGS	3287-3313	0.1319	13.19
LGS	3496-3517	0.1129	11.29

4.4. Water saturation calculation

Water saturation is very important for knowing gas saturation in any gas field.

Water saturation is calculated through simandoux equation (6) which is shown on below:

Table 4: Water Saturation of Beani Bazar Gas Field

Zones	Depth (m)	Sw-Average (fraction)	Sw-Average (%)
BB-1			
UGS	3230-3278	0.2497	24.97
LGS	3452-3466	0.2378	23.78
Sand-1	3573-3590	0.8018	80.18
BLGS	3768-3782	0.1985	19.85
BB-2			
UGS	3287-3313	0.4120	41.20
LGS	3496-3517	0.6950	69.50

4.5. Hydrocarbon saturation measurement

Hydrocarbon saturation is vital role for reserving gas in gas well. Equation (7) is reliable to calculate hydrocarbon saturation. According to Equation (7), the hydrocarbon saturation of Beani Bazar Gas field are given below:

Table 5: Hydrocarbon Saturation of Beani Bazar Gas Field

Zones	Depth (m)	S_{HC}-Average (fraction)	S_{HC}-Average (%)
BB-1			
UGS	3230-3278	0.7503	75.03
LGS	3452-3466	0.7622	76.22
Sand-1	3573-3590	0.1982	19.82
BLGS	3768-3782	0.8015	80.15
BB-2			
UGS	3287-3313	0.5880	58.80
LGS	3496-3517	0.3050	30.50

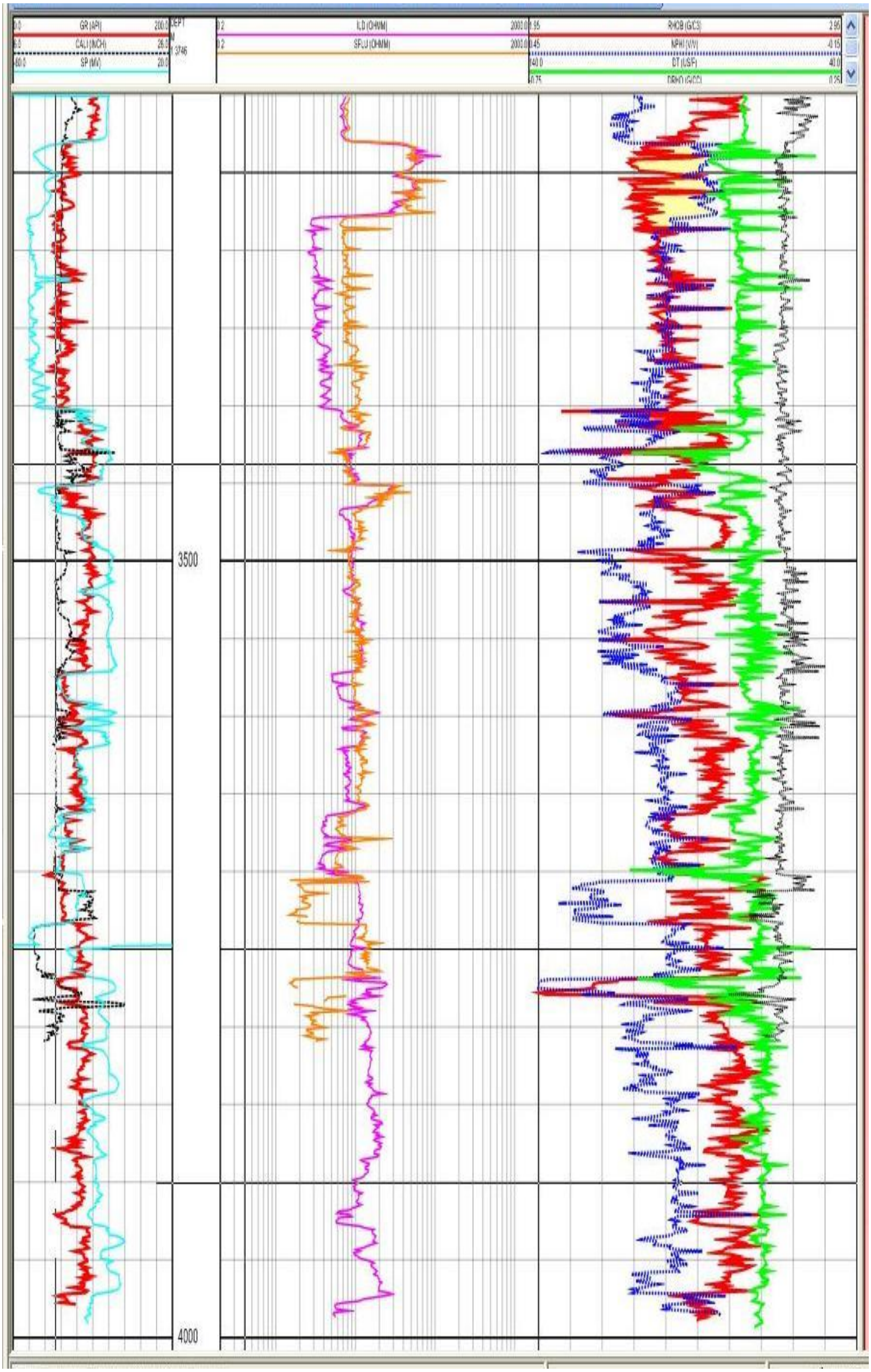

Fig. 2: Wireline log sheet of BB-1 of Beani Bazar Gas Field.

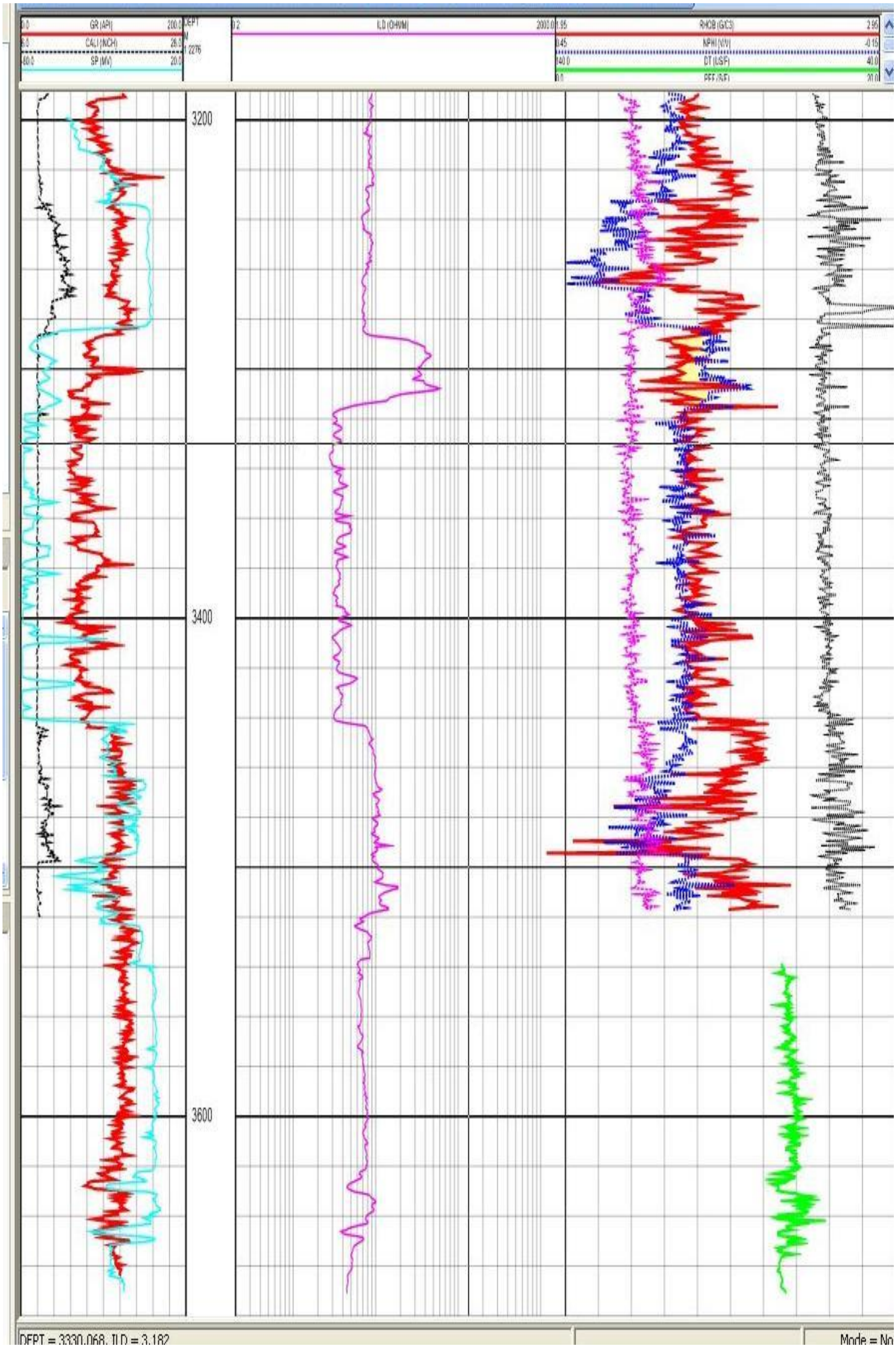

Fig. 3: Wireline Log sheet of BB-2 of Beani Bazar Gas Field.

5. Discussions

The quantitative analysis of wireline log data evaluates the petrophysical properties (such as lithology, shale volume, porosity, water saturation and hydrocarbon saturation) of Beani Bazar Gas field. Hydrocarbon bearing zones are defined by the help of high resistivity, high SP, low GR values (Asquith & Gibson, 1982), low density and neutron values (Fertl, 1987). In Beani Bazar Gas field well-1 (BB-1), four hydrocarbon bearing zones were identified. The depth range of hydrocarbon bearing zones (Fig. 4) as Upper Gas Sand (UGS) is 3230.118–3402.5 m, Sand Zone (sand-1) is 3572.561–3590.087 m, Lower Gas Sand (LGS) is 3451.098–3465.424 m and Bellow Lower Gas Sand (BLGS) is 3768.242–3781.806 m having thickness 172.382 m, 17.526 m, 14.326 m and 13.564 m respectively. Though the UGS thickness is 172.382 m, but its Gas content thickness is 47.701 m at depth 3230.118–3277.819 m and 124.681 m are fully water saturated. For that reasons the petrophysical properties of UGS in BB-1 are shown at depth 3230.118–3277.819 m.

In the Beani Bazar Gas field well-2 (BB-2), two hydrocarbon bearing zones were identified. The depth range of hydrocarbon bearing zones (Fig. 4) as Upper Gas Sand (UGS) is 3286.963–3313.328 m and Lower Gas Sand (LGS) is 3496.056–3517.087 m having thickness 26.365 m and 21.031 m respectively.

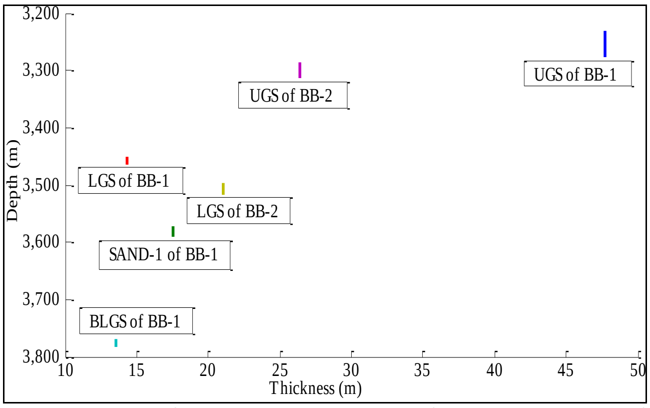

Fig. 4: Thickness of UGS, LGS, Sand-1, BLGS of BB-1 and UGS, LGS of BB-2.

The UGS hydrocarbon productive thickness of both BB-1 and BB-2 is greater than all of others sand zones thickness.

The average shale volume of UGS, Sand-1, LGS and BLGS of BB-1 are respectively 14.67%, 11.69%, 21.58% and 21.28% (Fig. 5) which show that sand volume respectively 87.03%, 88.31%, 78.42% and 78.72%. UGS, LGS, Sand-1 and BLGS of BB-1 are denoted as Shaly-Sand lithology (Islam & Islam, 2014).

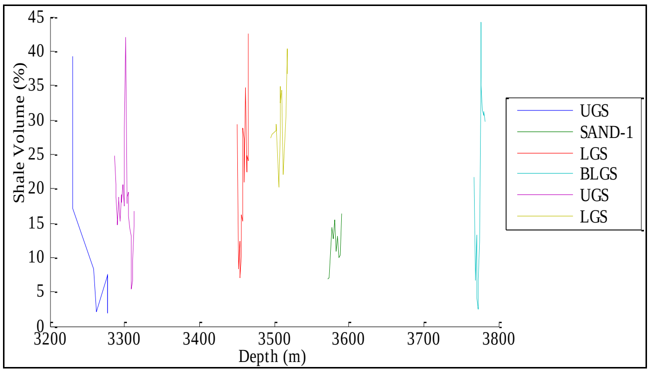

Fig. 5: Shale volume of UGS, LGS, SAND-1, BLGS of BB-1 and UGS, LGS of BB-2.

And the average shale volumes of UGS and LGS of BB-2 are respectively 17.91% and 29.33% (Fig. 5) which show that sand volume respectively 82.09% and 70.67%. That means all zones are indication of good quality sand (Eze et al. 2013).

Porosity determination is a vital important for estimating fluid saturation in the reservoir characterization (Ruhovets, 1990). The average porosity (Fig. 6) of UGS, Sand-1, LGS and BLGS of BB-1 are respectively 17.55%, 18.07%, 16.60% and 31.10%, which refers good porosity of these respective zones. And the average porosity (Fig. 6) of UGS and LGS of BB-2 are respectively 13.19% and 11.29%, which refers good porosity of these respective zones. Like observation of average porosity values ranged are found in the Laja Oil Field, Rickie Field, KN Field and Y Field, Niger delta (Ajisafe & Ako, 2013, Amigun et al. 2012, Richardson, 2013, Adeoti et al. 2014).

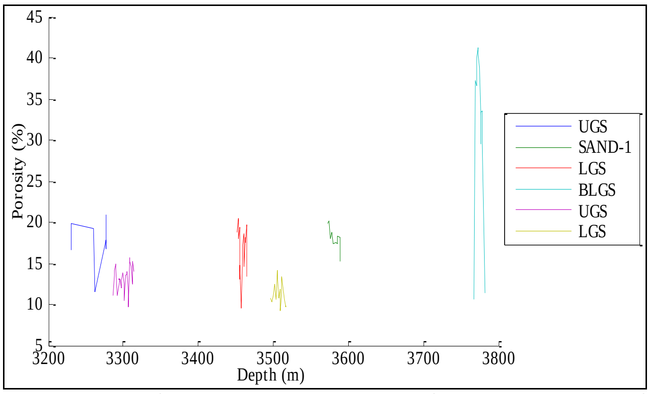

Fig. 6: Porosity of UGS, LGS, SAND-1, BLGS of BB-1 and UGS, LGS of BB-2.

The porosity of BLGS zones of BB-1 is greater than the other zones of BB-1 and BB-2.

The average water saturation (Fig. 7) of UGS, Sand-1, LGS and BLGS of BB-1 are estimated as respectively 24.97%, 80.18%, 23.78% and 19.85%, which revised to hydrocarbon saturation (Fig. 8) as respectively 75.03%, 19.82%, 76.22% and 80.15%. And the average water saturation (Fig. 7) of UGS and LGS of BB-2 are respectively 41.20% and 69.50%, which revised to hydrocarbon saturation (Fig. 8) as respectively 58.80% and 30.50%. The hydrocarbon saturation value exceeds 60% which indicates that the reservoir is productive (Asquith & Gibson, 1982). Similar observations are made by Islam et al., (Islam et al.2009, Islam, 2010) in Bengal Basin.

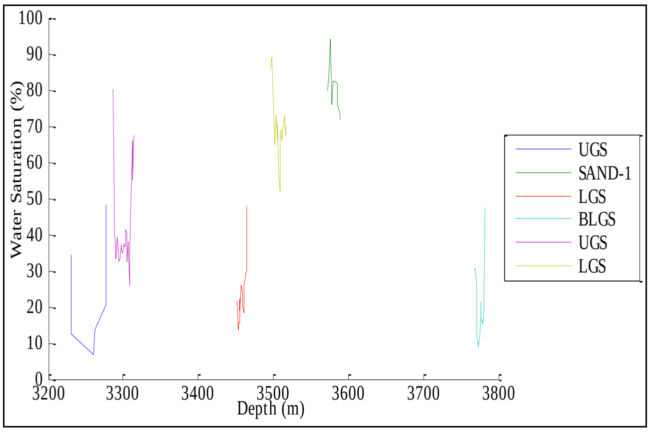

Fig. 7: Water saturation of UGS, LGS, SAND-1, BLGS of BB-1 and UGS, LGS of BB-2.

From this above study mentioned that the petro physical properties of Below Lower Gas Sand of Beani Bazar Gas field as thickness is 13.564 m, average shale volume is 21.28% which show that sand volume is 78.72%, average porosity is 31.10%, average water saturation are estimated as 19.85% which revised to hydrocarbon saturation as 80.15%.

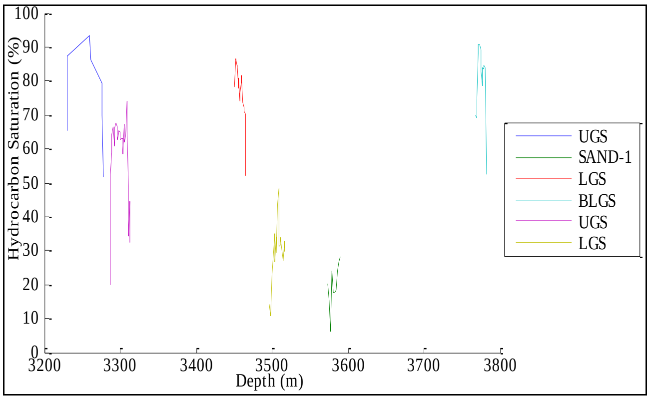

Fig. 8: Hydrocarbon saturation of UGS, LGS, SAND-1, BLGS of BB-1 and UGS, LGS of BB-2.

Below Lower Gas Sand of Beani Bazar Gas field is very significance zone which may be commercially hydrocarbon prospective in future. This zone is still now undiscovered. So this study will be very effective for this zone.

6. Conclusions

The reservoir efficiency analysis of the Beani Bazar Gas Field were obtained by using well logs such as GR log, resistivity log, neutron log and density log. Six hydrocarbon bearing zones were defined in the Beani Bazar Gas field (BB-1 and BB-2) on the basis of composite log responses. The four zones in BB-1 are Upper Gas Sand (UGS), Lower Gas Sand (LGS), Sand-1 and Bellow Lower Gas Sand (BLGS), and the two zones in BB-2 are Upper Gas Sand and Lower Gas Sand. The gas reservoirs of Beani Bazar Gas field are demonstrated an average shale volume of about 19.44%, average porosity 17.97%, average water saturation 43.25%, and average hydrocarbon saturation 56.75%. All these measured parameters indicate that these reservoirs are good quality.The Upper Gas Sand and Lower Gas Sand of both BB-1 and BB-2 are producing gas in the present time. The Sand-1 zone of BB-1 contains an average clay volume of about 11.69%, average porosity 18.07%, average water saturation 80.18% and average hydrocarbon saturation 19.82%. The amount of water saturation is excessively high, which refers that, this zone is water bearing zone. The BLGS zone is very significant part of this study. This zone is shown an average clay volume 21.28%, average porosity 31.10%, average water saturation is 19.85% and average hydrocarbon saturation 80.15%. After analysis the petrophysical properties of BLGS, it is found that, this zone can be hydrocarbon prospective in near future. The study recommended that specific in-depth study (i.e., 3D Seismic Survey) is needed to depict the real picture in a BLGS zone subsurface of Beani Bazar Gas field.

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