International Journal of Oil, Gas and Coal Engineering
2013; 1(1): 7-15
Published online August 10, 2013 (http://www.sciencepublishinggroup.com/j/ogce)
doi: 10.11648/j.ogce.20130101.12

Reservoir characterization of Habiganj gas field

Islam Md. Shofiqul*, Jahan Labiba Nusrat

Department of Petroleum and Mining Engineering, Shahjalal University of Science and Technology, Sylhet 3114, Bangladesh

Email address:
sho_fiq@yahoo.com (Islam M. S.)

To cite this article:
Islam Md. Shofiqul, Jahan Labiba Nusrat. Reservoir Characterization of Habiganj Gas Field. *International Journal of Oil, Gas and Coal Engineering*. Vol. 1, No. 1, 2013, pp. 7-15. doi: 10.11648/j.ogce.20130101.12

Abstract: Although Habiganj Gas Field is one of the best gas field with good reservoir characteristics but it is least analyzed. This paper presents the critical view on four wells (HBJ -7, HBJ-8, HBJ-9, and HBJ-10) of upper gas sand using wire line log data for further development. It is found from the analyses data that a thick zone (~40 m, depth between 1410 to 1450 m) of Bokabil Formation in well no. 8 HBJ-8 shows greater porosity (>43%) and permeability (5-16 D) which may be the indicators of a big fracture zone within the reservoir that yet to be noticed. The similar phenomenon also observed in HBJ-9 with laser thickness. The consistency in porosity and permeability of different wells shows that the reservoir of Habiganj Gas Field is well-sorted. However the stratigraphical model shows that the structure of Habiganj Gas field is almost symmetrical and trending SSE, which supports the structure of Surma Basin. The multi-log 3-D model shows both lithology and stratigraphy, which also resemblance with the lithology and stratigraphy of the Surma Basin.

Keywords: Habiganj Gas Field, Surma Basin, Reservoir Characterization, Porosity, Permeability

1. Introduction

Reservoir characterization is essential for a sound petroleum management purposing of improving estimation of reserves and making decisions regarding the development of the field. Characterizing a reservoir includes lithology, porosity, permeability, temperature etc. There are many different methods for determining petrophysical characteristics have been published in the literatures for but there is no single method that yields the most reliable answer. The accuracy of the reservoir characterization depends on the availability and reliability of data whereas there are many limitations in data acquisition.

A model of a reservoir that incorporates all the characteristics of the reservoir that is pertinent to its ability to store hydrocarbons. Moreover, a model with a specific volume incorporates all the geologic characteristics of the reservoir and such models are used to quantify characteristics within the subsurface volume. These attributes include the structural shape and thicknesses of the formations within the subsurface volume, their lithology, and the porosity and permeability distributions. The model result can detect heterogeneity of the reservoir. However, the two parameters; porosity and permeability are stable in the near-geologic timeframe and do not change due to the movement of fluids or gases through any of the formations pore spaces.

Habiganj Gas Field is located in the north-eastern part of Bangladesh, lies in Madhabpur Upazila under Habiganj district (Figure 1). From the gross estimation, it is found that the upper gas sand of this field lies at depth of 1320 m to 1550 m. Reservoir characters of this gas field preliminarily analyzed using empirical method by [1], but there is no detailed analysis yet to be done. We believe that it is one of the least analyzed structures in term of reservoir characterization and has an appeal to assessment its properties. In this paper we tried to i) figure out some distinguishing features which yet to be known using well log data of the gas field, iii) identify lithology and stratigraphy of different wells based on log data, iv) to analyze changes of different properties with depth of different wells, and v) visualize the entire gas field in three dimensional model.

2. Geology

The Surma Basin is a dynamically subsiding [2] sub-basin of the Bengal Basin situated in the northeastern part of Bangladesh. Habiganj Gas Field lies in the southern part of the Surma basin. However, the Aeromagnetic explanation plot [3] indicates a steady deepening of basement towards the center of the basin and also reveals subsurface synclinal features and faults within the basin. Its topography is predominantly flat with some north-south trending ridges of twenty to several hundred meters elevation present in the north-eastern border. The thickness of sedimentary strata in the Sylhet Basin ranges from about 13 to 17 km has been estimated by some workers [4,5]. Much of these strata are Neogene in age [2]. The sedimentary strata in the Sylhet Basin are believed to have been deposited in a deltaic to shallow marine environment [6]. Mostly all of the discovered gas/oil fields have been found within the Bokabil/Bhuban Formation of the Sylhet Basin. However, upper sand zone is relative loose and is disturbing the oil/gas production.

Fig. 1: *Location map of Habiganj Gas Field, Bangladesh (downloaded from Google Earth)*

3. Methodology

Reservoir characterization involves the integration of a vast amount of data from seismic surveys, from geophysical well logs, and from geological samples. In this study, firstly we calculate porosity and permeability of different formation of reservoir from well log data (Appendix-1-3) collected from Bangladesh Gas Field Company Limited (BGFCL) with kind permission from Bangladesh Oil Gas and Mineral Corporation (Petrobangla).

3.1. Data Calculation

Formation porosity was determined from the density log and neutron log

3.1.1. Porosity Determination

Porosity from density Log

The bulk density is the overall gross or weighted-average density of a unit of the formation. It can be expressed by

$$\rho_b = \phi\rho_f + (1-\phi)\rho_{ma} \quad 3.1$$

Solving for porosity yields,

$$\phi_D = (\rho_{ma} - \rho_b)/(\rho_{ma} - \rho_f) \quad 3.2$$

Where, $\rho_{ma}$is the densityof the rock matrix, ρ_b is the bulk density and $\rho_f$is the formation fluid density. Common values of ρ_{ma} are given below in the table 1.

Table 1: *Common values of density of rock matrix and resistivity [7]*

Rock Type	Matrix Density (gm/cm^3)	Rock Type	Resistivity (ohm-m)
Sand or Sandstone	1.9-2.65	Compact formation	300-1000
Clay	1.1-1.8	Sandstone and Limestone	50-300
Shale	2.4-2.8	Sand and Gravel	20-100
Limestone	2.71	Clay and Shale	2-10
Dolomite	2.87		
Anhydrite	2.98		

Because of the tool's depth, it investigates the invaded zone, and the ρ_f is expressed by

$$\rho_f = S_{xo}\rho_{mf} + (1-S_{xo})\rho_h \quad 3.3$$

Where is the mud-filtrate density, S_{xo} is the mud-filtrate saturation in invaded zone, and ρ_h is the invaded zone hydrocarbon density. ρ_{mf} can be approximated according to the mud type. However we use the value of ρ_{mf} for oil-, water-, and salt-based mud are 0.9, 1, and 1.1 respectively.

Porosity from neutron log

The neutron log usually measures the hydrogen density of a formation. Neutron porosity (φ_N) can computed directly from the logs (Appendix-2). However, investigating the effect of hydrocarbons on the neutron and density logs, [8] have shown that, a range of reasonable and practical values of S_{xo}, a good approximation is

$$\phi = \{(\phi_D^2 + \phi_N^2)/2\}^{1/2} \quad 3.4$$

3.1.2. Permeability Determination

Permeability value were calculated using empirical models are given below-

Empirical Models

A more general empirical relationship, proposed by [9] is

$$K = C\phi^{x}/(S_{wi})^{y} \quad 3.5$$

The most two common relationships with which permeability can be estimated from porosity and irreducible water saturation derived from equations 3.6 and 3.7 from well logs are according to [10, 11] respectively

$$K^{1/2} = 250(\phi^{3}/S_{wi}) \quad 3.6$$

$$K^{1/2} = 100(\phi^{2.25}/S_{wi}) \quad 3.7$$

Where, K is permeability (md), φ is porosity, and S_{wi} is irreducible water saturation

3.2. Lithology Determination

Lithology of different strata is determined on the basis of reference values of density, gamma ray and resistivity of different rock types. For example, if the density of a rock matrix is 2.19 and the value of resistivity is 100, than the rock matrix will be Sandstone. However, the common values of density and resistivity (Table 1), of different rock matrix were used to established lithology of the field.

3.3. Data Analysis and Modeling

We analyses the log data on the basis of porosity and permeability with depth variation as described in previous section (3.1). After calculation, we modeled the Habiganj Gas Field using reservoir modeling software Rock Works 14®.

4. Result and Discussion

Well log data of four wells of Habiganj Gas Field (HBJ-7, HBJ-8, HBJ-9, and HBJ-10) were analyzed to identifying the prospective reservoir formation. We mainly analyzed the Upper gas sand layer of the gas field. The upper gas sand layer lies at a depth from 1320 m to 1550 m [12]. According to our data analysis, the Habiganj Gas Field has mostly Sandstone and Shale and they belong to the Bhuban and Bokabil formation of Surma Group of Miocene-Pliocene age [13]. Most of the analyzed well shows a consistent value of porosity (30-35%) and permeability (2000-3000 mD) with some exceptions. The average porosity of HBJ-7 lies between 30 to 35% and average permeability lies between 3000 mD to 4000 mD. A major decrease of porosity and permeability occur near about the depth of 1375 m and a major increase of porosity and permeability occur near about the depth of 1400 m. For HBJ-8, average porosity lies between 35 to 45% and average permeability lies between 8400mD to 12600mD. A major decrease of porosity and permeability occur near about the depth of 1470 m and a major increase of porosity y and permeability occur near about the depth of 1415m. In HBJ-9, average porosity ranges between 30 to 40% and average permeability between 4000mD to 8000mD. A major decrease of porosity and permeability occur near about the depth of 1400 m and a major increase of porosity and permeability occur near about the depth of 1420 m. average porosity lies between 30 to 35% and average permeability lies between 500mD to 2000mD for HBJ-10. A major decrease of porosity and permeability occur near about the depth of 1410 m and a major increase of porosity and permeability occur near about the depth of 1500 m. These findings are consistence with the previous result (Imam, 2005). However, the Figs. 2 and 3 are evident that there is a thick (~40 m, depth between 1410 to 1450 m) sand layer of HBJ-8 with abnormal value of porosity (>43%) and permeability (>10 D) which indicative for reservoir fracture [14]. Moreover, HBJ-9 also shows two prospective layers with 30-40% porosity and greater permeability (8000-16000 mD). However, these two layers have thickness ~15 m and ~20 m, respective (Fig. 2).

Characterizing a reservoir is very complicated with little data. By this, only approximation of the performance of the reservoir can be done, not the exact prediction. From the stratigraphical model (Fig.3) it is clear that the structure of Habiganj Gas field is almost symmetrical and trending SSE, which supports the structure of Surma Basin. The multi-log 3-D model shows both lithology and stratigraphy, which resemblance with the lithology and stratigraphy of Surma Basin. Again, the correlation between wells (Fig.4) shows that there is continuity among different layers of reservoir of different stratigraphy. For example, if we connect the layers of Bokabil formation of different wells, it shows a continuous layer of Bokabil formation among wells.

5. Conclusion

Characterizing a gas reservoir is a complex procedure and in most of the cases the gas reservoir are associated with heterogeneity. Though the data is not sufficient for modeling a big and an excellent reservoir like Habiganj Gas Field, however we try to understand the nature of Habiganj Gas Field. Modeling results indicates that there are some remarkable features like faults in the upper sand land of Habiganj Gas Field that was unrevealed. Moreover, 3-D model can predict and maintain the reservoir performance.

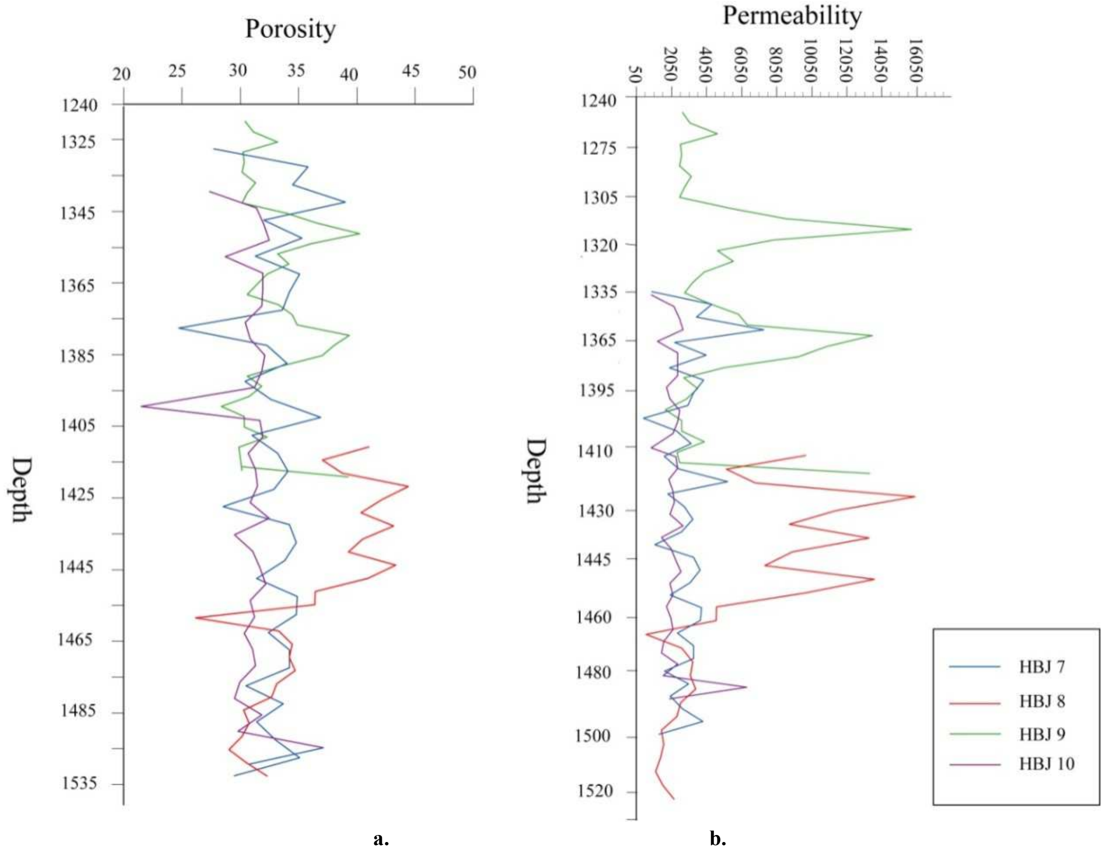


Fig. 2: *a) Porosity and b) permeability of different wells of Habiganj Gas Field*

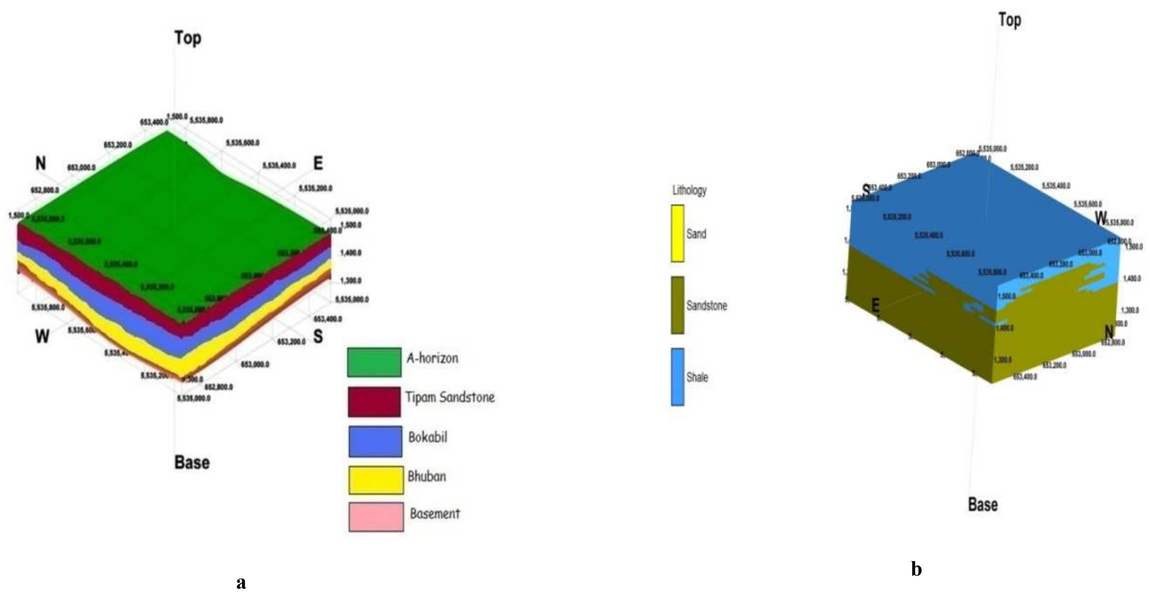
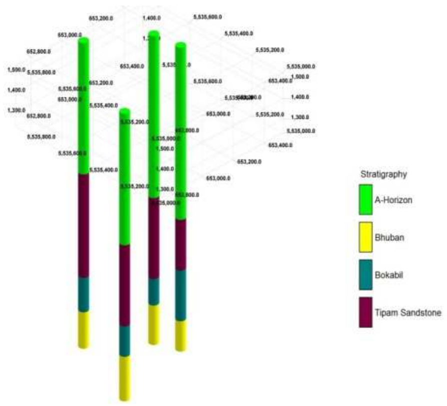
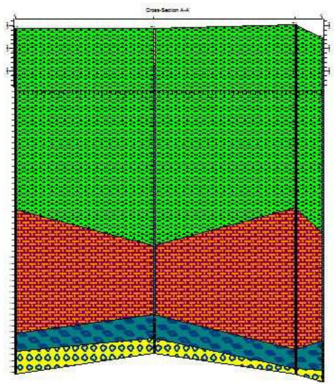


Fig. 3: *a) Stratigraphic and b) Lithological model of Habiganj Gas Field*



a



b

Fig. 4: *a) Multi-log 3d (stratigraphy) and b) Section straight-line correlations*

Appendix 1

Log data of HBJ-7

Depth, m	Density (gm/cc)	Resistivity (ohm-m)	Neutron (%)
1325	2.193633	100	21
1330	2.059563	150	25
1335	2.081169	200	21
1340	2.0065	55	39
1345	2.121742	30	31
1350	2.067454	200	27
1355	2.133205	65	21
1360	2.070617	250	21
1365	2.085613	100	24
1370	2.095713	90	24
1375	2.242981	50	31
1380	2.11738	300	22
1385	2.089728	300	25
1390	2.147765	100	22

Depth, m	Density (gm/cc)	Resistivity (ohm-m)	Neutron (%)
1395	2.112166	270	19
1400	2.040951	205	31
1405	2.137702	100	22
1410	2.102135	260	21
1415	2.086941	300	27
1420	2.107127	190	22
1425	2.179099	90	30
1430	2.085613	250	24
1435	2.075928	50	39
1440	2.091675	390	21
1445	2.132152	100	17
1450	2.07368	180	26
1455	2.075454	300	24
1460	2.115721	160	24
1465	2.085613	300	24
1470	2.085613	200	24
1475	2.147359	330	16
1480	2.094241	200	30
1485	2.132152	195	17
1490	2.1055	40	33
1495	2.071558	125	33
1500	2.16374	120	21

Log data of HBJ-8

Depth, m	density %	Resistivity (ohm-m)	Neutron (%)
1400	35	2.6	51
1405	28	2.6	48
1410	30	2.6	50
1415	40	2.6	54
1420	38	2.6	51
1425	36	2.7	49
1430	38	2.6	53
1435	35	2.6	50
1440	33	2.6	49
1445	37	2.6	54
1450	30	2.7	54
1455	26	2.8	48
1460	24	3	49
1465	24	5	30
1470	21	3.6	45
1475	21	4	47

Depth, m	density %	Resistivity (ohm-m)	Neutron (%)
1480	20	4.1	47
1485	22	4.4	47
1490	18	5.3	46
1495	16	6.8	46
1500	38	40	24
1505	40	81	22
1510	40	110	20
1515	39	105	18
1520	34	28	30
1525	35	25	33

Log data of HBJ-9

Depth, m	density (gm/cc)	Resistivity (ohm-m)	Neutron (%)
1250	2.26	7.5	37
1255	2.25	6.7	38
1260	2.18	6.8	39
1265	2.27	5.8	37
1270	2.24	5.1	36
1275	2.25	4.8	36
1280	2.2	4.4	36
1285	2.25	4.4	37
1290	2.25	4.2	36
1295	2.15	4	39
1300	2.1	3.6	42
1305	1.97	3.4	43
1310	2.12	3.2	42
1315	2.18	3.1	39
1320	2.16	3	40
1325	2.22	3	39
1330	2.24	3.1	38
1335	2.25	3.1	37
1340	2.2	3.1	40
1345	2.17	3.2	41
1350	2.15	3.2	41
1355	1.99	3.1	42
1360	2.04	3.1	42
1365	2.08	3.2	42
1370	2.16	3.3	39
1375	2.23	3.5	36
1380	2.22	3.5	38
1385	2.2	4	35
1390	2.31	3.8	35
1395	2.24	3.7	36
1400	2.24	3.6	36
1405	2.22	3.7	39
1410	2.24	3.8	35
1415	2.25	3.6	36
1420	1.96	3.3	40

Log data of HBJ-10

Depth, m	Density (gm/cc)	Resistivity (ohm-m)	Neutron (%)
1335	2.097	30	24
1340	2.0295	45	28
1345	1.8925	200	15
1350	1.871	700	14
1355	2.069	180	25
1360	1.899	500	17
1365	1.894	250	17
1370	1.8845	500	14
1375	1.9555	100	18
1380	1.9405	150	15
1385	1.899	280	18
1390	1.8875	550	14
1395	1.909	770	14
1400	2.335	165	20
1405	1.904	310	16
1410	1.902	800	17
1415	1.933	640	17
1420	1.9275	550	17
1425	1.896	500	15
1430	1.9165	920	15
1435	1.873	1500	14
1440	1.97	550	17
1445	1.9175	850	16
1450	1.911	330	16
1455	1.8875	850	16
1460	1.9215	300	15
1465	1.892	300	14
1470	1.963	30	20
1475	2.0135	80	27
1480	1.9085	110	17
1485	2.0195	120	24
1490	2.001	140	21
1495	1.899	300	17
1500	2.318	30	32
1505	1.871	33	31
1510	2.0515	26	29

Appendix 2

Data Analysis of HBJ-7

	Porosity		Permeability		
Depth, m	φ_D%	φ_{D-N}%	KTixier, mD	KTimur, mD	Lithology
1325	33	27.7	1093.011	1202.26	sandstone
1330	44	35.8	5126.002	3831.458	sandstone
1335	44	34.5	4098.62	3239.725	sandstone
1340	39	39	8590.683	5643.529	sandstone
1345	33	32	2629.128	2322.142	sandstone
1350	42	35.3	4728.429	3606.348	sandstone
1355	39	31.3	2304.873	2103.853	sandstone
1360	45	35.1	4576.456	3519.062	sandstone
1365	42	34.2	3910.188	3127.362	sandstone
1370	41	33.6	3508.688	2883.292	sandstone
1375	16	24.7	550.0749	718.367	sandstone
1380	40	32.3	2762.124	2409.697	sandstone
1385	41	34	3742.208	3026.049	sandstone
1390	37	30.4	1941.674	1849.96	sandstone
1395	42	32.6	2928.376	2517.678	sandstone
1400	42	36.9	6175.179	4405.723	sandstone
1405	38	31	2187.113	2022.709	sandstone
1410	42	33.2	3271.718	2735.973	sandstone
1415	40	34.1	3855.303	3094.382	sandstone
1420	41	32.9	3096.876	2625.565	sandstone
1425	27	28.5	1319.208	1384.411	sandstone
1430	42	34.2	3910.188	3127.362	sandstone
1435	30	34.8	4330.464	3376.221	sandstone
1440	43	33.8	3664.853	2979.013	sandstone
1445	41	31.4	2333.183	2123.203	sandstone
1450	42	34.9	4433.223	3436.131	sandstone
1455	43	34.8	4351.964	3388.785	sandstone
1460	39	32.4	2814.138	2443.65	sandstone
1465	42	34.2	3910.188	3127.362	sandstone
1470	42	34.2	3910.188	3127.362	sandstone
1475	40	30.5	1951.12	1856.705	sandstone
1480	37	33.7	3564.951	2917.898	sandstone
1485	41	31.4	2333.183	2123.203	sandstone
1490	33	33	3152.998	2661.171	sandstone
1495	37	35.1	4532.061	3493.428	sandstone
1500	36	29.5	1599.372	1599.529	sandstone

Data Analysis of HBJ-8

	Porosity	Permeability		
Depth, m	φ_D%	KTixier, mD	KTimur, mD	Lithology
1400	43.73786	9921.706	5488.076	Shale
1405	39.29377	5261.549	3388.581	Shale
1410	41.23106	6962.868	4207.959	Shale
1415	47.51842	16315.98	7969.669	Shale
1420	44.97221	11724.84	6220.29	Shale
1425	42.99419	8951.582	5080.485	Shale
1430	46.11399	13628.17	6963.195	Shale
1435	43.15669	9156.516	5167.471	Shale
1440	41.7732	7530.568	4462.735	Shale
1445	46.28715	13938.11	7081.631	Shale
1450	43.68066	9844.112	5455.854	Shale
1455	38.60052	4688.136	3127.739	Shale
1460	38.58108	4673.992	3120.659	Shale
1465	27.16616	569.6532	643.707	Shale
1470	35.1141	2656.627	2042.812	Shale
1475	36.40055	3296.773	2401.857	Shale
1480	36.11786	3146.108	2319.053	Shale
1485	36.69469	3459.876	2490.438	Shale
1490	34.9285	2573.481	1994.67	Shale
1495	34.43835	2364.261	1871.768	Shale
1500	31.7805	1460.177	1304.021	sandstone
1505	32.28002	1603.41	1398.826	sandstone
1510	31.62278	1417.234	1275.15	sandstone
1515	30.37269	1112.604	1063.496	sandstone
1520	32.06244	1539.646	1356.894	sandstone
1525	34.0147	2195.035	1770.36	sandstone

Data Analysis of HBJ-9

	Porosity		Permeability		
Depth, m	ϕ_D%	φ_{D-N}%	KTixier, mD	KTimur, mD	Lithology
1250	26.3	32.1	2673.703	2351.608	Shale
1255	26.9	32.9	3108.225	2632.778	Shale
1260	31	35.2	4664.07	3569.471	Shale
1265	25.7	31.9	2557.018	2274.209	Shale
1270	27.5	32	2634.695	2325.829	Shale
1275	26.9	31.8	2514.044	2245.482	Shale
1280	29.8	33.1	3185.702	2681.846	Shale
1285	26.9	32.3	2796.627	2432.237	Shale
1290	26.9	31.8	2514.044	2245.482	Shale

	Porosity		Permeability		
1295	32.7	36	5323.437	3941.614	Shale
1300	35.7	39	8544.41	5620.715	Shale
1305	43.3	43.1	15731.81	8884.112	Shale
1310	34.5	38.4	7870.11	5284.642	Shale
1315	31	35.2	4664.07	3569.471	Shale
1320	32.2	36.3	5580.175	4083.343	Shale
1325	28.7	34.2	3920.762	3133.703	Shale
1330	27.5	33.2	3247.058	2720.492	Shale
1335	27	32.3	2796.627	2432.237	Shale
1340	29.8	35.3	4208.567	3594.981	Shale
1345	31.6	36.6	5862.646	4237.407	Shale
1350	32.7	37.1	6370.735	4509.955	Shale
1355	42.1	42.1	13502.1	7921.928	Sandstone
1360	39.2	40.6	10958.86	6774.138	Sandstone
1365	36.8	39.5	9280.548	5980.124	Sandstone
1370	32.2	35.7	5093.085	3812.99	Sandstone
1375	28.1	32.3	2761.865	2409.527	Sandstone
1380	28.7	33.7	3546.634	2906.647	Sandstone
1385	29.8	32.5	2885.2	2489.785	Sandstone
1390	23.4	29.8	1698.522	1673.337	Sandstone
1395	27.5	32	2634.695	2325.829	Sandstone
1400	27.5	32	2634.695	2325.829	Sandstone
1405	28.7	34.2	3920.762	3133.703	Sandstone
1410	27.5	31.5	2370.496	2148.619	Sandstone
1415	26.9	31.8	2514.044	2245.482	Sandstone
1420	43.9	42	13351.66	7855.638	Sandstone

Data Analysis of HBJ-10

	Porosity		Permeability		
Depth, m	ϕ_D%	φ_{D-N}% [0,1]	KTixier, mD	KTimur, mD	Lithology
1335	33.5	28.3	1107.266143	1177.754	sandstone
1340	37.6	32.8	2697.89052	2296.856	sandstone
1345	45.9	33.5	3079.213259	2536.269	sandstone
1350	47.2	34	3340.84	2696.232	sandstone
1355	35.2	29.8	1527.158947	1498.921	sandstone
1360	45.5	33.4	2977.708777	2473.302	sandstone
1365	45.8	33.4	2977.708777	2473.302	sandstone
1370	46.4	33.3	2961.680613	2463.311	sandstone
1375	42.1	31.7	2178.8899	1956.78	sandstone
1380	43	32.2	2411.671159	2111.563	sandstone
1385	45.5	33.6	3120.450526	2561.701	sandstone
1390	46.2	33.3	2961.680613	2463.311	sandstone
1395	44.9	32.6	2619.715641	2246.757	sandstone
1400	19.1	20	138.4083045	247.5923	sandstone
1405	45.2	33.1	2847.172503	2391.53	sandstone
1410	45.3	33.4	2977.708777	2473.302	sandstone
1415	43.5	32	2339.155765	2063.763	sandstone
1420	43.8	32.7	2641.895608	2261.009	sandstone
1425	45.7	32.9	2728.076232	2316.103	sandstone
1430	44.5	32.2	2411.671159	2111.563	sandstone
1435	47.1	34	3340.84	2696.232	sandstone
1440	41.2	30.7	1822.166969	1711.223	sandstone
1445	44.4	32.4	2521.44081	2183.243	sandstone
1450	44.8	33.1	2847.172503	2391.53	sandstone
1455	46.2	33.7	3208.24906	2615.571	sandstone
1460	44.2	32.2	2411.671159	2111.563	sandstone
1465	45.9	32.6	2619.715641	2246.757	sandstone
1470	41.6	31.6	2162.631152	1945.819	sandstone
1475	38.6	32.4	2496.368425	2166.941	sandstone
1480	44.9	32.7	2641.895608	2261.009	sandstone
1485	38.2	31.2	1989.073429	1827.484	sandstone
1490	39.3	30.7	1810.614558	1703.08	sandstone
1495	45.5	33.3	2977.708777	2473.302	sandstone
1500	31	31	1925.338008	1783.388	sandstone
1505	47.2	39.2	7875.4405	5129.46	sandstone
1510	36.3	32.1	2383.874309	2093.283	sandstone

References

[1] Sultan, J B M Reservoir characterization of Habigonj Gas Field using empirical methods, *unpublished B.Sc thesis*, 2011, Shahjalal University of Science and Technology, Sylhet, Bangladesh.

[2] Johnson, S Y and Alam, A M N Sedimentation and tectonics of the Sylhet trough, Bangladesh. Geological Society of America Bulletin, 1991.103,1513–1527.

[3] Hunting, Aeromagnetic survey of Bangladesh. Geology and Geophysics Ltd.1980

[4] Evans, P The tectonic framework of Assam, Journal Geological Society of India, 1964. 5, 80–96.

[5] Hiller, K and Elahi, M Structural development and hydrocarbon entrapment in the Surma Basin, Bangladesh (northwest Indo-Burman fold belt), *Singapore Fifth Offshore Southwest Conference,*1984. 656–663.

[6] Rahman, M. J J , and McCann, T Diagenetic history of the Surma Group sandstones (Miocene) in the Surma Basin, Bangladesh, Journal of Asian Earth Sciences, 2012. 45(2), 65–78

[7] Schlumberger, Oil field Review, 2012, 84-86.

[8] Gaymard, R and Poupon, A Response of neutron and formation density logs in hydrocarbon bearing formations, The Log Analyst, 1968, 9, 3 - 12.

[9] Wyllie, M R J and Rose, W D Some Theoretical Considerations Related to the Quantitative Evaluation of the Physical Characteristics of Reservoir Rock from Electric Log Data, Trans., AIME, 1950, 189, pp105.

[10] Tixier, MP Evaluation of permeability from Electric-Log Resistivity Gradients, Oil & Gas Journal, 1949. 113.

[11] Timur, AAn investigation of permeability, porosity, and Residual Water Saturation relationship for sandstone Reservoirs, The Log Analyst, 1968. 9(4),90-123.

[12] Imam, B *Energy Resources of Bangladesh*, University Grants Commission Publication, 2005, pp280.

[13] Reimann, K.-U., 1993. *Geology of Bangladesh*. Gebrüder Borntraeger, Berlin. Schlumberger Log Interpretation Principles/Application; Seventh printing, March 1998 © Schlumberger 1991; Selley, RElements of Petroleum Geology, 2nd edition, 1998. 470

[14] Laongsakul, P and Dürrast, H Characterization of reservoir fractures using conventional geophysical logging, 2011. 33 (2), 237-246.