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Full Length Research Paper

Prediction of formation water resistivity from R_{wa} analysis of Titas gas field using wireline log data

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Abstract

The Titas gas field is the biggest gas field in Bangladesh which lies in the south central part of the Surma Basin. This paper predicts the formation water resistivity from wireline log data by Inverse Archie's formula (R_{wa} analysis). The formation water resistivity is the most important rock fluid properties for saturation (water or hydrocarbon) and salinity of NaCl estimation, Petrophysical analysis and Formation evaluation in the Petroleum field. The geothermal gradient ranges from 1.68-2.44 ^{0}C per 100 meter following surface temperature at 25 ^{0}C. The average formation temperature is 80.92 ^{0}C of A_2 gas sand based on log data. The average formation water resistivity is 0.139 ohm-meter based on R_{wa} analysis and salinity of NaCl is 19670 mg/L of A_2 gas sand which implies that the formation water resistivity value is slightly lesser than the assumed value by Reservoir Management Project-2 of Petrobangla (2009) and Interkomp Kanata Management (1991). Though, the estimated value is slightly lesser but more reliable for calculating water or hydrocarbon saturation and formation evaluation of Titas gas field.

Keywords: Titas Gas Field, Geothermal Gradient, Formation Temperature, Formation Water Resistivity

INTRODUCTION

The Titas gas field is situated in Brahmanbaria district in the vicinity of Brahmanbaria town about 4 km north of Brahmanbaria town and 96 km ENE of Dhaka, Bangladesh and also this field lies in the south central part of the Surma Basin and on the western margin of the Tripura high. Interkomp Kanata Management (IKM) studied about Geological, Geophysical and Petrophysical Analysis of the Titas Gas Field in December, 1991 based on combined evidence of seismic data, well data and log data. In Petrobangla, RMP-2 also studied about Petrophysical analysis of Titas gas field based on Petro Log software in 2009. From the previous studies, it is clear that no research has yet been performed on the present research. Thus, the objectives of this study are the prediction of formation water resistivity from R_{wa} analysis based on wireline log data and salinity of NaCl (mg/L) in this field.

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MATERIALS AND METHODS

Formation water sometimes called connate water is the water, uncontaminated by drilling mud that saturates the porous formation rock. The resistivity of this formation water (R_w) is important interpretation parameters since it is required for the calculation of saturation (water or hydrocarbon) from basic resistivity logs. There are several sources for formation water resistivity information which includes SP curve, chemical analysis, water catalogs and various resistivity-porosity computations and also cross plots (Schlumberger, 1998a). Geothermal gradient has been calculated using the following equation (Bassiouni, 1994): $G_g = [\{(BHT-T_s)/TD\}\times 100]$ where BHT is the Bottom Hole Temperature in ^{0}C, T_s is the surface (ambient) temperature in ^{0}C and TD is the Total Depth in meter. Also formation temperature (T_f) has been estimated using equation (Bassiouni, 1994): $T_f = [T_s + (Gg/100)]$. The R_w calculated from R_{wa} analysis (Archie, 1942) using wireline log data. The steps of calculating the R_w are as follows:

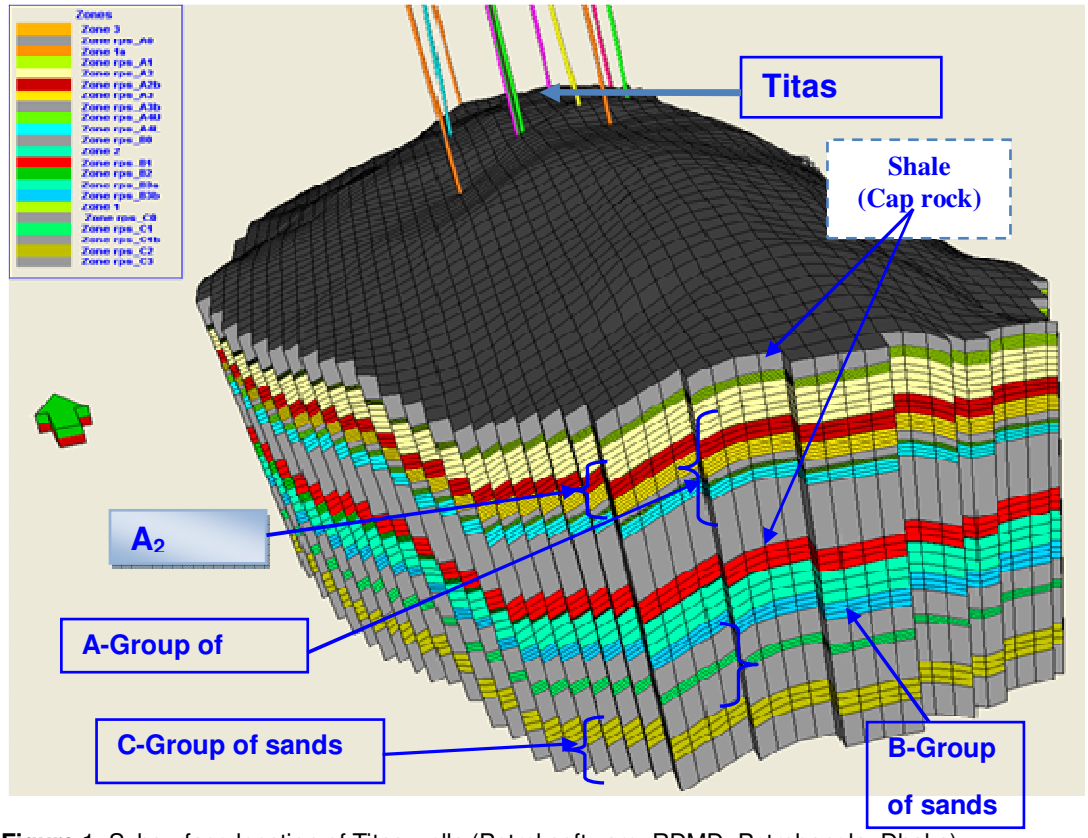

Figure 1. Subsurface location of Titas wells (Petrel software, RDMD, Petrobangla, Dhaka)

Step-1: Estimation of True resistivity, R_t from Deep Induction log

Step-2: Determination of porosity (Φ_{N-D}) from Neutron Density combination formula (Asquith, 1982)

Step-3: Calculation of Rw from Rwa analysis, Rwa = [(ΦN-D ^{m} * Rt)/a] in wet sand zone where a and m are the tortousity and cementation exponent, respectively

Step-4: Prediction of Rw at formation temperature and depth.

Finally, salinity of NaCl (mg/L) calculated using Chart Gen-9 at formation temperature (Schlumberger, 1998b).

Data quality and modification

Titas well no. 1, 2, 10, 11,1 2 and 13 (Figure-1) have been selected from South-North direction which have all logs data available as Caliper log (Borehole measurement log), Lithology log (Gamma Ray and Self-Potential logs), Compensated Neutron and Density porosity logs, and Resistivity logs. The quality of log data of studied well is good. In all studied wells caliper log shows borehole caving and washout which indicates shale zone, and mud-cake is so small but negligible to count at the hydrocarbon bearing sand intervals. No environmental corrections have been applied in the value of Gamma Ray and SP logs.

RESULTS OF ANALYSIS AND DISCUSSIONS

Petrophysical zonation has been used based on the log responses especially on Gamma Ray log response throughout the A_2 gas sand. Shale and sand zone have been identified with respect to Gamma Ray and SP log responses (well no. 11). High and low GR response indicates the shale or clay zone and clean sand zone, respectively. The major gas sand of A-group is A_2 gas sand. The used surface temperature (T_s) is 25 ^{0}C. BHT (^{0}C) and TD (m) have been considered with respect to several wells from log header which is shows in Table 1.

From the analysis it is found that True formation water resistivity ranges from 16-32 ohm-m of A_2 gas sand. The estimated geothermal gradient and average formation temperature ranges from 1.68-2.44 ^{0}C per 100 meter and 70.66-90.39 ^{0}C, respectively. In R_{wa} analysis, the tortousity factor (a) of 1.0 and cementation exponent (m) of 2.25 (IKM, 1991) has been used in this research. Pure water bearing sands are un-common in Titas wells. The common water bearing major sand overlying A-group of sands is found in all wells (IKM, 1991a). In well no. Titas-11, some water bearing zones found above this major water bearing sand. R_{wa} analysis has been used from taking data of several water bearing sands in well no. Titas-11. The minimum

Table 1. Predicted formation water resistivity and NaCl salinity of Hydrocarbon (gas) sand zone

A_2 gas sand	Depth interval (meter)	TD (meter)	BHT (^{0}C)	G_g per 100m	Tf (^{0}C)	Rw (ohm-m)	NaCl (mg/L)
Well. 1	2668-2694	2916	96.11	2.44	90.39	0.127	19800
Well. 10	3159-3241	3669	93.33	1.86	84.33	0.134	19750
Well. 11	2651-2701	3187	79.44	1.71	70.66	0.154	19500
Well. 12	2778-2790	3000	86.67	2.06	82.41	0.137	19700
Well. 13	3058-3090	3234	79.44	1.68	76.79	0.144	19600

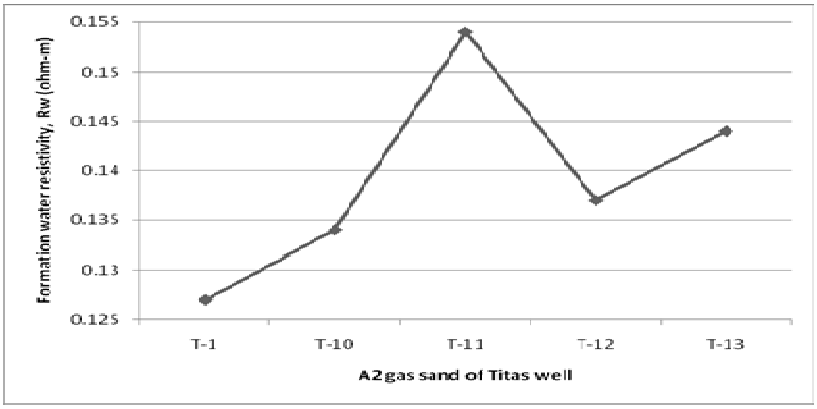

Figure 2: Formation water resistivity vs. different wells of Titas gas field

value of R_w is 0.179 ohm-m and porosity 23.4 % (fluid and grain density 1 and 2.68 gm/cc, respectively (IKM, 1991)) found in interval from 2220 to 2226 meter. Considering this interval, R_w calculated for hydrocarbon bearing gas zones and corrected them for formation temperature with respect to depth. The all result is summarized shown in Table1. The formation geothermal gradient changes from well to well because of bottom-hole temperature and other rock properties.

From R_{wa} analysis, it is found that well no. Titas-11 shows highest amount of formation water resistivity being 0.154 ohm-m and lowest is 0.127 ohm-m in well no. Titas-1. Except these wells, other wells show Rw ranges from 0.134-0.144 ohm-m. The average formation water resistivity is 0.139 ohm-m in hydrocarbon (gas) bearing of A_2 sand. Average formation salinity 19670 mg/L of NaCl at formation temperature using Chart Gen-9 of Schlumberger (1998b). Figure 2 shows average R_w vs. A_2 gas sand of Titas wells from R_{wa} analysis. Formation water resistivity increases from South to North direction for A_2 gas sand reservoir which indicates that gas saturation will be decreases in this direction.

CONCLUSIONS

In the present research, the prediction of formation water resistivity from R_{wa} analysis of Titas gas field has been performed based on wireline log data. The results shows that the average geothermal gradient is 1.95 ^{0}C per 100 meter following surface temperature at 25 ^{0}C. The average formation temperature is 80.92 ^{0}C of A_2 gas sand based on log data. Reservoir formation temperature and water resistivity varies from depth to depth. The average formation water resistivity is 0.139 ohm-meter based on R_{wa} analysis of A_2 gas sand which implies that the formation water resistivity value is a slightly lesser than the assumed value of 0.34 and 0.304 ohm-m by Reservoir Management Project-2 of Petrobangla (2009) and IKM (1991), respectively. R_w is important parameters since it is required for the calculation of water saturation from basic resistivity – porosity logs. Average salinity of A_2 sand is estimated about 19670 mg/L of NaCl with respect to average R_w value. The estimated geothermal gradient can be used to calculating the formation temperature at any subsurface depth in this field. The predicted Rw value is more reliable for calculating water or hydrocarbon saturation and formation evaluation than the other previous studies for A_2 gas sand of Titas gas field.

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