Impact on Estimation of Water Saturation Values Using Laboratory Determined 'a', 'm' & 'n' Parameters – A Case Study

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Summary

This paper deals with the laboratory determination of petrophysical parameters and their inter-relationships on core samples of Upper and Middle Bhuban formations of Baramura field of A & AA Basin. In the absence of the laboratory determined parameters, the conventional 'a', 'm' & 'n' parameters being used were 0.62, 2.15 & 1.80 which overestimate the water saturation values. The laboratory determined values of 'a', 'm' & 'n' parameters were found to be '1.10', '1.89' & '1.46' and '0.90', '1.88' & '1.40' for Upper and Middle Bhuban formations respectively. The data thus generated was validated against water bearing zones. The hydrocarbon saturations for Upper and Middle Bhuban formations have increased by about 5 to 10 % as compared with the earlier estimated values using conventional parameters.

These parameters were also successfully used in the study undertaken to evaluate hydrocarbon potential of Bhuban formation by Petrophysics Division of KDMIPE.

Introduction

The electrical properties of reservoir rocks are very important in the quantitative well log interpretation. For clean formations, Archie gave the following relationships which form the basis for interpretation of well logs:

a) $$F = \frac{R_o}{R_w} = \frac{a}{\phi^m}$$

b) $$RI = \frac{R_t}{R_o} = S_w^{-n}$$

Where F is the formation factor,

R_o – Resistivity of the rock 100% saturated with the formation fluid

R_t – Resistivity of the partially saturated rock

R_w – Resistivity of formation water

RI – Resistivity Index

a, m & n are constants and normally derived from core analysis in the laboratory at ambient conditions. In the absence of the core derived data, the normal practice is to take the values a = 1, m = 2 & n = 2. For Upper and Middle Bhuban formations, the 'a', 'm' and 'n' parameters being used were a = 0.62, m = 2.15 and n = 1.80 Main producing formation in Baramura structure is Bhuban formation. Conventional interpretation techniques using conventional 'a', 'm' & 'n' parameters do not yield realistic water saturation values. Humble's parameters were being used for evaluation of water saturation values in the wells in this structure.

The study has been carried out on 104 core plugs of 1" diameter of Upper and Middle Bhuban formations from four wells of Baramura (Lal & Bahuguna, April, 2000) under ambient conditions. These parameters were then used to calculate water saturation values in the study undertaken to evaluate the hydrocarbon potential of Bhuban formation (Sharma et al. May, 2001).

Methodology & Results

Initially, porosity and Matrix density of individual dry core plugs were determined with the help of 'Helium porosimeter' using Boyle's Law. Plugs were then fully saturated with brine of 200 gm/lit NaCl salinity and their porosities and saturated bulk densities determined. The Matrix density 'ρ_m' was determined from cross plot of porosity vs saturated bulk density. The resistivity 'R_o' was measured with the help of a digital resistivity meter. Flim was then calculated using

$$F_{lim} = \frac{R_o}{R_w}$$

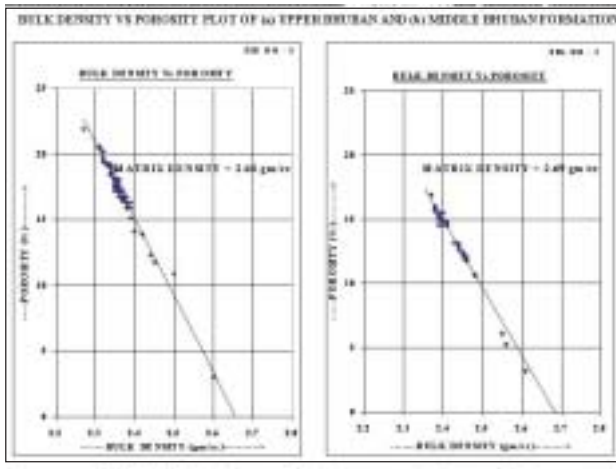

Fig 1&2

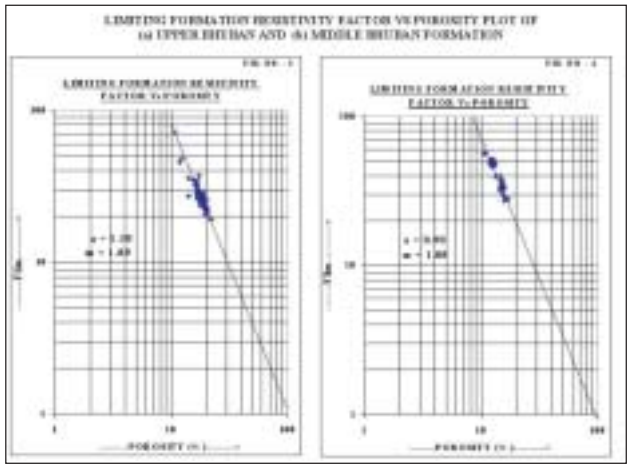

Fig 3&4

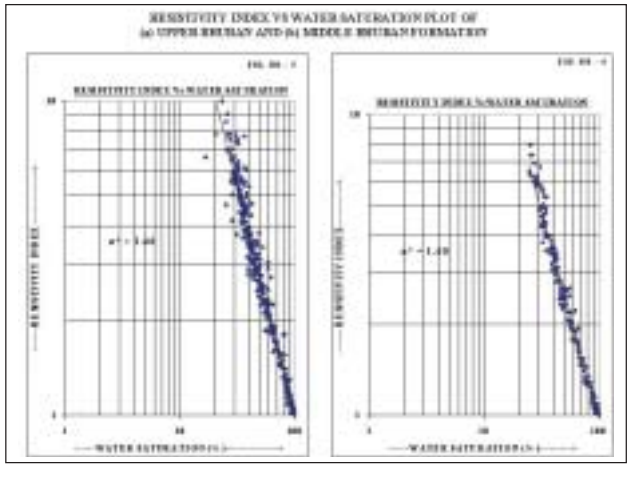

Fig 5&6

The cross plot of Flim and porosity on log-log scale yields the values of 'a' and 'm'.For the measurement of 'n', the fully saturated core plugs were subjected to desaturation at successively increasing speeds in a centrifuge. At each stage, the resistivity R_t of each plug is measured with the help of a resistivity meter. The values of resistivity index 'I' and corresponding water saturation 'Sw' were then plotted on log – log scale. The slope of the line gives the value of 'n*'

The formation under study was known to have low to good porosity. Accordingly, the porosity of the core plugs is found to lie between 3% to 22%. The core plugs also covered a wide range of permeabilities from very low to very good. Average values of Matrix density are found to be 2.66 gm/cc and 2.69 gm/cc. for Upper and Middle Bhuban formations

There was a good correlation between porosity and Flim yielding 'a' and 'm' values of 1.10 & 1.89 and 0.90 & 1.88 for Upper and Middle Bhuban formations respectively. The correlation between water saturation values 'Sw' and resistivity index 'I' was also very good which gave the values for the saturation exponent 'n*' as 1.46 & 1.40 for the two formations. The values of the electrical parameters thus established were then validated using Indonesian equation against water bearing zones of the formation. Subsequently, water saturations 'Sw' at various depths were calculated using laboratory determined parameters as given in Table Nos. 1 & 2.

Conclusions

The 'a', 'm' & 'n' parameters which were being used in the absence of laboratory determined parameters were significantly different. Therefore, the effect of these parameters on hydrocarbon saturations cannot be ignored. These parameters have been validated against water bearing zones and used in the study to develop interpretation model for Bhuban formations for evaluation of their hydrocarbon potential. The hydrocarbon saturations for Upper and Middle Bhuban formations have increased by about 5 to 10 % as compared with the earlier estimated values using conventional parameters. The study will help in evolving strategy for the development of the field and realistic estimation of oil in place.

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Table No.1 : Validation of Data

WELL NO. : A						FORMATION : UPPER BHUBAN	
CONVENTIONAL PARAMETERS USED					LABORATORY GENERATED PARAMETERS		
a =0.62 m =2.15 n=1.80					a =1.10 m =1.89 n=1.46		
DEPTH (mts)	Rt (ohm-m)	Rsh (ohm-m)	Rw (ohm-m)	ϕe	Vsh	Sw (Conventional Parameters)	Sw (Lab.)
758 - 775	25	10	0.7	0.19	0.2	57	54
825 - 828	30	10	0.7	0.19	0.2	52	48
1559 - 1565	8	6	0.45	0.16	0.3	84	85
1646 - 1650	9	6	0.45	0.16	0.12	100	100
1665 - 1670	9	6	0.45	0.16	0.12	100	100

Table No.2 : Validation of Data

WELL NO. : A						FORMATION : MIDDLE BHUBAN	
CONVENTIONAL PARAMETERS USED					LABORATORY GENERATED PARAMETERS		
a =0.62 m =2.15 n=1.80					a =0.90 m =1.88 n=1.40		
DEPTH (mts)	Rt (ohm-m)	Rsh (ohm-m)	Rw (ohm-m)	ϕe	Vsh	Sw (Conventional Parameters)	Sw (Lab.)
2331 - 2334	30	10	0.3	0.12	0.2	55	42
2369 - 2379	35	10	0.3	0.14	0.2	43	32
2501 - 2550	50	10	0.3	0.14	0.2	36	25

Views expressed in this paper are that of author only and may not necessarily be of ONGC.

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