Gas Identification in Shaly Sand Reservoirs Using Neutron Porosity vs. Sonic Travel Time Log Overlay Technique – Case Studies from Tripura Basin

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Summary

Agartala Dome Structure lies in a broad synclinal area between two exposed N-S to NNW-SSE trending Baramura and Rokhia anticlines in Tripura basin. Rokhia is the westernmost folded belt of Tripura. Major accumulation of gaseous hydrocarbon lies within upper and middle Bhuban formations of Miocene age. Encouraging log responses in Bokabil sands in Agartala Dome has necessitated exploring shallow prospects also in Tripura basin.

In general, Neutron-Density overlay technique is used to identify gas sand. This technique is established very well to detect gas within clean pay sand. In shaly sand reservoirs, this technique fails to detect gas. This paper discusses a methodology to identify the gas bearing layers in shaly sand formations evaluate.

Sonic travel time is around 100 sec/ft whereas as density is 2.5 gm/cc against shale. It may be due to the presence of some clay mineral like Kaolinite and illite and heavy mineral like mica. Due to these reasons, the density and neutron porosity are comparatively higher in shaly sand. Hence, Neutron-Density cross-over is not observed clearly against shaly sand reservoirs.

Neutron porosity ($Ø_N$) – Sonic travel time (D_T) overlay technique has been used successfully to detect gas and found useful to detect gas in shaly sand reservoirs encountered in Bokabil and Bhuban formations in Tripura basin. This method can also be used as an additional technique to detect gas against the clean sand reservoirs also in this basin.

Introduction

Tripura basin covers an area of about 90,000 sq.km and is located in the northeastern part of India. This basin forms a part of Assam-Arakan frontal belt, characterized by a number of N-S trending long narrow elongated anticlines and broad flat intervening synclines, occurring in en-echelon fashion (Fig-1).

The exploration activity in Agartala Dome and Rokhia structure started in 1986 and 1988 respectively. As on date, 23 wells have been drilled in Agartala Dome out of which 10 wells are gas bearing. In Rokhia, 45 wells were drilled out of which thirty wells are gas bearing. Seven gas bearing sands have been established in Bokabil, Upper & Middle Bhuban formations of Miocene age in Agartala Dome. Twelve pay sands in Manikyanagar and five in Konaban field have been established in Rokhia structure.

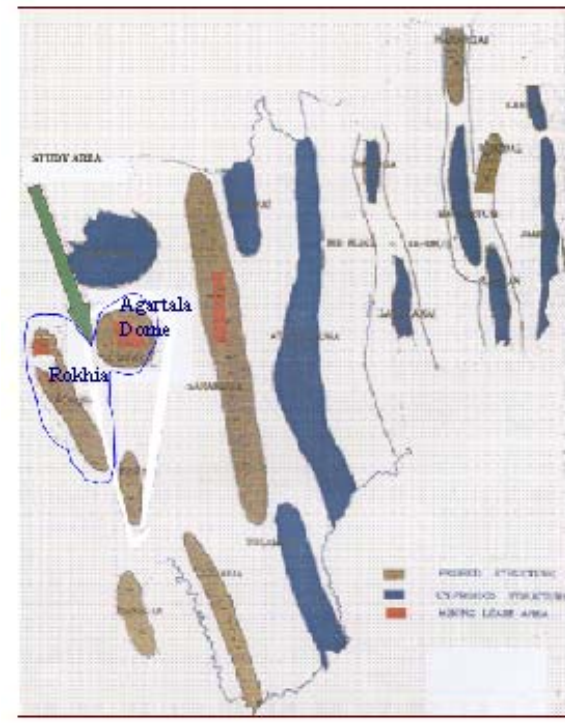

Fig.1: Prospect Map of Tripura.

The formation evaluation of twenty wells in Agartala Dome and thirty wells in Rokhia have been carried out using multi-mineral evaluation technique. The identification of gas in shaly sand reservoir in Bokabil and Bhuban formations has been difficult from well log responses**.** This paper discusses a methodology to identify gas within shaly sand reservoirs and evaluate their potential.

General Geology

Agartala dome, a geomorphic high, has been identified as a gentle and oval shaped subsurface structure concealed by the recent sediments. Subsequent geophysical surveys had brought out structural configuration of the domal features.

Rokhia anticline is the westernmost anticline of the folded bed of Assam-Arakan geosyncline. It is a gently folded, doubly plunging, near symmetrical anticline trending NNW-SSE. This structure exhibits two culminations separated by a broad saddle. The northern culmination is broadened and structurally higher than the southern culmination. The northern culmination is divided into two blocks separated by geomorphic low. The northern block is Konaban field and southern block is Manikyanagar field. Litho-stratigraphically, in both the structures, Surma group of sediments are conformally overlain by the Tipam group of sediments, which in turn are unconformably overlain by the sediments of Dupitilla formation. The same group of sediment comprises of two formations viz. Bokabil and Bhuban formations. The Bokabil formation was deposited transitional environment while Bhuban formation was deposited in the transgressive delta environment.

Methodology

Generally, the presence of gas is detected by the overlay of Density-Neutron log in clean and compacted sandstone reservoirs. In case of shaly sand reservoirs and in presence of mica in the reservoirs, this overlay technique fails to detect gas because of neutron log reads higher porosity in such formations.

Against shale section, sonic travel time is around 100 μsec/ft, whereas shale density is 2.5 gm/cc. It may be due to the presence of some clay mineral like Kaolinite, illite and mica. Due to these reasons, the density and neutron porosity are comparatively higher in shaly sands. Hence, Neutron-Density cross-over is not observed clearly in shaly sand reservoirs.

Effort has been made to detect gas in shaly sands using the overlay of Sonic travel time (D_T) and Neutron porosity logs by normalizing the two logs against water bearing sands. This technique has been used successfully and found useful to detect gas in shaly sand reservoirs encountered in Rokhia and Agartala Dome structures.

In Rokhia, reservoir rock is sandstone which constitutes silt, fine to very fine grained sand. Sometimes sandstones are intercalated with shale and clay matrix. In Agartala Dome, Bokabil formation comprises of shale with minor sandstone and Bhuban formation comprises of mainly sandstone with shale. Presence of mica is reported in Bokabil and Bhuban formations.

Discussion of Results

Well-A

This well was drilled in Agartala Dome structures. Both Neutron porosity-density and Neutron porosity – sonic travel time overlay techniques were used to identify gas in clean sands. Both the techniques show very good cross-over which confirms the presence of gas sands in the interval X720 m – X765 m. GWC is observed at X765 m (Fig-2). This sand is producing gas @ 76,000 m^3/day through 6 mm bean.

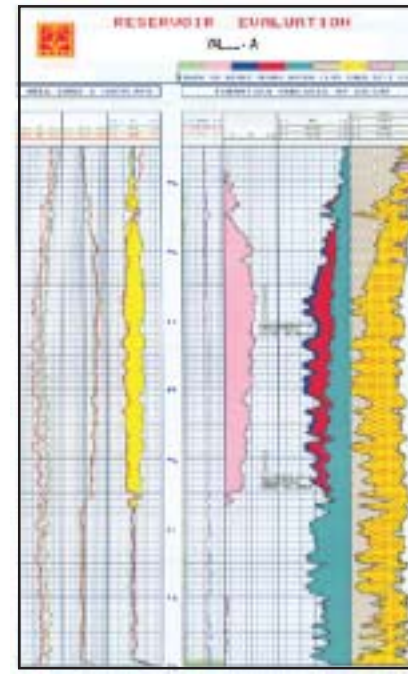

Fig.2: In the interval X720 – X765m, both Density-Neutron and Neutron-Sonic overlays show good cross-over against gas bearing clean sand in Agartala Dome field. On testing the well produced gas @76,647 m^3/day

Well-B

This well was drilled in Agartala Dome. In the interval X736 m – X771 m, the formation comprises of shaly sand. The water saturation varies from 50-80%. Both the techniques were used successfully to detect gas against this interval. Better cross-over is observed in Neutron porosity – Sonic travel time overlay (Fig-3). On testing, the interval produced gas@81785 m^3/day through 6 mm choke.

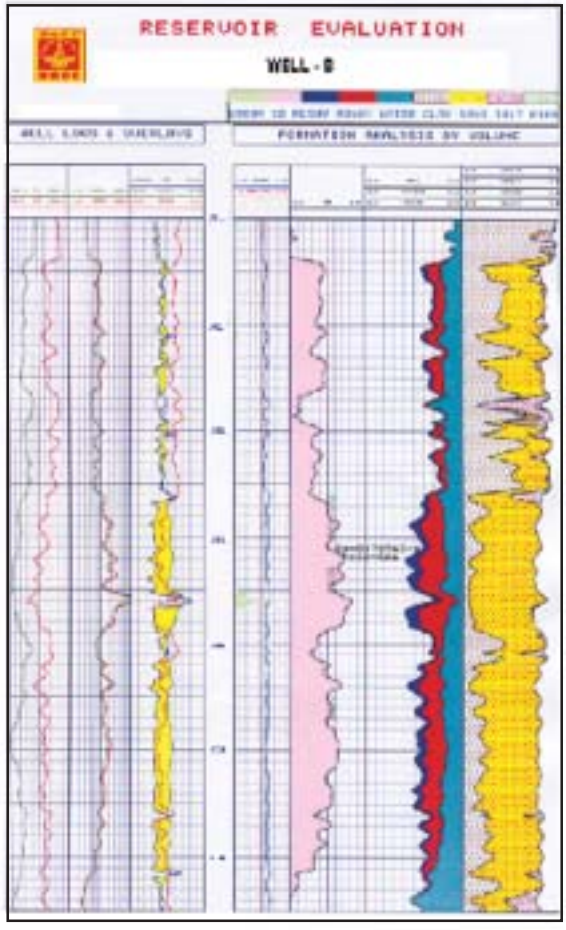

Fig.3 : Better separation is observed on Neutron-Sonic logs overlays in the interval X736-X771m than Neutron-Density overlay against fairly low shaly-sand section in Agartala Dome field. On testing the well produced gas @81785m^3/day.

Well-C

This well was drilled in Rokhia structure. The interesting horizon comprises mainly shaly sands. The water saturation values are ranging from 30-75% in the interval X435 – X472 m. Both the techniques were used to identify gas bearing zones. Against the clean gas bearing sand, both the overlay techniques show very good cross-over but against gas bearing shaly sands, Neutron porosity – Sonic travel time technique show cross-over whereas Neutron-density fails (Fig-4).On testing, the interval produced gas @ 90000 m^3/day through 8 mm choke.

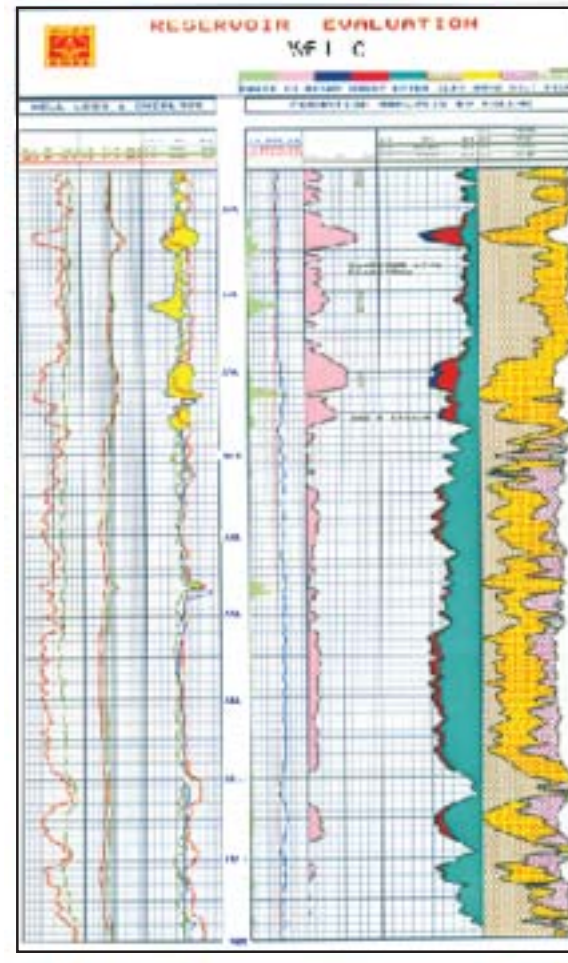

Fig. 4 : In the interval X435-X472 m, Neutron-Sonic logs overlays shows very good crossover whereas Neutron-Density log failed against highly shaly sand gas bearing layer in Rokhia field. On testing, the well produced @90,000m^3/day. GSC observed at X466m

Well-D

This well was drilled in Rokhia structure. The formation encountered is highly shaly sand reservoir. The interval X449 m – X460 m, the water saturation shows 80-100%. Both the techniques were applied in this interval. The neutron-density overlay technique has failed to show cross-over but Neutron porosity – Sonic travel time shows good cross-over which helps to identify the presence of gas. On testing, the interval produced gas @64370 m^3/day through 6 mm choke.

Conclusions

The overlay technique using neutron and sonic logs has resulted into identification of gas particularly in shaly sand reservoirs where as the neutron-density overlay technique fails in Agartala Dome and Rokhia structures in Tripura basin. This method can also be used as an additional overlay tool to detect the gas bearing clean sand in this basin. This overlay technique has been used and found useful in Tripura basin.

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Views expressed in this paper are those of the authors only and may not necessarily be of ONGC.

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