



## Identification and Evaluation of Hydrocarbon Bearing Reservoirs in Girujan Formation of North Shelf of Assam Arakan Basin of India

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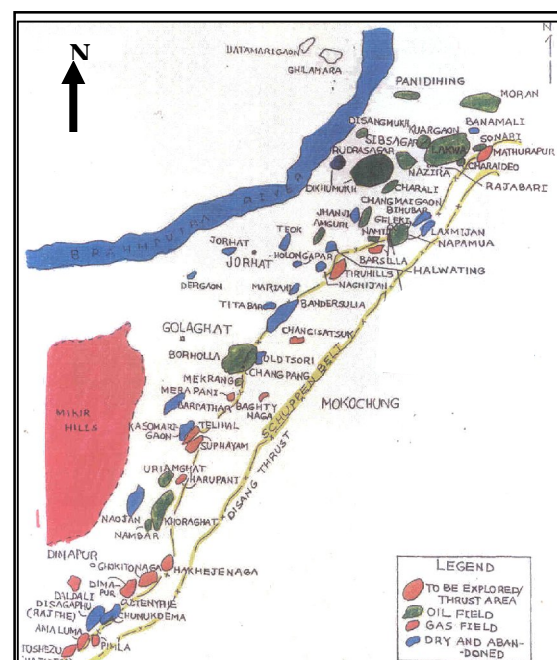
### Summary

The occurrence of hydrocarbons in Girujan formation of North Shelf of Assam & Assam Arakan Basin is known since long, yet identification and their realistic evaluation has remained elusive to log analysts till date. Non availability of sufficient logs especially reliable porosity log against this formation has been biggest constraint. The present paper, based on analysis of more than 500 wells in this area, suggests suitable interpretation technique for such reservoirs with limited logging suit. The study of well log data integrated with available testing results in twenty wells has helped in formulating suitable criteria for identifying hydrocarbon bearing sands. The log signatures of different sands have been compared with known water bearing sands to arrive at qualitative as well as quantitative evaluations. More than 330 hydrocarbon bearing sands in 120 wells have been identified. The study also established the special characteristics of sands developed within Girujan Formation such as limited aerial extent, high clay content and poor permeability of sands in spite of their good porosity which will be useful in exploitation of their potential.

### Introduction

Assam and Assam Arakan basin is one of the major onland producing basins of India. Commercial hydrocarbons are known to occur in Tipams, Barails, Kopili and Sylhet formations. The occurrence of hydrocarbons in Girujan formation is known since long and some of the wells have produced gas on testing. The present paper, based on study of log data of more than 500 wells, suggests suitable methodology for identifying hydrocarbon prospects within Girujan formation and estimating their hydrocarbon potential. The study area includes Lakwa, Lakhmani, Geleki, Charali and Changmaigaon field (Plate -1).

Girujan formation overlies a sequence of massive sandstone known as Tipam sandstone and is overlain by Nazira sandstone. The thickness of Girujan formation is maximum in Lakwa-Lakhmani and Geleki area and it decreases towards west and south-west side of A&AA basin. Stratigraphically it belongs to Tipam Group of





Miocene Age. This formation comprises of mainly variegated and molten sticky clays deposited as the fine grained sediments of floodplains and represent seasonal events. The sand layers in between Girujan Clay formation represent high energy flows. Electrolog facies indicate the presence of channel fills, point bars and superposition of channels indicating frequent lateral shifts. The representative facies indicate presence of seasonal river systems that resulted in flood plain deposits with laterally shifting channels that were fed by seasonal discharge.

Very little correlation exists between various sands bodies developed within Girujan formation which is likely for such depositional environment. The hydrocarbon generation system of the Girujan formation is not fully understood. However the deeper system contributing to the Tipams and older sediments are considered to be source of gas accumulation in Girujan sands also. The sand bodies encased in clay could be good stratigraphic prospects. Due to their limited lateral extent, the hydrocarbon pools are hydrodynamically isolated. The gas accumulated in sand bodies indicates the vertical migration system through leaky faults.

### **General Characteristics of Girujan Formation:**

The study brings out following general characteristics associated with Girujan formation

- A) It is difficult to estimate the porosity of various sands developed within Girujan formation due to non-availability of Neutron-Density logs against this formation. The sonic porosity log has been used to compute the porosity of various water bearing sands. The same is supported by Neutron-Density logs, wherever available. It has been observed that average porosity is around 25%.
- B) The fluvial depositional environment of this formation predicts the shaly nature of sands developed within this formation. The evidence is also supported by description of core available in one well. The N-D logs against water bearing sands in different fields as well as testing results also support the view.
- C) The uncompacted nature of sands within this formation is well known. The compaction factor of 1.3 has been arrived at after comparing the sonic porosity and Neutron-Density porosity in known water bearing sands.
- D) The correlation of Girujan formation in the different wells clearly brings out that the sands developed

within this formation do not correlate with each other. All sands are discreet in nature and appear to have limited aerial extent

### **Theory and Methodology**

Log attributes of different sands have been compared with those of known water bearing sections for identification of hydrocarbon bearing sands. First of all, water-bearing sands were identified in number of wells. These are the sands with good reservoir facies, lowest range of resistivity ranging from 10-12 ohms-m and sonic travel time varying from 90-100  $\mu$ s/ft. Log motifs against water bearing sands are presented in Plate-2. Presence of gas increases the formation resistivity and sonic travel time. Critical analysis of log data integrated with available testing results helped in formulating the following guidelines for identifying hydrocarbon bearing sands and estimating their hydrocarbon potential.

- A) The sands with formation resistivity more than 20 ohms-m sonic travel time more than 110  $\mu$ s/ft are considered good gas bearing sands as the effect of gas is clearly seen on both the logs. The example with such log features is shown in Plate-3
- B) In some cases the effect of gas is not seen on resistivity logs due to increased shaliness or presence of some conducting minerals but gas effect is clearly visible on sonic log and sonic travel time reads equal to or more than 110  $\mu$ s/ft. Many sands with this log attribute have produced gas on testing. Such cases also indicate that considerable amount of gas is present in the flushed zone which may be due to low permeability. Plate – 4 illustrates log attributes of these sands.
- C) There are instances where the effect of hydrocarbons is clearly seen on resistivity logs resulting in higher resistivity equal to or greater than 20 ohms-m. In such cases, sonic travel time ranges between 100-110 $\mu$ s. This may be due to very little gas present in the flushed zone. The sonic tool has minimum depth of penetration.  
The effect of gas is not seen on sonic log due to lower depth of investigation of sonic tool. These examples indicate that entire gas has been flushed out of invaded zone and reservoir has good permeability. The sands with higher formation resistivity and low sonic travel time may have oil also. The examples of such cases are shown in figures Plates -5
- D) It is difficult to predict the nature of fluids in wells having only Russian resistivity logs and no porosity logs. In such case, sands with formation resistivity of more than 25 ohm-m are interpreted gas bearing.



- E) In hydrocarbon bearing sands the water saturation has been computed using following equation  
$$S_w = R_o/R_t \quad [n=1]$$

$R_o$  has been taken equal to 10 ohms-m after scanning data of large number of wells. Value of saturation constant  $n=1$  is also justified considering shaly nature of sands.

## Results & Discussion

The study of voluminous log data established the special characteristics of sands developed within Girujan formation such as limited aerial extent, high clay content and poor permeability of sands which is likely for such depositional environment. The gas bearing wells in Geleki are located along the structural high trend observed at the base of Girujan formation, whereas in Lakwa area, gas bearing wells are mostly located in clusters around NE-SW major fault. The in-depth analysis resulted in formulating criteria for identifying gas bearing sands and interpretation technique for estimating their hydrocarbon potential. The formulated guidelines stand validated by the testing results

of twenty wells in Lakwa area. The identified criteria not only explained the occurrence of hydrocarbons in tested wells but also helped in identifying more than 300 sands in 120 wells of this area.

## Conclusions

The study indicates that thickness of Girujan formation ranges from less than 200 mts in W & SW to 800 mts in N & NE. The identified hydrocarbon bearing sands have been quantitatively evaluated to estimate their hydrocarbon potential. The average porosity of sands is around 25% and about 8 BCM of gaseous hydrocarbons may be entrapped within these sands. The sands have been prioritized for testing to validate the findings.

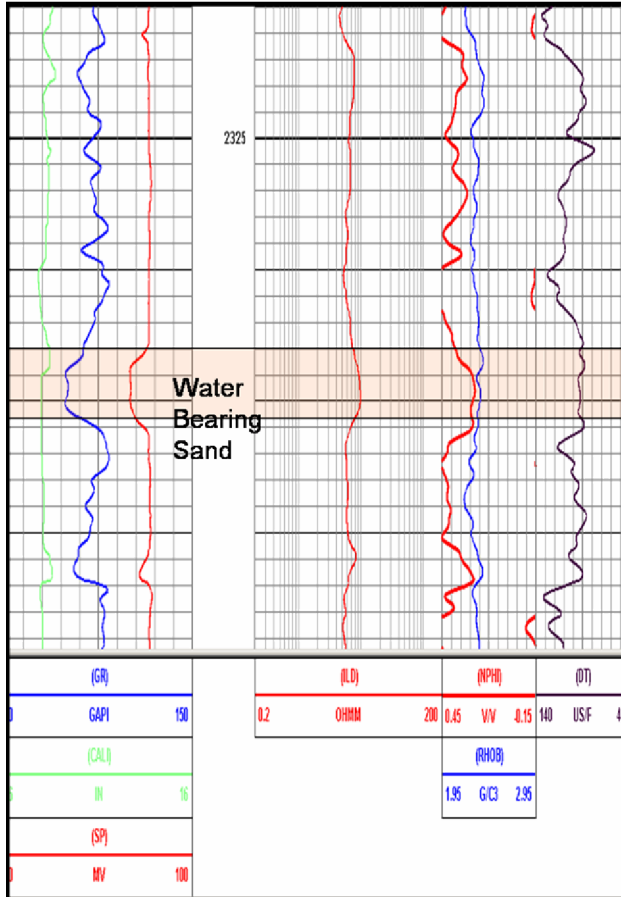
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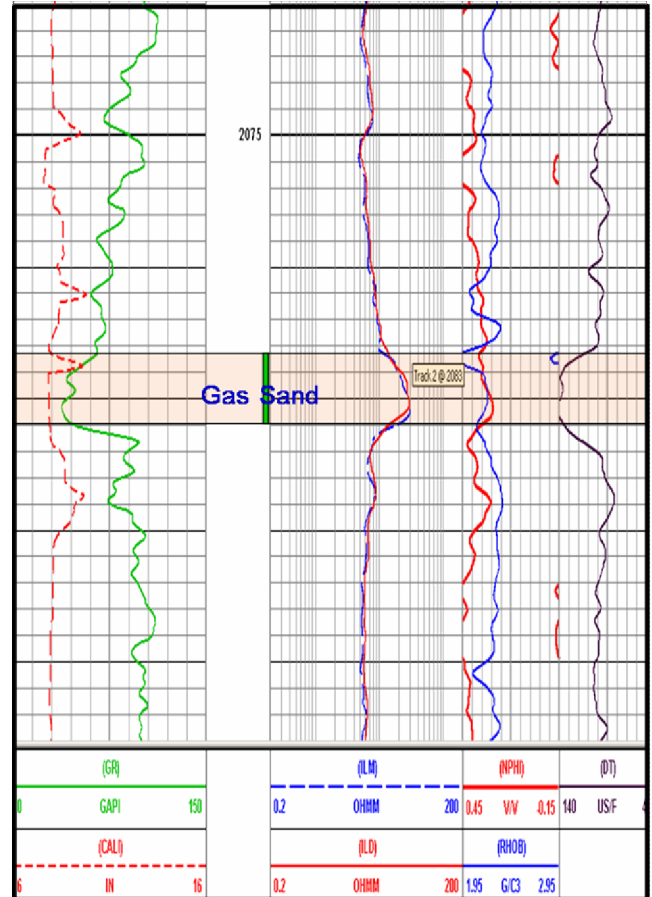
**WELL # A**  
**WATER BEARING SAND**

**Plate-2**



**WELL # B**  
**GOOD GAS BEARING SAND**

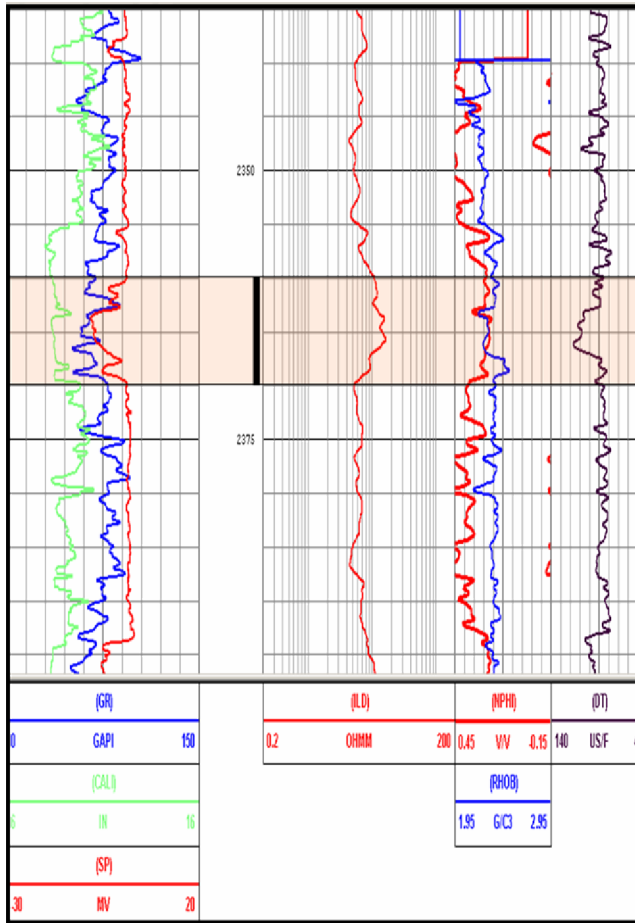
**Plate-3**





**WELL # C**  
**GAS BEARING SAND**

**Plate-4**



**WELL # D**  
**GAS BEARING SAND**

**Plate-5**

