P 346

Integrated approach to understand the influence of clay minerals on the reservoir character of productive facies - A case study of Bhuban Formation in West Tripura field

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Summary

The present study aims at understanding the influence of clay minerals on the reservoir character of Bhuban Formation in West Tripura fields for optimum exploitation of hydrocarbons.

Detail Log data analysis and extensive core studies were carried out to assess the impact of various clay and other minerals. Integration of these two studies reveal that the Bhuban Formation consists of fine grained Quartzose with poor to fair porosity.. The clay minerals are found to be Kaolinite, Illite and Chlorite. These clay minerals are present in dispersed form and have significantly affected sandstone porosity/permeability and reservoir character in general thus affecting their producibility. The study shows that Sandstone diagenesis and clay mineralogy plays an important part in the evaluation of the behaviour of the reservoir thus affecting their producibility. A proper understanding of the influence of specific clay minerals and their distribution will lead to better understanding of reservoir character and adoption of suitable stimulation techniques for optimum exploitation of hydrocarbons.

***Keywords**: Bhuban Formation, Wireline logs, log Z-plots, Diagenesis, Quartz overgrowth**,** pore bridging.*

Introduction

Tripura forms a part of the frontal folded belt of the Assam-Arakan Geosyncline. It is bounded in the west by the plains of Bangladesh, in the north by Cachar hills, in the east by the hills of Mizoram and Chittagong hills are located to the south. Gas fields have been established in western part. Surface seepages of gas are known from most of the exposed anticlinal structures. The main producing fields in West Tripura are Baramura, Agartala Dome, Gojalia and Rokhia. Sandstones of Bokabil, Upper and middle Bhuban constitute the reservoir rocks in Tripura fields. Bhuban formation of these areas was deposited in a distal delta front to pro-deltaic environment. The reservoirs are mostly lenticular in nature, number of independent gas pools are distributed laterally and vertically. The sand bodies trend in a general NE-SW direction over Rokhia and Agartala Dome. In Bhuban Formation, many factors have interacted to influence the petro-physical properties of sandstones, but the types of clay minerals, together with their abundance and crystal size, are particularly significant for understanding the log responses and the corresponding reservoir character. Without detail log analysis and

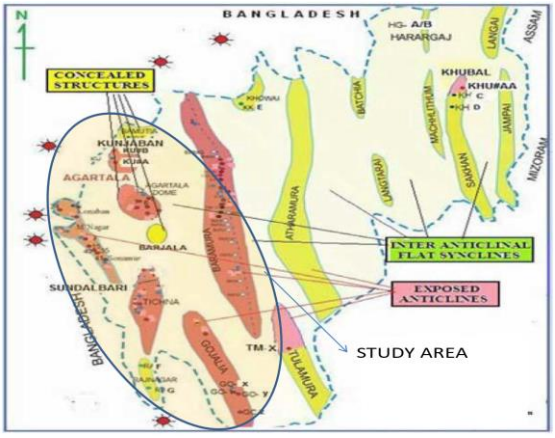

Fig: 1 Map of West Tripura Area Showing Fields Under Study

sedimentological core studies it will be difficult to identify and characterise the complex mineralogy of clays combined with its fine crystal size. Without an in-depth understanding of clays and their properties, it can be hard to assess why a hydrocarbon well is producing poorly and, therefore, to determine what remedial actions might be taken for optimum exploitation of hydrocarbons. The present study has been carried out in Bhuban Formation of

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these fields to understand its reservoir character by integrating log analysis with core studies.

Methodology

In order to understand the influence of clay mineralogy on the reservoir character of Bhuban Formation, log response and their analysis were integrated with the sedimentological studies on the corresponding core samples. Core samples from Bhuban formation of four wells from fields of Baramura, Agartala Dome, Gojalia and Rokhia were studied for Megascopy, Thin section petrography and Scanning electron microscope to characterize sandstone sections in terms of lithology, microfacies, matrix and clay minerals; their percentages and assessment of reservoir quality.

Discussion

Analysis of OH-Wireline logs are helpful in providing details of the lithology and petrophysical properties of the reservoirs. To study the effect of mineral envelop of Bhuban formation in different fields under study, a combination of PHIN-RHOB, DT-NPHI Z- plots were generated from the log data in wells of Rokhia, Baramura, Gojalia and of Agartala Dome. Log analysis through Z-Plots of RHOB-PHIN-GR indicates a combination of clay minerals which appear mainly as Kaolinite, Chlorite and Illite. Analysis of these Z-Plots shows that the percentage of clay minerals and mica in the reservoir sands is high as compared to other formations. The RHOB-NPHI X–plots (Fig: 2A) bring out this fact vividly. The data points belonging to Bhuban formation are more towards clay and heavy minerals such as Mica. This observation is further confirmed by DT-NPHI X-Plots (Fig: 2B) and were also corroborated by sedimentological findings. Sedimentological studies show that these samples are fine to very fine grained and are of Quartz wacke category. Sandstone consists of 6075% quartz and Chlorito-Micaceous matrix (20-35%) along with iron oxide grains. X-Ray diffraction analysis reveals presence of Kaolinite, Illite and Chlorite.

Reservoir character of Bhuban Formation

Integration of the above two studies reveal that hydrocarbon bearing reservoirs in Bhuban formation of fields under study are found to contain three types of major clay minerals These clay minerals are Kaolinite, Chlorite and Illite. The dominant clay mineral is Kaolinite followed by Chlorite and Illite. These clay minerals are in dispersed form.

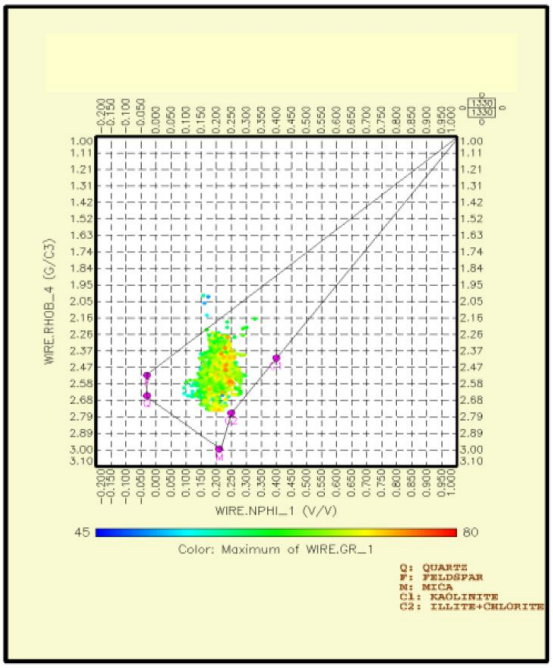

Fig: 2a. Rhob-Nphi Z-Plot For Mineral Identification

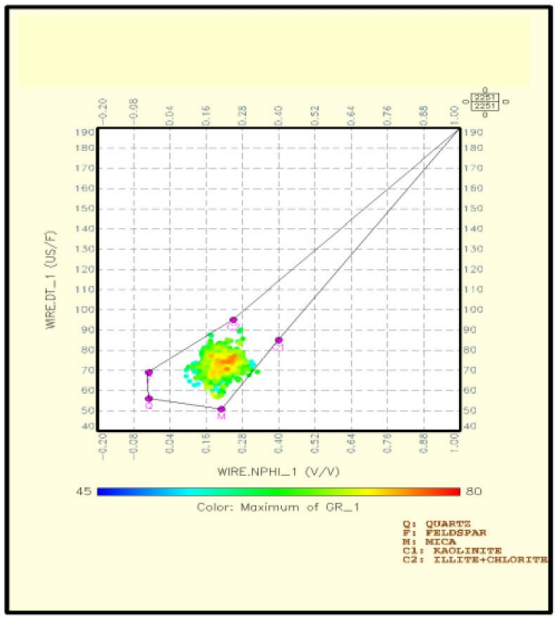

Fig: 2b. Dt-Nphi Z-Plot For Mineral Identification

These dispersed clay types are found to occur in pores in the following three categories namely, Discrete (not intergrown) particles i.e. in pore filling form, Pore lining-as lining on pore walls and Pore bridging-across pores. These dispersed clay categories significantly affect sandstone porosity/permeability and reservoir character in general. Conversion of Mica flakes into authigenic Chlorite and rare presence of Smectite clay is also noted.

In cores of reservoirs of Bhuban Formation, SEM studies shows Bent Mica as diagenetic imprints resulting from compaction (Fig:3A). Quartz overgrowth leading to porosity damage is also seen (Fig: 3B). This indicates that diagenesis exerts a strong control on the quality of the reservoirs of Bhuban Formation. Kaolinite is seen in pore filling form (FIG 3C) this greatly reduces the porosity and permeability. The core study also shows Illite clay as bridging the pore-wall and obstructing permeability (FIG: 3D). XRD study of core sample in Bhuban formation shows that dominant clay mineral is Kaolinite followed by Chlorite and Illite (Fig: 3E). The Quartz grains are medium to fine grained and moderate to well sorted. SEM studies indicate poor to fair inter-granular porosity. Integrating the log and core studies the Bhuban Formation was processed for better understanding of its reservoir character (Fig: 4). The study shows that log derived average effective porosities are high in Baramura and Rokhia in middle Bhuban formation as compared to Agartala Dome due to relatively lower clay content and higher Quartz content. Effective porosity of Upper Bhuban (25%-28%) is higher as compared to Middle Bhuban (10-20%) in the reservoir section. These porosity range compare well with the core derived effective porosity.

The integrated study has shown that clays and their properties exert a strong control on the log responses and its corresponding reservoir character. An in-depth understanding of clays and their properties will be helpful in assessing the producibility of reservoirs of Bhuban Formation and, therefore, to suggest the stimulation techniques for optimum exploitation of hydrocarbons.

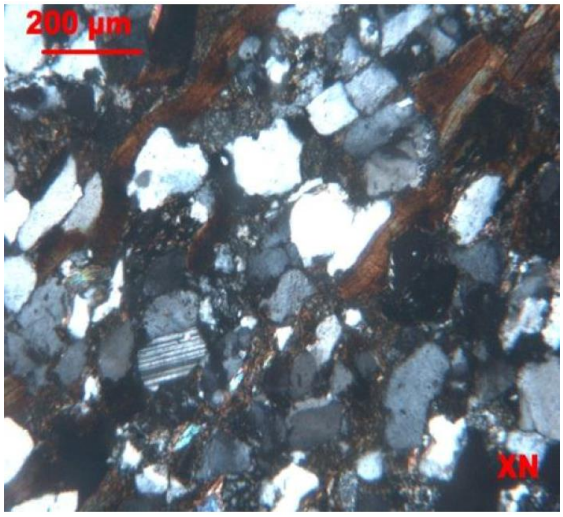

FIG:3A Sub-lithic quartz wacke: Fine grained. Main constituents are Quartz, Plagioclase Feldspar, bent Biotite Mica and shale /clay clasts

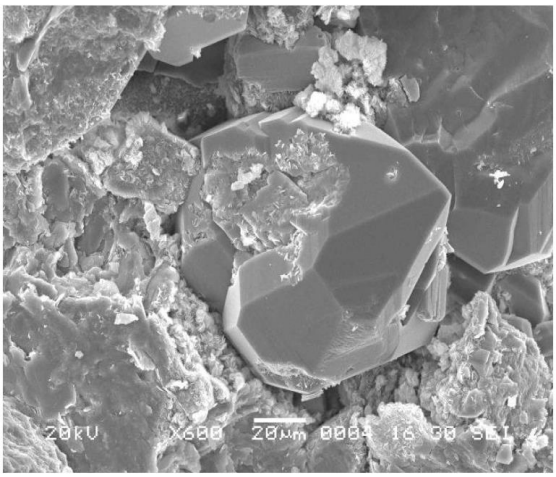

FIG: 3B Quartz overgrowth damaging porosity

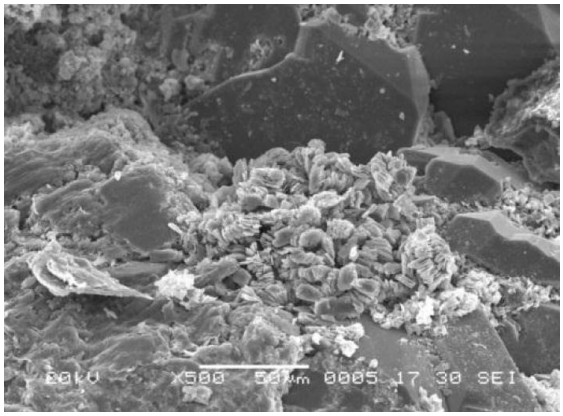

FIG 3C Pore filled Kaolinite damaging porosity

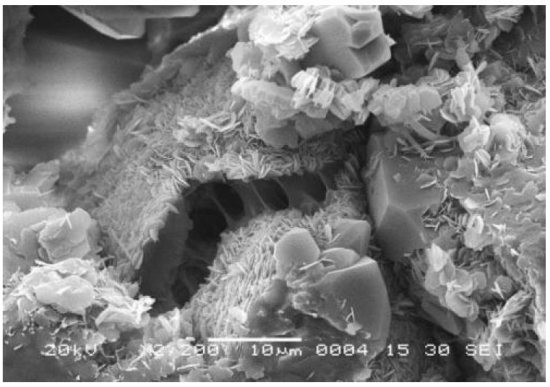

FIG: 3D Illite clay bridging the pore-wall and obstructing permeability

Understanding the reservoir character: Core showing Quartz, Mica, Feldspar and clay as main minerals, partly occluded by Quartz overgrowth, Kaolinite clay filling the pores and Illite-Chlorite clay coating the grains and bridging the pore lines

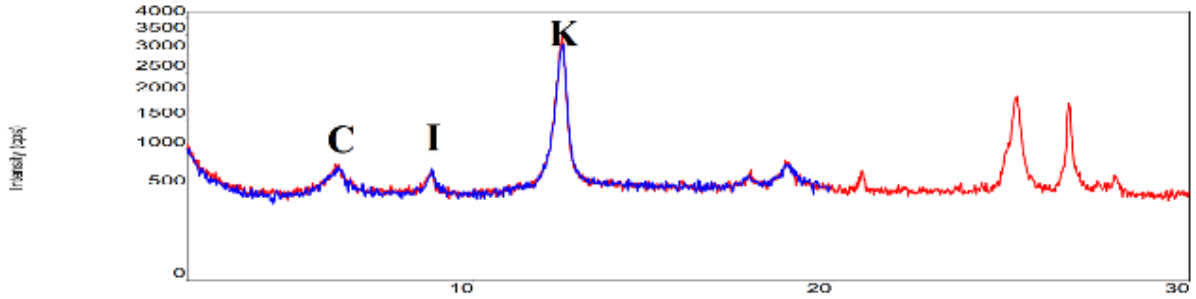

FIG: 3E XRD study of core sample in Bhuban formation showing dominant clay mineral as Kaolinite followed by Chlorite and Illite

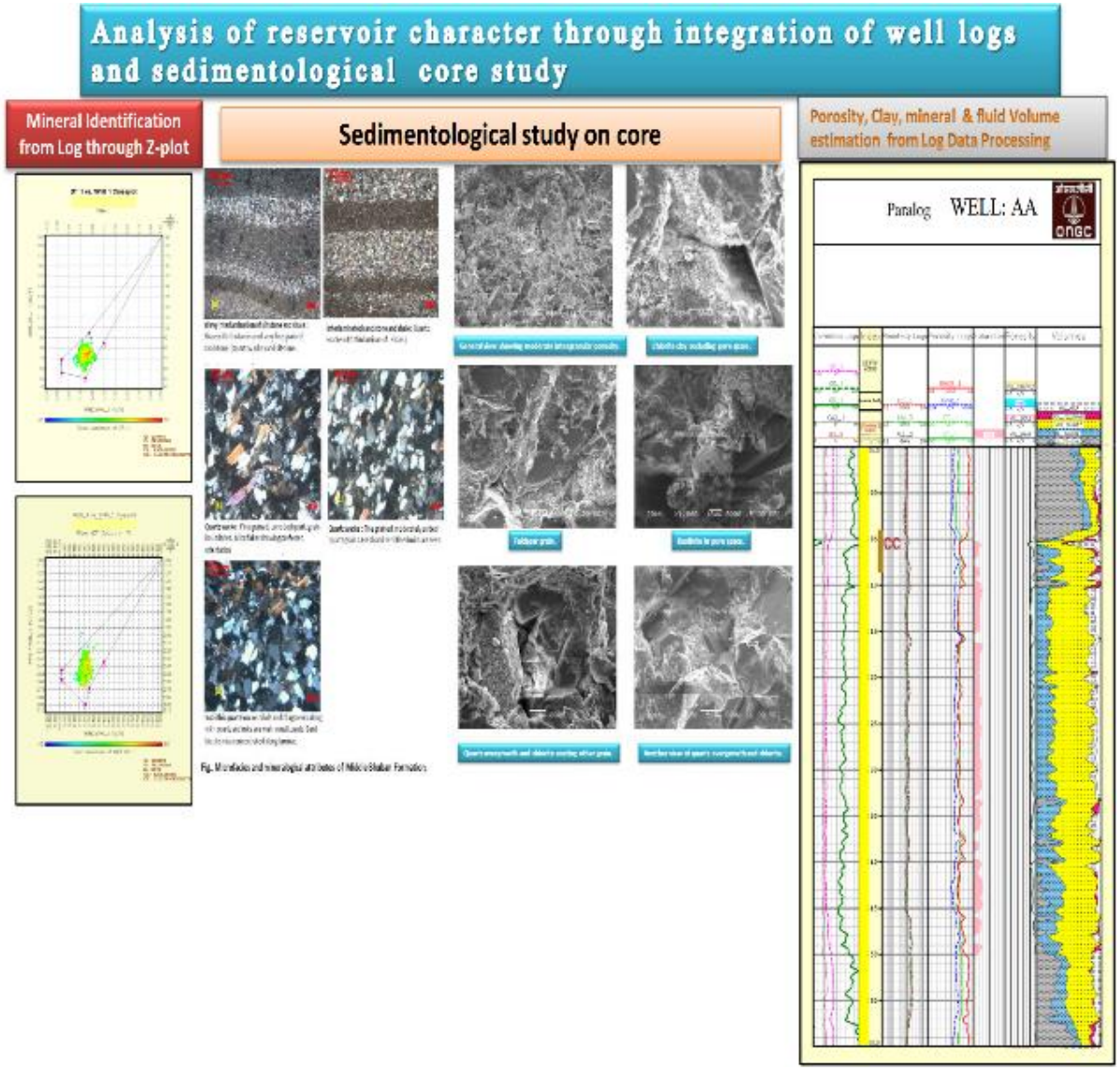

FIG: 4. Integrated analysis of logs and cores to understand the reservoir character

Conclusions

The present work has led to a better understanding of reservoir character of Bhuban Formation in various fields of West Tripura. The integrated study shows that the reservoir character in Baramura and Rokhia in Middle Bhuban Formation is better as compared to Agartala Dome due to relatively lower clay content and higher Quartz content. Log derived effective porosity of Upper Bhuban (25%-28%) is higher as compared to Middle Bhuban (10-20%) in the reservoir section. In Bhuban formation, many factors have interacted to influence the petro-physical properties of sandstones, but the types of clay minerals that fill pore spaces, together with their abundance and crystal size, are particularly significant for understanding log response and the reservoir character. For example, coarsely crystalline clays, such as Kaolinite, has filled up pore spaces thus damaging the porosity, whereas fine fibrous clays, such as Illite, has grown between pores and greatly reduce permeability. The very fine crystal size and mineralogy of clays has made the log response and corresponding Reservoir character of Bhuban formation quite complex. Porosity loss in Bhuban formation is mainly due to diagenetic compaction, and presence of authigenic Kaolinite in pores. Quartz over growth is the other diagenetic change which has contributed to lessening of porosity. The in-depth understanding of clays and their properties will be helpful in assessing as to why a hydrocarbon well is producing poorly and, therefore, to determine what remedial actions might be taken for optimum exploitation of hydrocarbons.

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