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Refined Petro-physical Model for Better Definition of Reservoirs of Gamij Field of Cambay Basin and Un-masking of Potentials in Low Resistive Formations

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Abstract

The Gamij field is developed in the eastern flank of Cambay basin. It has complex lithology due to the presence of low resistive shaly sands, which do not appears to be promising on conventional logs but the field yields water free oil production. The log response is affected due to the presence of fine grained sand having higher surface area and coupled with the presence of conductive minerals which results in high irreducible water saturation and low apparent resistivity for hydrocarbon bearing layers respectively. Hence, for realistic log evaluation the petro-physical model based on conventional sand/shale model needs to be refined.

Therefore, the present conventional model of log data processing has been refined based on i) a, m, n parameters, ii) presence of iron rich minerals in the formation like siderite; ilmenite, hematite and pyrite. Among which, ilmenite ($Fe\ TiO_3$) is found to be the most commonly occurring mineral in Gamij field, iii) Revised formation water resistivity (Rw), which has derived from salinity data. All the associated parameters stated above, along with the conventional Quartz+Clay model have been used in ELANPLUS to observe comparative effect and it was found that the refined model is giving better solutions for formation evaluation.

Introduction

Wells selected for re-evaluation are situated from north to south of Gamij field has been reprocessed in ELAN using both the conventional and refined model. And while comparing both the processing output, some new zones were identified & found to be interesting from hydrocarbon point of view in almost all the wells. Earlier some of these zones have been recommended, only on the basis of cutting details and initial testing results of nearby wells. Hence, no effective porosity and saturation values are available for these zones. However, after re-processing the wells using the refined model it was possible to identify the exact interval to be perforated as well as the estimated effective porosity, saturation and net pay thickness values are also available for proper reserve estimation.

Experimental Details

Petro-physical parameters: For a normal sandstone reservoir the established values of a, m, n parameters are 0.62, 2.15 and 2 respectively. The Gamij field is having complex lithology and hence a, m & n parameters needs to be established from the core study. On the basis of core study carried out in KDMIPE Dehradun, ONGC, the “a”, “m”, “n” parameters for the Kalol formation of Gamij field has determined as 1, 2, 2 respectively. These a, m, n parameters has been used for the present study.

Rw determination: Salinity data for nearly 18 wells of Gamij field has been collected from regional Chemistry lab and it has been found that the average salinity in Kalol formation of Gamij field is around 11.7 gpl. From the salinity value, the estimated Rw is 0.21 @ 80 degC.

Ilmenite concentration: 54 core samples of Gamij field have been used for mineralogical studies using XRD technique by the Petro-physical Laboratory, Institute of Reservoir Studies, ONGC, Ahmedabad.

It has been observed that the cores are having high concentration of iron rich minerals like siderite; ilmenite, hematite and pyrite. However, out of these iron rich minerals, ilmenite ($FeTiO_3$) is the most commonly occurring mineral and its concentration found to vary from 12-25% in the studied samples. The mineralogical distribution of some of the core samples of few wells are presented in Table 1.

ECS Log Analysis: Elemental capture Spectroscopy Tool was run in recent two wells of Gamij field, and it has been observed that Titanium and Ferrous percentage (found in the form of oxides) are comparatively high in Kalol formation (Figure 4). The higher concentration of Titanium and Ferrous inferred the presence of ilmenite ($FeTiO_3$) in the said formation.

Results and Discussion

Well Log data of 15 wells were loaded on workstation and processed using 'GeoFrame' software. Formation parameters were evaluated using ELAN_PLUS. Three models viz. sand/Quartz, coal and shale were run as convention and all these models were combined according to log motif to get the final output. The refined petro-physical model viz. sand/Quartz + Ilmenite, coal and shale were run with a, m, n parameters, estimated from core study and the calculated Rw from salinity of 11.7gpl. The processed output of both the conventional and refined model has been compared and the result of three wells has elaborated below:

Well Gamij # AAA (Figure.1): From the output of conventional model, it is observed that K-V layer is not developed properly. However, from the output of refined model, it is observed that K-V layer is having good reservoir characteristics and additional pay thickness. The K-VIII layer also found to be more promising from hydrocarbon point of view in the refined model.

Well Gamij # BBB (Figure.2): It has been observed that in the refined model, layers viz K-IV, K-VI+VII, K-VIII and K-X appears to be promising from hydrocarbon point of view whereas in the conventional model only partial development of K-VI+VII layer has been observed.

Well Gamij # CCC (Figure.3): When both the processed output from conventional and refined models has been compared then it is observed that the K-IV and K-IX layers are missing in the conventional model but appears to be prospective in the refined model.

The comparative study of these wells Gamij #AAA, Gamij # BBB and Gamij# CCC has been presented in Table 2.

In all the 15 wells, which were re-processed, newer zones have been identified for testing using the refined model. Although many of the zones which were identified earlier has already been included in REC estimation but none of these intervals has been shown in any of the processed output.

Conclusions

Based on the present study, there are number of new zones have identified which were earlier missed or appears to have not developed in reservoir point of view. After incorporation of Ilmenite, the high density & conducting mineral, in the model, the reduction in shale content and increase in matrix percentage have observed, hence the porosity and saturation has been changed remarkably. In some of the wells increase in pay thickness of the existing zones have been identified. Moreover we are getting realistic effective porosity and water saturation for the realistic reserve accretion. The same refined model is being used for further processing of the well log data (new wells) of Gamij field. The processing output is matching with the production results of the field.

References

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Table 1: Mineralogical Distribution of Core samples.

Well No	CC No	Box No	Mineralogy
Gamij-X1	2	4/7	Framework minerals: Quartz (69%), ilmenite (14%), siderite (5%), graphite (<1%) & ankerite (<1%). Clay minerals: Clinochlore (6%), kaolinite (4%) & chlorite-montmorillonite (<1%).
Gamij-X1	2	5/7	Framework minerals: Quartz (65%), ilmenite (20%), graphite (4%), siderite (2%), albite (2%), anorthite (2%), pyrrhotite (<1%), halite (1%), barite (<1%) & hematite (<1%). Clay minerals: Kaolinite (3%) & chlorite-montmorillonite (<1%).
Gamij-X1	2	6/7	Framework minerals: Quartz (48%), ilmenite (25%), siderite (6%), pyrite (8%), albite (1%), microcline (1%) & dolomite (1%). Clay minerals: Kaolinite (4%), illite & chlorite-montmorillonite (<1%).
Gamij-X2	1	1/5	Framework minerals: Quartz (43%), ilmenite (15%), hematite (4%), siderite (4%), microcline (2%). Pyrite (3%), Talc (2%) & Graphite (1%). The other minerals like albite, calcite, leucite and muscovite have also been observed less than one percent. Clay minerals: Clinochlore (20%), illite-montmorillonite (2%), & Kaolinite (<1%).
Gamij-X2	1	2/5	Framework minerals: Quartz (46%), ilmenite (25%), microcline (3%) siderite (2%). Other minerals are albite, andalusite, beryl, muscovite, leucite & pyrite have also been observed less than one percent. Clay minerals: Clinochlore (13%), illite-montmorillonite (2%) & Kaolinite (<1%).
Gamij-X3	1	1/7	Framework minerals: Siderite (51%), quartz (19%), ilmenite (11%), albite (2%), graphite (6%), chloritoid (2%), leucite (<1%) & beryl (<1%). Clay minerals: Clinochlore (6%), illite (<1%), smectite-kaolinite (<1%) & chlorite-montmorillonite (<1%).
Gamij-X3	1	1/7	Framework minerals: Quartz (45%), ilmenite (13%), siderite (6%), chloritoid (7%), pyrite (1%), graphite (1%) & anorthite (1%). Clay minerals: Kaolinite (24%) & clinochlore (2%)
Gamij-X4	1	4/8	Framework minerals: Quartz (72%), ilmenite (13%), orthoclase (4%), graphite (4%), albite (1%), chloritoid (1%), pyrite (<1%) & leucite (<1%). Clay minerals: Clinochlore (5%).
Gamij-X4	2	3/10	Framework minerals: Quartz (55%), ilmenite (15%), siderite (3%), orthoclase (2%), chloritoid (2%), graphite (1%), albite (<1%), microcline (<1%), phlogopite (<1%) & pyrite (<1%). Clay minerals: Clinochlore (19%), smectite-kaolinite (<1%), montmorillonite (<1%) & leucite (<1%).

Table 2: Comparative Details of Conventional and Refined Model.

SL. No.	Well	Observation from conventional model	Pay thickness (Gross in m)	Observation from refined model	Pay thickness (Gross in m)	Remarks
1	GM-AAA	K-V K-VIII	1.6 3.5	K-V K-VIII	4 5	Completed in K-V
2	GM-BBB	K-VI+VII	Less than 1.5	K-IV K-VI+VII K-VIII K-X	3 5 1 1.5	Completed in K-X on zone transfer
3	GM-CCC	K-IV K-VII	1 2.5	K-IV K-VII K-IX	3.5 3.5 8	Completed in CH-I. Recommended for zone transfer

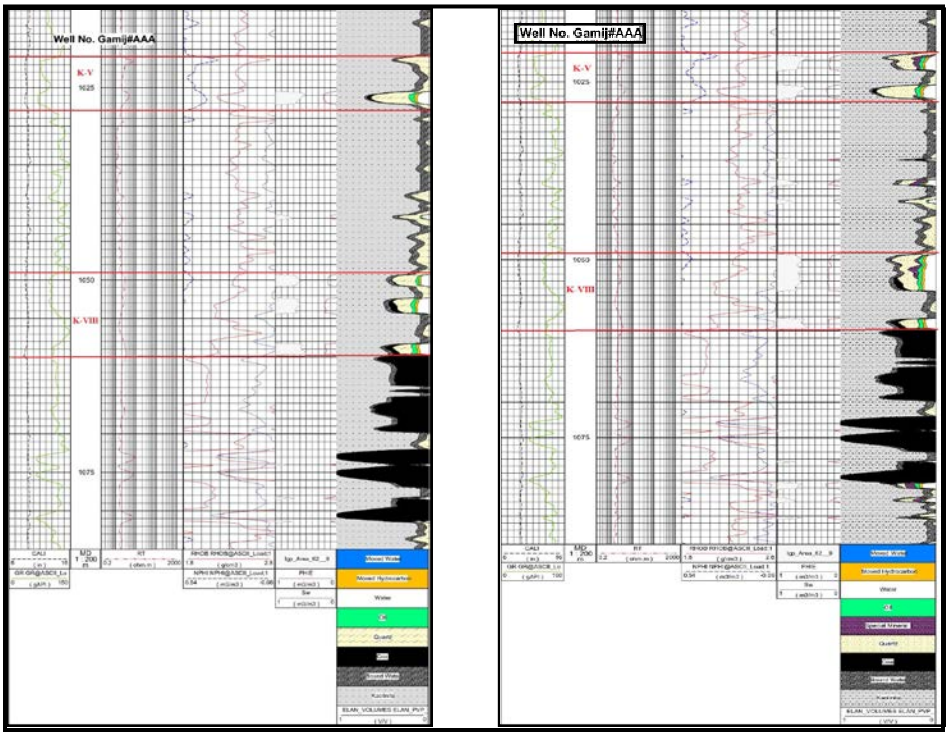

Figure 1. Comparison of processed output from conventional and refined model of well Gamij#AAA

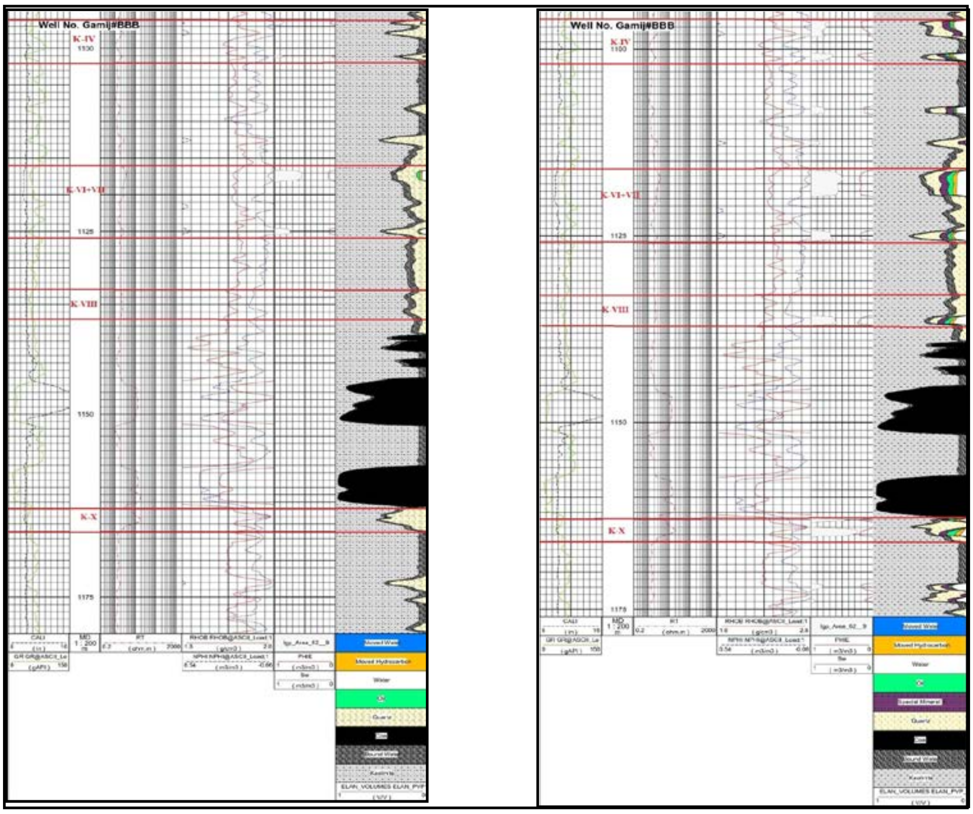

Figure 2. Comparison of processed output from conventional and refined model of well Gamij#BBB.

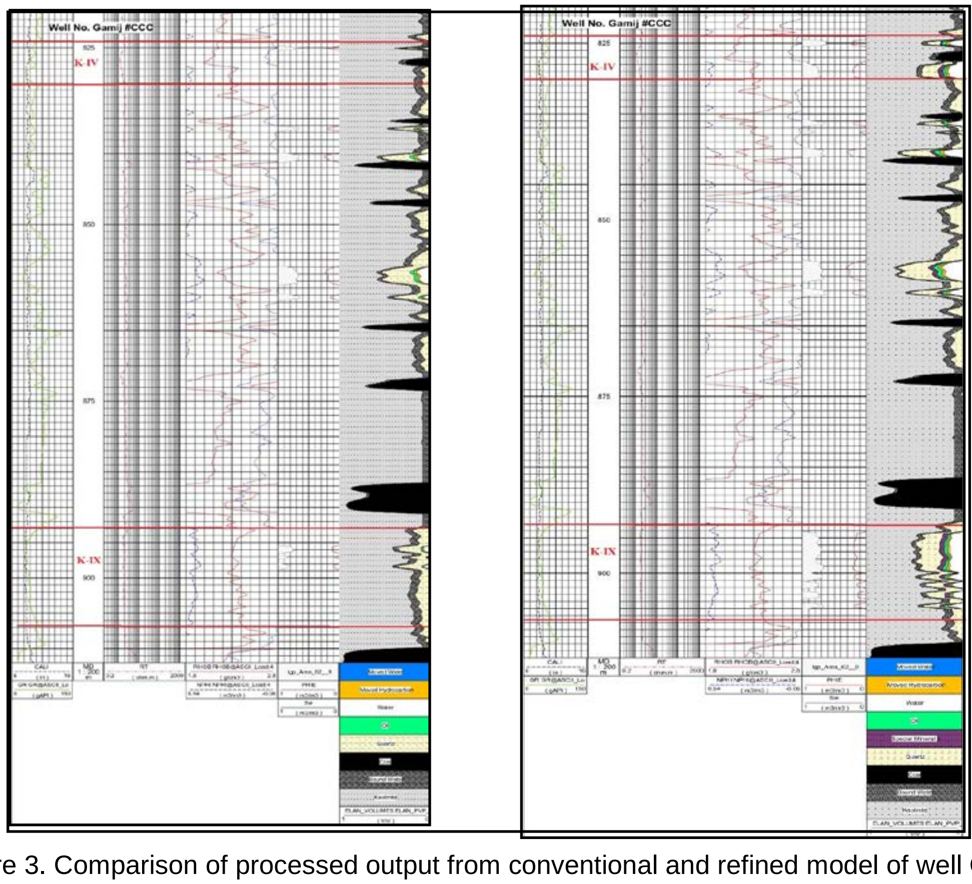

Figure 3. Comparison of processed output from conventional and refined model of well Gamij#CCC

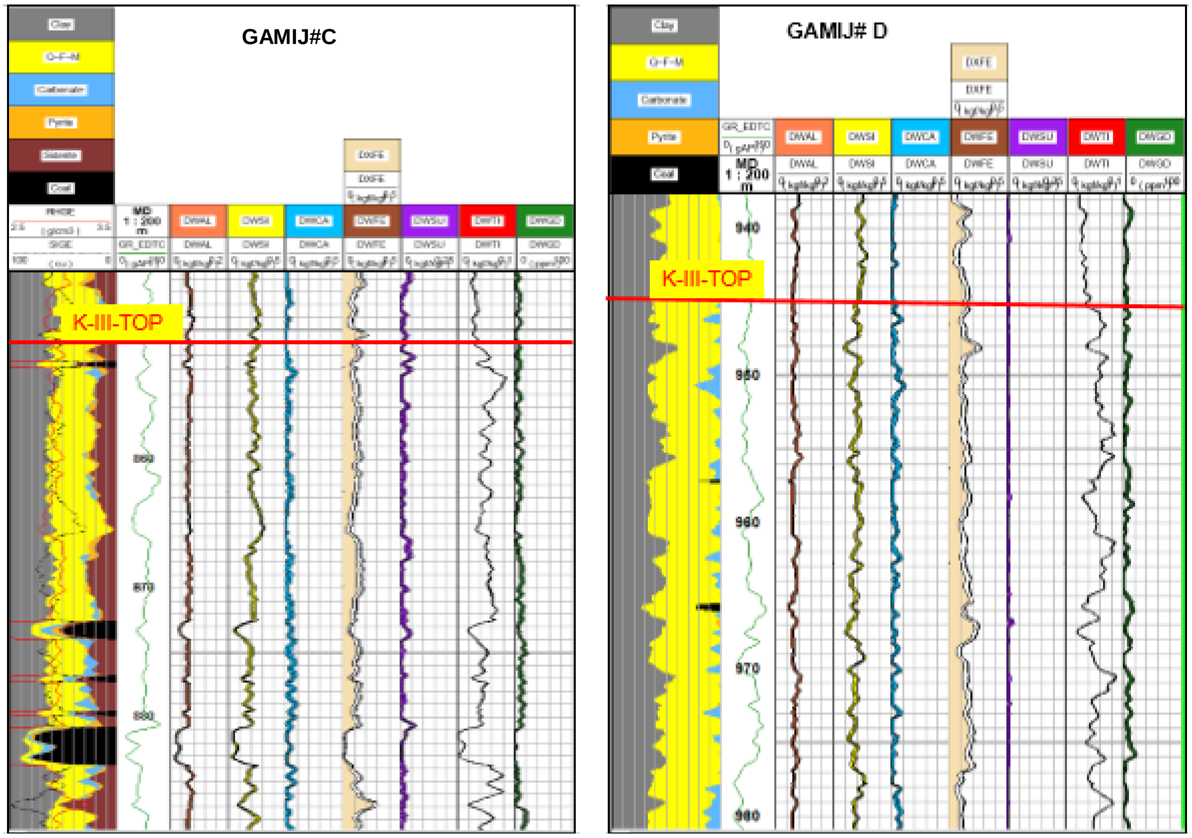

Figure 4. Comparative high concentration of Titanium (Track-8) and Ferrous (Track 6) is observed in Kalol formation in both the wells.