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# Analyzing Low Resistivity Low Contrast pay of Matar field in The South Cambay Basin.

## Abstract:

LRLC reservoirs have always posed challenging task with respect to their identification as well as in estimation of the hydrocarbon potentials of a field. In spite of advancement in well logging and evaluation techniques, LRLC reservoir identification remains daunting task mainly because of complex geological process that characterize them. The present study has been carried out in a field of South Cambay basin to investigate possible reasons of LRLC characteristics and role of geological processes in it. Nearby fields around study area have LRLC reservoirs wherein dominantly mineralogical effect is the cause of LRLC but in the present study area additional causes of LRLC have also been identified. Lack of contrast and cross-over in porosity log in the area led to development of unique quick look technique Neutron porosity ($\Phi_N$) and Photoelectric factor (PE) quick look plot. The plot has indicated considerably good and consistent results in identifying potential Hydrocarbon bearing zones in the study area.

**Keywords:** Low resistivity low contrast pay, Neutron porosity ($\Phi_N$) & Photoelectric factor (PE) quick look plot, Geological play analysis, Reservoir characterization.

## Introduction:

In the era of ever increasing hydrocarbon demand, need arises to explore new HC plays. However at the same time the available resources should be explored and evaluated judiciously. The presence of geological complexities may jeopardize HC potential evaluations of a field. Evaluation of the reservoir with bias towards high resistivity and cross over in porosity log may lead to missed opportunities in detection of LRLC reservoir. The present study has been carried out on a field of South Cambay Basin. The South Cambay Basin is well explored and most of the fields are categorized as Brownfield. The LRLC pay has been found in some of the fields of the basin and in the current study an attempt has been made to delineate LRLC pay in the Matar field of South Cambay Basin.

The study area falls in the Matar region of Broach-Jambusar block of Southern Cambay basin and geographically Matar lies in the eastern side of main producing fields viz, Gandhar and Jambusar Fields. In this part of Broach sub-block, the main hydrocarbon producing sands are Gandhar Sands - 3, 8 & 9 along with Lower Ardol pay sands. The main source rock is envisaged to be Cambay Shale while Kanwa shale forms sealing for the Hazad sands. Telwa shale and shales within Ardol sands appear to be the seal in Ardol sands. Hydrocarbon entrapment for Hazad sands is envisaged mainly structural against NS trending longitudinal faults. HC bearing underlying sands of Hazad and fault pattern appears to have charged the Lower Ardol pay. Therefore hydrocarbon entrapment in the overlying Ardol sand unit is considered to be strati-structural unit.

## Geological play of the study area:

**Fig.-1**: Location map of study

A holistic approach has been developed to understand LRLC reservoir with special emphasis is given on geological play and its impact on reservoir properties. Unde[illegible]des key details of depositional environment and its influence on the reservoir. The Matar area is characterized by low resistivity and low contrast sands which hinders HC potential estimation. Log litho-facies of wells in Matar indicate bulky, fining upward trend indicating signatures of point bar, channel bar & crevasses splay deposition. The ECS log (Fig.-2A) of a well-CC indicates significantly high amount of Fe-minerals deposited in the shale/siltstone of lower Ardol formation. Fe-mineralization along with high clay content in the sandstone signifies reducing/marshy environment of deposition. While fining upward sequence with the intercalations of Shale and Sand indicates alternating high and low energy depositional regime which points towards channel, point bar deposition. Therefore, the Mid-Eocene Ardol sands may probably have been deposited under fluvial silici-clastic depositional environment.

## Analyzing causes of Low Resistivity and low Contrast reservoir:

Generally, deep resistivity logs in low resistivity pay reservoir read values in the range 0.5 to 5 ohm-m. Low contrast is used in conjunction with low resistivity, indicating low contrast between sands and adjacent shale (Austin Boyd et el. 1995). Clay because of its inherent conductivity, in the reservoir is envisaged to be primary cause of low resistivity (Moore D). Pyrite, Siderite as well as other Iron rich minerals are known to lower resistivity values and same phenomenon has also been observed in few reservoir sands of nearby fields such as Gandhar. The presence of Pyrite & Fe rich minerals in the study area is established from ECS log of a well. Clay minerals have substantial negative surface charge that causes log resistivity values to plummet (Scala C et el. 1989).

The conductive minerals such as pyrite, Fe-rich minerals are present in the reservoir sands of Hazad and Matar but interestingly the producing sands of Lower Ardol pay have very low content of Fe minerals as shown in the figure 2B. However high clay content (upto 70%) against pay zone has also been observed in the log. Secondly high amount of irreducible water saturation ($S_{WIR}$) has been discovered through petro physical studies. High clay content and $S_{WIR}$ is evident from ECS and CMR log as shown in the figure-2a& 2b. The clay type, dispersal pattern, cation exchange capacity is known to affect the resistivity values. Silt-sand altercation in the upper alluvial and distributaries channel is one of the the most common depositional pattern for low resistivity pay. The Ardol sand is the alluvial sand deposit as explained earlier. Understanding geological processes which might have been operated in the depositional set up has immensely helped in finding root causes of LRLC reservoir

In the Ardol pay sand bulk density values ideally should have been lower against pay zones in the presence of low density hydrocarbons. It has been observed that the small pore spaces are partly filled by clay minerals. Therefore triple combo of resistivity-porosity log and quick look method fails to accurately evaluate the hydrocarbon reserves. In the absence of advanced logs and core data in most of the studied area wells a unique approach was developed to characterize/understand the reservoir of study area as mentioned ahead -

## Methodology:

- Neutron porosity ($\Phi_N$) and Photoelectric factor (PE) quick look plot of the wells falling in study area was developed to characterize the reservoir. The plot was made on the basis of properties observed from ECS and CMR log of the wells falling in the same area. Assumption is made that nearly same depositional environment must have prevailed in whole area under consideration. The Photoelectric factor is characterized by the mineralogy of formation with little effect of porosity and fluid of the formation (Darwin V. Ellis).

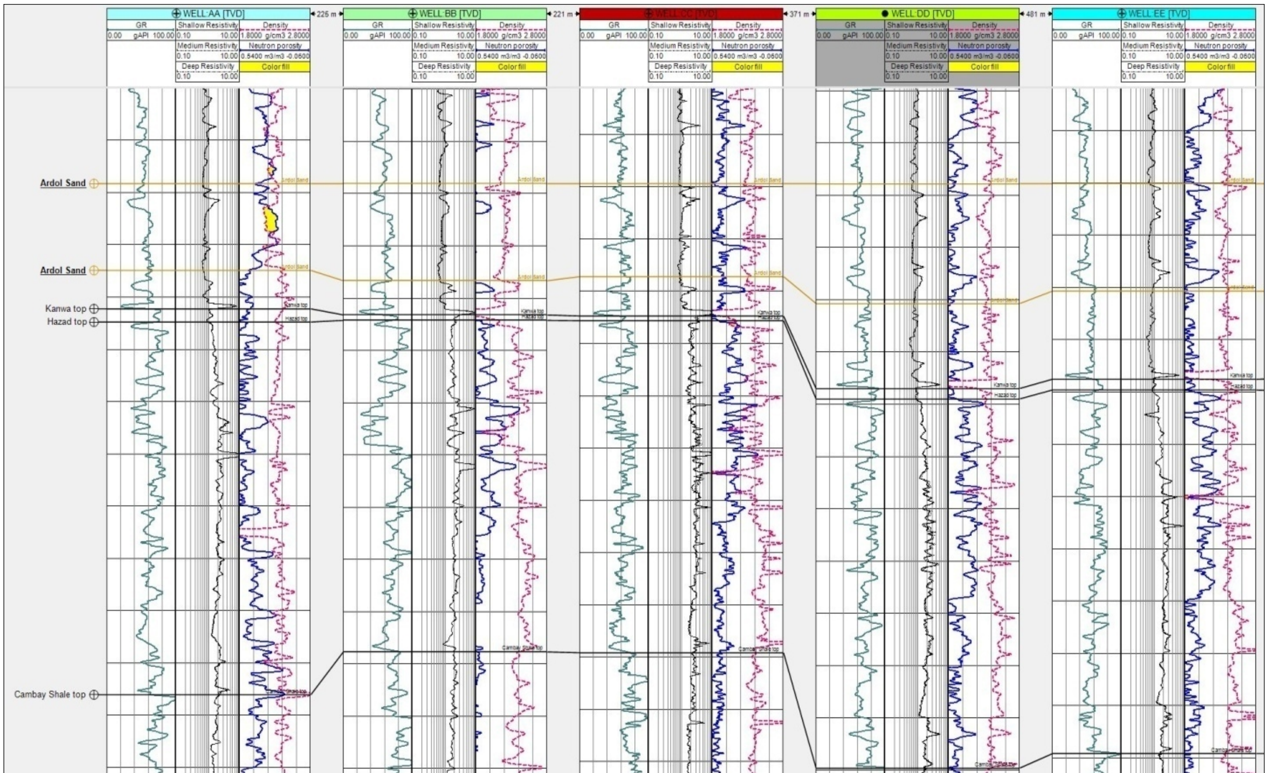


**Fig-3A**, In triple combo log Low resistivity has been observed against Ardol formation 2-6 Ohm-m. The quick look method of Bulk density v/s neutron porosity log fails to detect HC presence. Resistivity log scale -0.1-10 Ohm-m

- The PE and Neutron porosity log plot was modified in such a way that the crossover of PE against Neutron porosity was obtained by adjusting PE scale. The base reading for PE taken to be 3 and 1 PE = 10 Porosity Unit (PU). The crossover appears to be suitable indicator for reservoir characterization in the otherwise low contrast area. As illustrated in the figure
- The same plot methodology has been deployed in the currently producing sands of study area and except at few intervals such as Ardol sand in Well-AA, overall good conformity has been observed. The same has been illustrated in the figure-3B.

**Fig-3A**, In triple combo log Low resistivity has been observed against Ardol formation 2-6 Ohm-m. The quick look method of Bulk density v/s neutron porosity log fails to detect HC presence. Resistivity log scale -0.1-10 Ohm-m

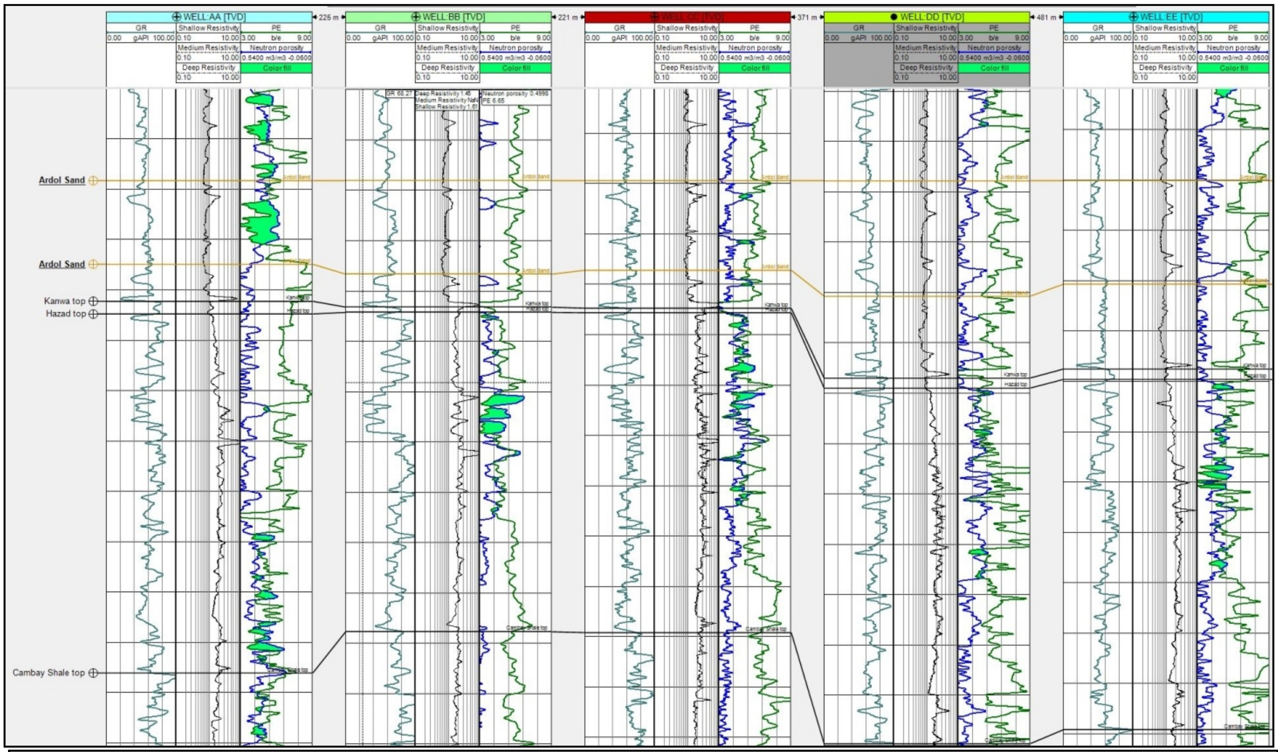


**Fig-3B**, A unique plot developed to overcome the drawbacks of Neutron Porosity V/S Bulk density log. The PE V/S Neutron porosity log crossover as observed in the green colour, when used with the resistivity plot imparted good results in the Ardol and Hazad Pay sand. All the wells shown in the diagram are LRLC pay reservoirs and

## Conclusion & Discussion:

- Low resistivity low contrast is apparently due to clay presence as structural as well as dispersed clay. Secondly high capillary bound water in the reservoir. Small pore spaces are partly filled with clay hence the corresponding density of concerned reservoir i.e. Ardol pay sand is higher than usual sandstone reservoir. While presence of Pyrite, Fe-rich minerals appears to have moderate to low effect on resistivity values. The Geological play analysis has thus aided immensely to understand the reservoir behavior.
- The three causes of low resistivity low contrast viz, high clay content, high irreducible water saturation and conductive minerals are present and affect the log values. In reservoir evaluation of the Matar or geologically similar areas all above mentioned factors must be properly studied before coming to conclusion. Also the importance of geological modeling has been reinstated through the study as log behavior, facies variations and LRLC characters and their reasons are clearly captured through it.
- In PE and NPHI plot care should be taken to first thoroughly understand the mineralogy of the study area as PE is mostly dependent upon mineral composition with little effect of pore spaces.
- The technique should be used as Quick look method similar to triple combo log of resistivity and porosity logs, while quantitative estimation are not advisable through it. Also it is more useful when the conventional porosity log shows anomalous behavior i.e. no cross-over or cross over tendency.

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(Views expressed in this paper are of authors only)

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