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Analysis behind Casing for Better Understanding of Current Fluid Potential in Brown Field: Case Studies from Mumbai High field, India

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Summary

Multi-layered limestone reservoirs of Mumbai High field are heterogeneous in nature. This field is under oil production for more than three decades now and presently under active water-injection. Reservoir complexity and heterogeneity adds additional challenge for proper understanding of these reservoirs. To sustain oil production and reducing water-cut, formation evaluation behind casing is a powerful tool to determine the present day reservoir scenario. Present paper includes two case studies of two development wells from the same platform using analysis behind casing. Based on the data of cased hole logs, work- over jobs were carried out in these wells which resulted in increase in oil production.

Keywords: *Cased-hole resistivity, Cased-hole density, Cased-hole neutron, Brown field, Depletion*

Introduction

Mumbai High field is the biggest offshore oil field of India, which was discovered in 1974. This field is the largest contributor to Indian oil production and has been producing for more than three decades. Presently this giant field is under active water injection to sustain the reservoir pressure and production.

Limestone of Miocene age is the main reservoir rock for this giant oilfield. This limestone is sub-divided into several layers and sub-layers separated by shale. Present study includes an area towards the northern part of this oilfield (known as Mumbai High North). Two high angle development wells were studied which were drilled in 1984 and initially produced oil. Recently, it was observed that both of these wells are having poor production with high water-cut.

The challenge was to understand the present reservoir condition and revive the wells with increased oil production and reduced water cut. Only cased-hole formation resistivity data was acquired in the first well to understand the time lapse saturation. However in the second well cased hole porosity and cased hole density logs were also recorded in addition to cased hole resistivity data. The cased hole logs were studied in conjunction with conventional open hole logs to identify the zones which are not depleted. Based on this study selective perforations were carried out in both the wells, which resulted in increase in oil production.

Theory and Methodology

Cased-hole formation resistivity measurement is the key for analysis behind casing in addition to cased-hole density and neutron measurements. Saturation determination is primarily based on resistivity based methods. However, with production as saturation changes, a time-lapse resistivity measurement is the fundamental for identification of depletion in the reservoir. Additionally, with continuous production of oil for long period, fluid contacts may also change. Cased-hole neutron and density measurements are crucial tools for identification of such changes along with the cased-hole resistivity measurement for determining the left-over sweet zones in brown field wells.

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Cased-Hole Formation Resistivity

Cased-hole formation resistivity data was acquired using a laterolog-type tool which provides deep formation resistivity through casing. It is a station measurement tool where the current return path for the true formation resistivity (Rt) measurement is the same as for the open hole laterolog tools, which is basically described as a series measurement. This is a two way step measurement process for the CHFR* tool where casing segment resistance is computed first to calculate the leakage current (fig. 1). The later is used for calculation of resistivity (Aulia et al., 2001).

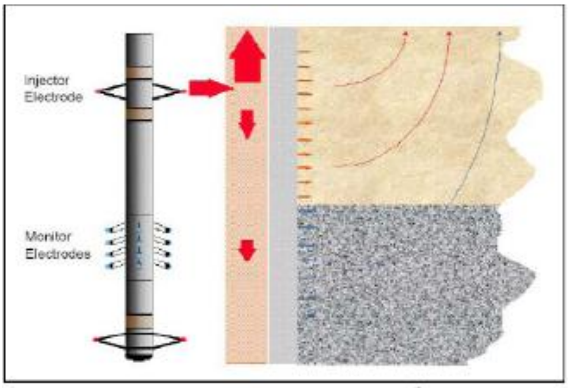

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Figure 1: Cased Hole Formation Resistivity Measurement Cased-Hole Formation Density.

Cased-hole formation density is measured in two stages: transformation of count rates into apparent density values for each detector (the single detector response), followed by computation of formation density from a combination of apparent densities (the dual detector response). The process is identical to the process used in open-hole. The only difference being the values assigned to certain key variables and the casing and cement correction in addition to the open-hole environmental corrections (Plasek et al., 2010).

Cased-Hole Neutron

Cased-hole neutron measurement can successfully be achievedusing a pulsed-neutron source based measurement. Epithermal neutron is a better measurement in cased-hole by avoiding the effects of thermal neutron absorbers commonly encountered in cement slurries apart from shaly formation and formation brines (Case et al., 1995).

In present study, an integrated approach is applied using cased-hole log data along with open hole logs for identification of left over sweet zones and understanding the shifting of fluid contacts.

Results

Case Study 1

The first case was from a deviated development well drilled around thirty years back and presently under production from multiple sub-layers of well known L-III reservoir. The oil production from this well decreased gradually with simultaneous increase in water production. The area was put under water injection to sustain the reservoir pressure and production. The oil producibility of this well decreased gradually with simultaneous increase in water production. Cased-hole formation resistivity data was acquired after cement squeezing and compared with the initial resistivity data to identify the depleted zones. The cased-hole logs indicated that the top gas zone is showing lower resistivity than the initial open hole resistivity (fig. 2). Also it was found that the reservoir is depleted differentially in different layers. Based on the cased hole resistivity, left over potential zones were re-perforated (fig. 3). The well production has increased after work-over job with reduced water-cut.

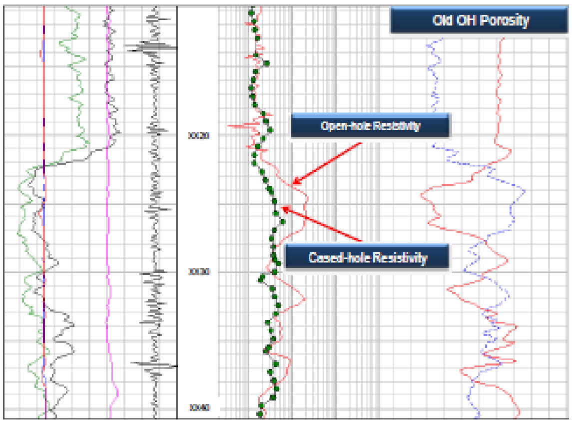

Figure 2: Time lapse resistivity in Gas zone (Case 1).

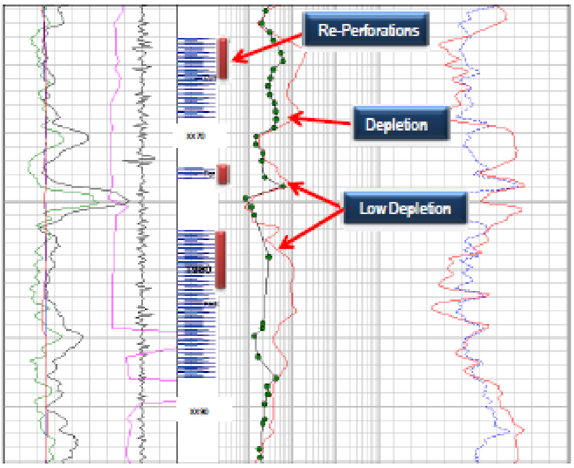

Figure 3: Depletion over produced layers.

Case Study 2

The second case study is from the same platform. This well was also drilled around thirty years back and producing from various sub-layers of L-III reservoir. Production from this well was also poor. In this well,full cased-hole logs were acquired behind casing, which includes resistivity, density, neutron and Gamma Ray. It was found that in the top zone cased-hole resistivity is higher than the earlier open-hole resistivity (fig. 4). Cased hole density-neutron data was also compared with the old open - hole

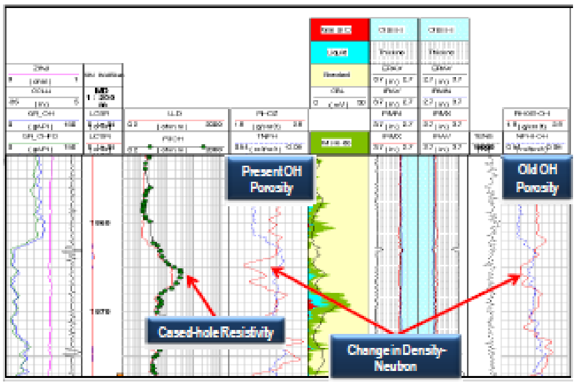

Figure 4: Change in gas saturation over time (Case 2)

density-neutron data. It was found that the density-neutron cross-over has increased. In the existing perforation zones, it was observed that the depletion was also differential in different sub layers. A cement squeeze job was carried out in the existing layers and re-perforation was done based on cased-hole log analysis to produce from the bypassed zone, which still has the hydrocarbon potential (fig. 5). Initially the well did not produce as per the expectation. However, after around a month time it started producing oil at a higher rate as compared to the earlier production.

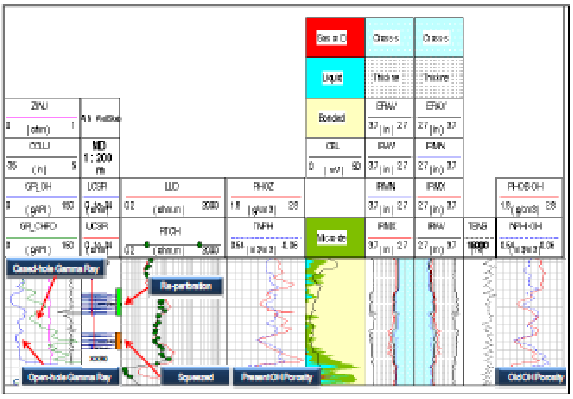

Figure 5: Left over potential zone for re-perforation.

Discussions and Conclusions

Brown field reservoirs like Mumbai High are under production for long time. Continuous production from different oil bearing sub-layers of L-III reservoir leads to differential depletion in various sub-layers. As a result of this, solution gas would be released due to drop in reservoir pressure and could cause higher gas saturation in the potential zone. This higher gas saturation can be observed by the increase in density-neutron cross-over and possible increase in resistivity values. On the other hand, a fall in gas zone resistivity could be an effect of reduction in gas saturation.

In present study, for case 1, a drop in resistivity was found in gas zone. Differential depletion was probably due to the production for long time. However, the change in saturation in gas zone may be either due to the effect of injection water from near-by area or due to production of gas from gas cap in this area. As a result, the gas-oil-contact might have shifted upwards in this well. In case 2, a distinct indication of increase in gas saturation was found from cased-hole resistivity as well as cased-hole density-neutron data. This may be due to the fact that release of solution gas during production might have caused higher gas saturation in the top most layer thereby forming a local gas cap. Based on cased-hole log analysis bypassed potential zones were identified and re-perforated, which led to an enhanced oil production in the well.

From these two case studies it can be inferred that the gas cap has shown shrinkage near the case 1 well. However near the case 2 well, gas saturation is showing increasing trend and thereby forming a local gas cap in the top most layer.

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