iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: IX Month of publication: September 2021

DOI: https://doi.org/10.22214/ijraset.2021.38143

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue IX Sep 2021- Available at www.ijraset.com

Exploration of Hidden Hydrocarbons in Old Wells Magid Field - Sirte Basin, Libya

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Abstract: It is increasingly important to improve field productivity in today's competitive market. One way to achieve this, is to add new wells which are expensive and time consuming. The other alternative is to identify bypassed hydrocarbons, track changes in saturations and detect movement of reservoir fluid contacts from existing well bores already in place.

It is considerably more cost effective and often more environmentally friendly to explore for those hidden hydrocarbons in old wells rather than drill new wells. As the field matures, there is a need to reevaluate the formation in older reservoirs and to focus the development strategy and approach on bypassed oil pockets and depletion levels in producing intervals. The ability to acquire essential logging data behind casing adds a new dimension to cased hole formation evaluation for locating and evaluating potential hydrocarbon zones in a mature field as in Magid field.

A basic petrophysical evaluation was performed incorporating the data recorded behind casing by applying {Cased Hole Formation Resistivity Logging (CHFRL)} in each of these wells. Based on the analysis of cased hole formation evaluation results. The un-depleted intervals were commercially exploited adding reserve to the asset.

Keywords: Hydrocarbon zones, Majid Field, Sirte Basin, Libya, CHFRL

I. INTRODUCTION

The need for resistivity measurement through casing remained dream till the last decade in previous century, as the measurement techniques could not successfully overcome the impediment of measuring resistivity changes, because of the large contrast of electrical and magnetic properties of steel casings and the surrounding geological formations. But with the advances in measurements technologies there had been intense engineering efforts in the last two decades to design tools that measure resistivity behind casing with reasonable accuracy and to have them available commercially[1-3]. Cased Hole Formation Resistivity Tool (CHFRT) of Schlumberger was introduced in Libya in 2006[4].

II. TOOL BASICS

Cased Hole Formation Resistivity Tool (CHFRT) is an electrode device, which measures the difference in voltage drop across two adjacent casing segments when a current electrode located above sends very low frequency alternating current down the casing. This voltage difference, in the range of nanovolts, is a measure of the current leaking into the formation and hence of formation conductivity [5,6]. Changes in casing resistance is accounted for by measuring it in a separate calibration step with the electrodes engaged to the same position as in the measurement cycle. Measurements are made on a station –to-station basis to eliminate noise arising out of tool movement. The measurement principle of the tool is akin to that of laterolog tool, casing acting as a giant focusing electrode. The focusing provided by casing makes the tool read deep and less sensitive to shoulder bed effects. As the monitor electrodes are anchored on the casing the measurement are independent of the borehole fluid[4-7]. The tool K-factor is a function of the casing geometry and the relative position of the tool in the casing. The resistivity of the formation is calculated using an assumed cement resistivity and profile behind the casing. If an open-hole resistivity log is available, tool accuracy could be improved by adjusting the K-factor to overlay the cased-hole resistivity across formations where no change of resistivity is expected, e.g. shale sections. Brief description of tool theory and operation is shown in Figure 1 and 2 [1-4].

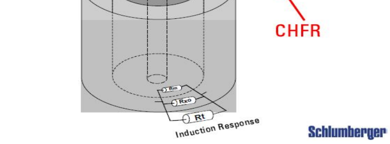

Figure -1. CHFR Principle Operation.

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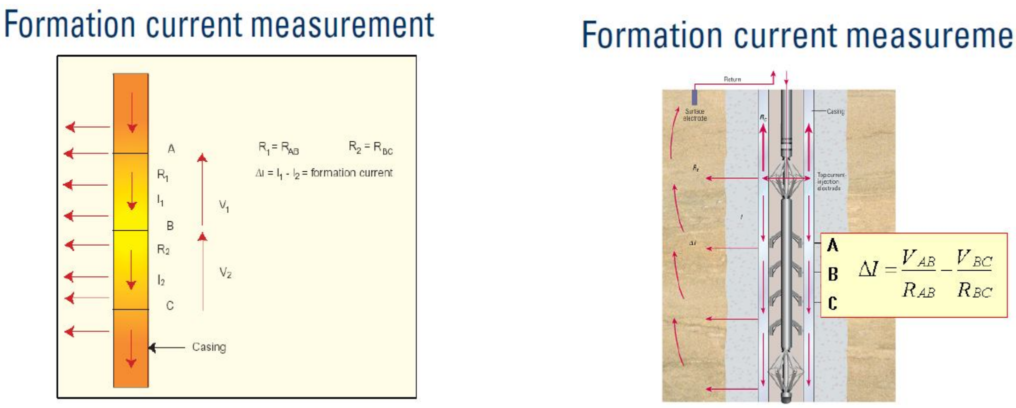

CHFR Apparent Resistivity

$$R_a = K_f \cdot \frac{V_{tool} - V_{ref}}{I}$$

K_f = K - factor of the tool

$V_{tool} - V_{ref}$ = tool voltage

$\boxed{I = \text{formation current}}$

Figure -2. Brief description of tool theory

The tool is practically unaffected by low resistivity cement and any residual effect of conductive invasion (low R_{Cement} / R_t or R_{xo} / R_t), as would be expected for a latero like tool which see the near borehole resistivity in series with the formation resistivity. Conversely measurements are affected by any resistive material between casing and formation like resistive cement and invasion fluids from a resistive invasion, especially if thick. The tool operates in the resistivity range of 1 – 100Ωm (ohm-m), the lower limit imposed by the uncertainty in the cement resistivity and thickness (R_{Cement} / R_t high) and the upper limit determined by the signal strength as the leakage current would be feeble at high formation resistivities. Investigation of the tool is typically more than 2m in depth and is better than conventional latero tools but vertical resolution is about 4ft which is poor in comparison [1,6-8].

III. TOOL APPLICATIONS

In new and old wells where resistivity data was not acquired due to safety or economic considerations the CHFRT is useful as a first resistivity measurement. The tool data could be interpreted with the benefit of the a previous resistivity measurement to provide change in fluid saturations. Where open-hole data provides erroneous resistivity values, the deeper depth of investigation is especially helpful in situations of hole enlargement and deeper invasion. With measurement accuracy within 10%, error in the interpreted saturation is less than 5% and hence could be used for quantitative estimates. The accuracy is much better for the range of formation resistivities of interest 10 – 40 oham-m [1,2,8].

Since the Cased-hole resistivity measurements investigate deeper into the formation and does not suffer from the restrictions of low salinity and porosity they are often advantageous over the hitherto popular time-elapse pulsed neutron techniques for reservoir monitoring. However combination of both could be of great use in accurately describing the fluid type as well as lithology. Where Cased Hole Formation Resistivity Tool may not be feasible one would be necessary if the conditions are not favorable to record the other as in the case of a scaled casing[6-9].

IV. CHFRT SUITABILITY FOR THE STUDY CASE

Sirte basin has many producing fields at various stages of exploration and exploitation, some of which are under water injection for pressure support [4].

The cased-hole resistivity measurements can be put in these fields almost in every area of the tool applications; assessing level of depletion of individual layers, observing movement of fluid contacts, water-flood monitoring, locating by-passed oil, providing only resistivity data in old wells where open-hole data could not be acquired in full or part in the past. In some of the wells due to mud loss conditions in depleted reservoirs, open-hole log data acquisition is problematic. As a contingency measure in occasional exploratory well where open-hole data would not be acquired due to hazardous borehole conditions the cased-hole surveys are needed [10-13].

As most formations of interest have resistivities in the range of 10 to 30 Ωm the tool operating range is appropriate, as it is the region of maximum accuracy for the tool. As some of the layers are thin and would be barely resolved by the tool, improved vertical resolution is desired [4,14].

V. WEEL BACKGROUND

The well Z was completed as an oil producer on Oct. 2000, and the following interval were perforated: (9836ft – 9848ft), (9860ft – 9870ft), (9886ft – 9906ft). as it can be seen in Fig. 3. The production test estimated 2100 BOPD and 16% water cut (WC). Now the well can´t produce naturally because of water cut increasing and ESP Installation [4,15-20].

VI. RESULTS & DISSCUSSION

The Cased Hole Formation Resistivity showed oil in three parts and 100% WC resulted by swab test, so the water channel behind the casing is expected.

The observation from the Cased Hole Formation Resistivity fig. 4 can be figured as following:

1) Very good overly of open and cased hole resistivity in the shale zone indicating the good data quality. This was obtained with a K factor of 0.1.
2) Higher reading of CHFR from (9806 – 9826ft) could be due to some hydrocarbon behind casing.

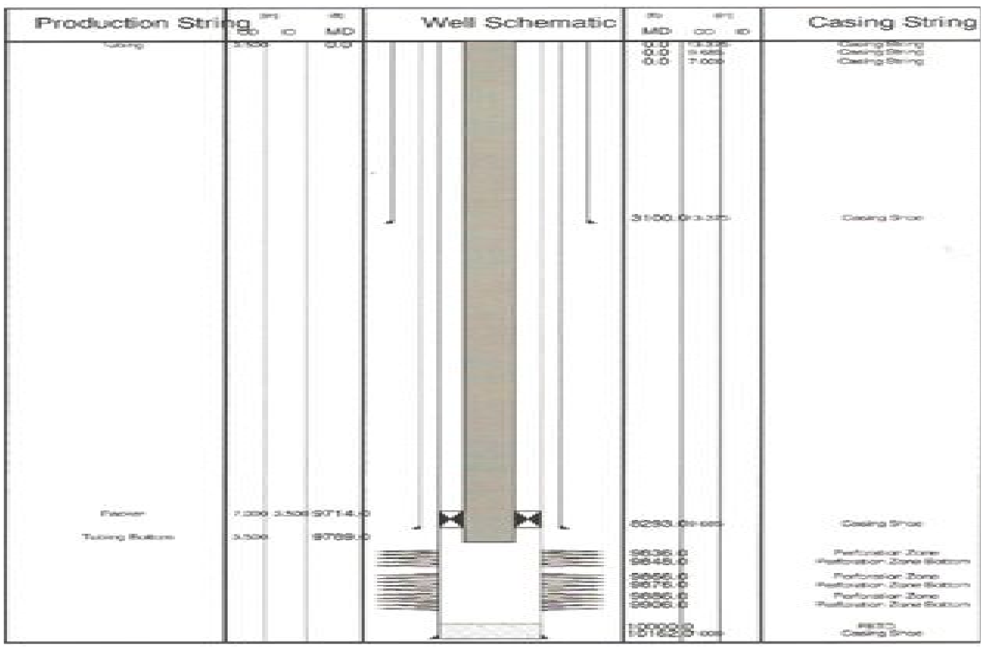

Figure -3 Well Information

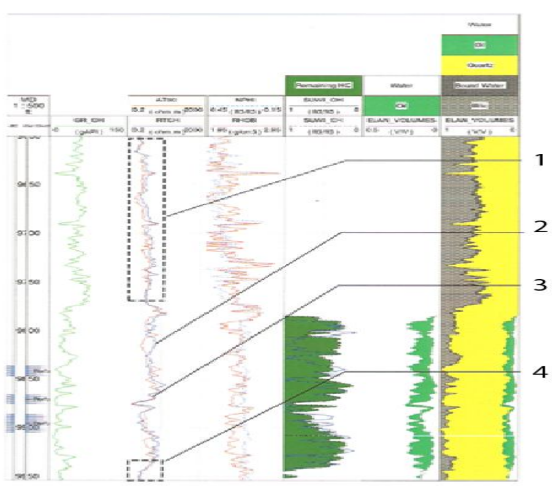

Figure -4 Cased Hole Resistivity Measurement

3) Reservoir observed over 9835-9940. ft MD, showed comparable reading between the cased hole and open hole resistivity. This could mean that there may not be appreciable depletion observed over this interval.

4) Very good overlay of open and cased hole resistivity in water zone (9942 – 9954ft), indicating the good data quality. This was obtained with a K factor of 0.1.

VII. CONCLUSIONS

A. The quality of Cased Hole Resistivity (CHFR) measurements was very good. The resistivity profile obtained overlaied perfectly with the initial open hole resistivity in the shale´s. water and tight intervals at the interest zonees. Hence, the CHFR could be used for quanititaive estimation with corresponding porosity logs.

B. Due to some hydrocarbon behind casing the Cased Hole Formation Resistivity showed high reading at (9806 – 9826ft).

C. No significant depletion indicated by the comparison of the Cased and Open hole resistivity across the reservoir section.

D. Cased hole resistivity measurements can be harnessed as an excellent tool for reservoir surveillance.

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