Oil & Gas Research
ISSN: 2472-0518
Hamada et al., Oil Gas Res 2019, 5:1
DOI: 10.4172/2472-0518.1000162
Review Article
Open Access

Performance Monitoring of Mature Oil Reservoirs Using Cased Hole Formation Resistivity (CHFR) Logging Data

Hamada GM[1]*, El Mahdy OA[2] and Chandran M[1]

[1]Petroleum Engineering Department, Faculty of Geoscience and Petroleum Engineering, Universiti Teknologi Petronas, Malaysia
[2]Petroleum and Natural Gas Engineering Department, Faculty of Engineering, King Saud University, Saudi Arabia

Abstract

Determining hydrocarbon and water saturation behind casing plays a major role in reservoir management. Saturation measurements over time are useful for tracking reservoir depletion, enhancing recovery strategies and diagnosing production problems such as water production that is one of the main challenges facing oil and gas producers. It is necessary to manage water production to enhance oil production. In order to identify watered out zones, traditionally thermal decay time logging (TDT) and carbon/oxygen (C/O) logging are used, these tools have shallow depths of investigation and their effective application is limited in low porosity and salinity. With the introduction of cased hole formation resistivity technology (CHFR) a new dimension has been added to cased hole evaluation. A deep reading formation resistivity can now be obtained through steel casing that means no effect of borehole fluid invasion on measurements as it has been the case with pulsed neutron tools.

In cased hole evaluation, cased hole resistivity finds it utility in two circumstances; as a first resistivity measurement in old and new wells to assess the formation in present conditions, or as a time-lapse technique to describe temporal behaviour of reservoir dynamic and reservoir fluids movements to mainly detect bypassed oil zones and water invaded zones. Four case studies of mature reservoirs suffer from water production problems attributed to different geological and reservoir conditions. In all cases, the remedial work over operations based on the cased hole resistivity results have allowed a significant enhancement of the oil production and the implementation of an optimum field management strategy.

Keywords: Water management; High water cut well; CHFR; Work over; Well Intervention

Introduction

Water management needs water shut off treatment. It is important to identify three main points

1. Water zones location.
2. Mechanism of movement in the formation and
3. Entry level or point to the wellbore.

These data were gathered from water production survey in the field and from the successful well logging techniques. Water saturation estimation is one of the important elements to understand the water production in a well and time lapse technique has been utilized for this purpose Monitoring of reservoir saturation performance through cased wells, usually is the main key factor for proper reservoir management and recovery optimization in the cases of developed and mature oil fields. As the water production is being very significant in oil and gas industry, there are few methods can be applied to overcome the problem. The easiest method is by performing typical mechanical water shut off such as patching and plugging followed by chemical water shut off. Then the third level is pre hardened chemical water shut off where the chemical used in this method will be hardened slightly before being injected into the reservoir. However, the ideal perforation zone to perform the well intervention job is only could detected using logging. It is important to detect and evaluate bypassed hydrocarbon and monitor fluid movement in sandstone reservoir. It is difficult to interpret the TDT and C/O data in reservoirs with low-salinity sandstone formation water. This problem cannot be solved because pulsed neutron measurements depend on the salt content in formation brine. Instead the cased hole formation resistivity tool (CHFR) is proposed to overcome the limitations associated with pulsed-neutron tools. The main purpose of CHFR is reservoir monitoring. During production of a reservoir through casing formation resistivity data may help understand fluid flow and recovery processes in several ways:

1. Evaluation of reservoir fluid saturation changes with time, including the identification of swept zones, bypassed oil, movement in oil/water contacts and potential flow barriers;
2. Identification of take-off rate induced water coning;
3. Estimating residual oil saturation to a water flood or a combined water-alternating-gas flood and
4. Contingency logging for primary evaluation of reservoirs when borehole instability or tool failures prevent successful openhole logging.

CHFR has limited applications under certain conditions completion and casing. It is not generally recommended to use CHFR in dual casing, chrome casing, heavy casing, fiber glass casing, scaled casing and small tubing. Special care should be taken while logging deviated wells [1,2].

CHFR Measurement This tool is current based where it can eliminate the formation related limitations. Even though the tool has

***Corresponding author:** Hamada GM, Petroleum Engineering Department, Faculty of Geoscience and Petroleum Engineering, Universiti Teknologi Petronas, Malaysia, Tel: +6016-2913908; E-mail: ghareb.mostafa@utp.edu.sa

Received January 24, 2018; **Accepted** February 11, 2019; **Published** February 18, 2019

Citation: Hamada GM, El Mahdy OA, Chandran M (2019) Performance Monitoring of Mature Oil Reservoirs Using Cased Hole Formation Resistivity (CHFR) Logging Data. Oil Gas Res 5: 162. doi: 10.4172/2472-0518.1000162

Citation: Hamada GM, El Mahdy OA, Chandran M (2019) Performance Monitoring of Mature Oil Reservoirs Using Cased Hole Formation Resistivity (CHFR) Logging Data. Oil Gas Res 5: 162. doi: 10.4172/2472-0518.1000162

its own limitation where its measurement can be affected significantly by cement, scale and casing, it still can be used to evaluate the formation resistivity provided the casing and cement are evaluated prior to formation data acquisition following by correction computations on formation data. The Archie equation used to compute the water saturation (S_w) from true formation resistivity of clean formation:

$$S_{WCHFR}=(FR_w/RCHFR)^{0.5} \quad (1)$$

The first CHFR tool introduced in 2000 uses two steps methods, where the first step is to prevent current leakage into the formation and measure the resistance of casing for 2ft sections. The second step is to measure the current leakage and to compensate the variation of casing resistance recorded in the first measurement. The disadvantage of this tool is a prolonged period required to obtain the formation data. Hence a new tool, CHFR – Plus introduced in 2001 where a 100% logging speed increment achieved.

Measurement precision of CHFR can be affected by formation resistivity, Rf and casing size. The lower the Rf, the more precise the readings are. The precision can be increased by increasing the signal-to-noise ratio. This ration can be increased by increasing the measurement time. Meanwhile for accuracy, CHFR is said to be more accurate if the Rf is high due to lower cement resistivity relative effect. The depth of investigation (DOI) of CHFR depends on the resistivity of shoulder beds.

Depletion Indicator (DI) is based on the Archie's Equation (Eq. 1), the depletion indicator can be computed as per below This equation assumes that the salinity of the formation for both open hole log and CHFR log is remain unchanged.

$$DI=S_{w-ch}/S_{w-oh}=(R_{CHFR}/R_{oh})^{0.5} \quad (2)$$

Where S_{w-ch}, cased hole water saturation; S_{w-oh}, open hole water saturation; R_{CHFR}, cased hole resistivity and R_{oh}, open hole resistivity. Depletion indicator is good indicator for zones depletion and its independent from formation water salinity and formation porosity [3].

Case Studies

Case one water management in Z field, Saudi Arabia

In Saudi Arabia, Z-321 is a horizontal well where the dip angle changes about 30° at 5500ft AHBDF to 90° at 6900ft AHBDF. The data of openhole log was lost so it was decided to perform CHFR. The open hole log and CHFR log were compared above the depth of 6100ft. It was agreed that the limitation of CHFR is from 1ohmm to 100ohmm. When the open hole log shows low resistivity (5540ft-5590ft), the CHFR shows repetition of data. When the resistivity is high, the CHFR turns out to be noisy due to low current leakage. CHFR Log, is used to confirm the openhole resistivity log (Figure 1). Both logs provide the same information which means CHFR can be used in carbonate reservoirs and shaky sandstones reservoirs [4].

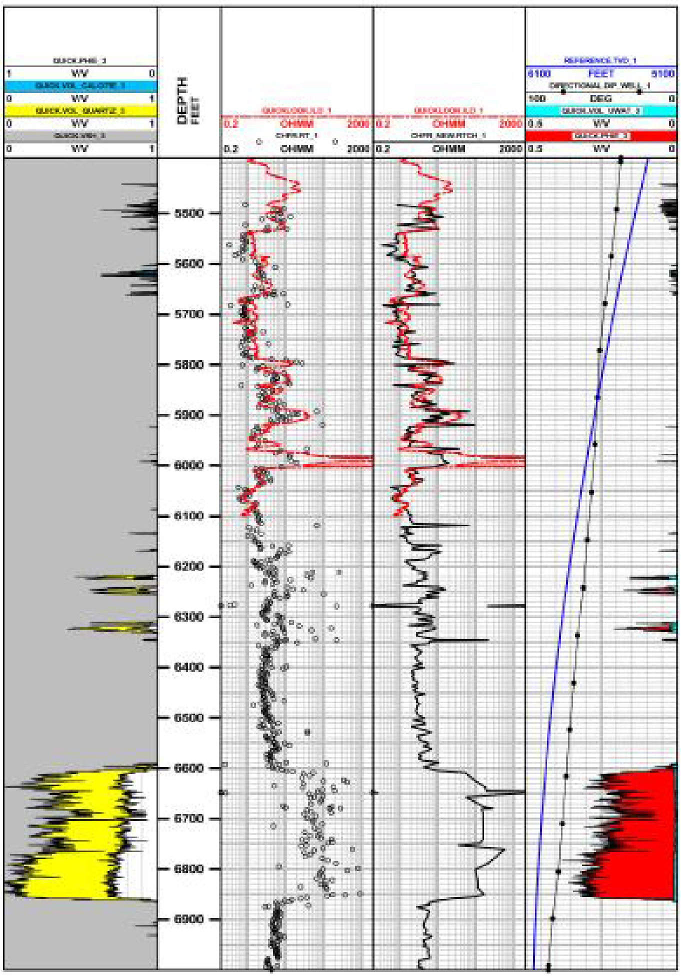

Figure 1: CHFR log and open hole log in Z-321 (Saudi Arabia).

Citation: Hamada GM, El Mahdy OA, Chandran M (2019) Performance Monitoring of Mature Oil Reservoirs Using Cased Hole Formation Resistivity (CHFR) Logging Data. Oil Gas Res 5: 162. doi: 10.4172/2472-0518.1000162

Case two water management in well A, Libya

For well A which produces from multiple sandstone reservoirs, the production dropped to 34 BOPD with water cut of 90%. This well has water injection from bottom of reservoir. So CHFR- plus Logging conducted in Well A to identify the oil-water contact. The resistivity from CHFR- Plus in March 2002 was compared with resistivity from openhole log which was conducted in the well in December 1978 (Figure 2). Based on the logging, it is identified that the OWC is at XY91ft, increased 28ft above from the original. This increase of OWC confirms that the impermeable shale layer at XX00ft is not a good barrier. So, a cement squeeze job was performed in order to in decrease the water

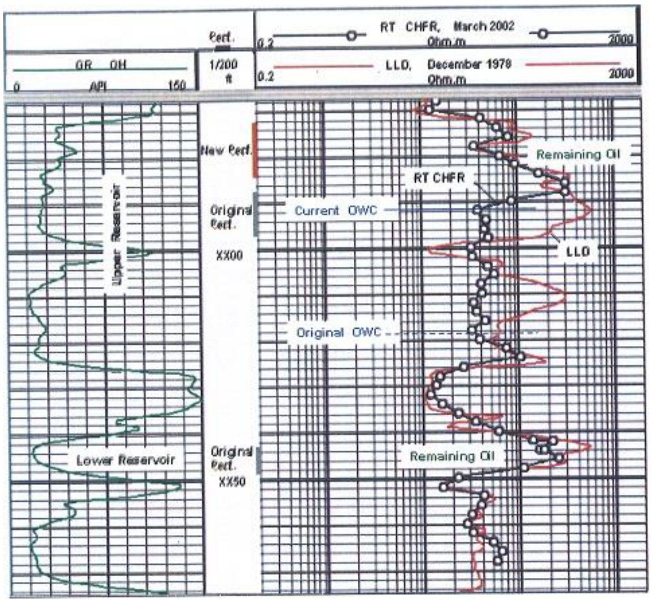

Figure 2: CHFR-Plus in Well A (Libya).

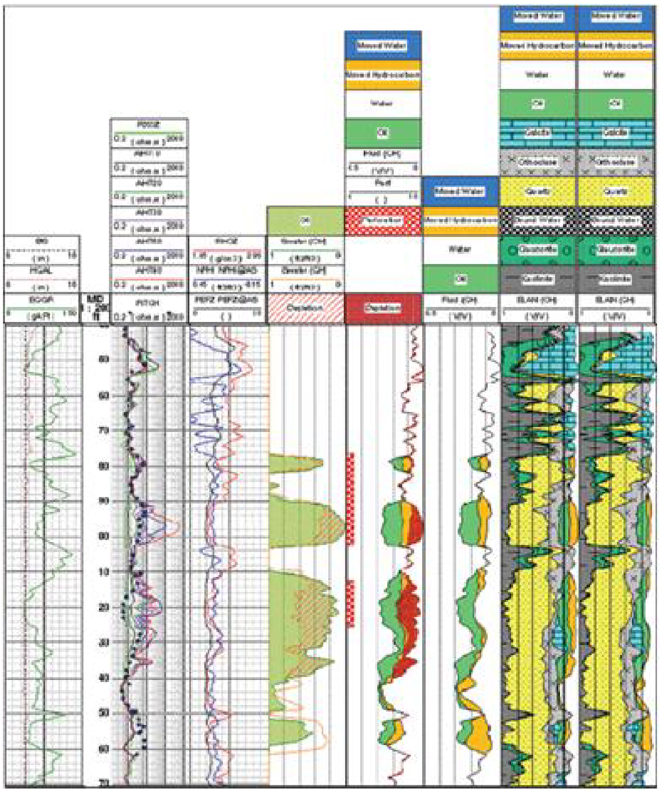

Figure 3: CHFR, Time Lapse Evaluation to show the level of depletion (Egypt).

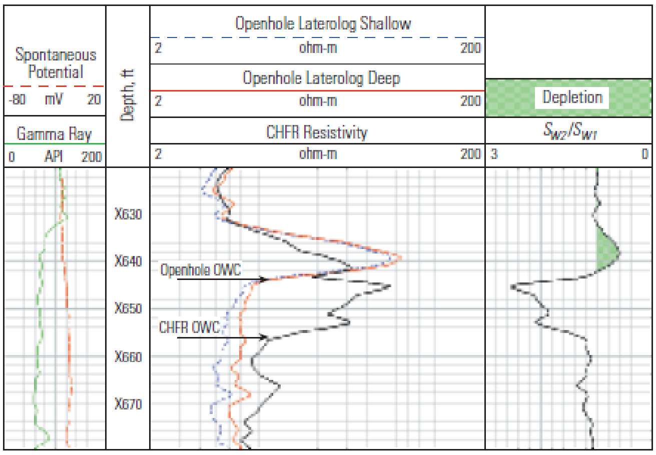

Figure 4: CHFR, Reservoir monitoring of different OWC levels, Indonesia.

cut. The old perforation interval which was flooded is squeezed with cement. After the remedial action, the water cut dropped from 90% to 0%. The well was completed with addition new perforation at the remaining oil depth. These jobs increased the oil production from 34 BOPD to 253 BOPD [5].

Case three water management in Aghar field, Egypt

In 18 months of Well-1 production, the oil production decreased by 70% and water production increased about 86%. It is suspected that the OWC in the well increased. A time lapse technique was used to identify the depletion (Figure 3). Hence, a cement squeeze job was executed in the well to shut off the water. The shut off records increase in oil production from 540 to 2250 BOPD with the decrease in water cut from 86% to 1% [6].

Case four abnormal OWC movement, Indonesia

This a case of an oil well in Indonesia where CHFR log showed an unexpected oil water contact 12 ft. below the original OWC determined from open hole logs (Figure 4). This lower section was perforated and three weeks later was producing 2150 BOBD with no water cut confirming the CHFR results [7].

Conclusion

1. In performing water shut off, it is always important; to detect water zones; to identify the water movement mechanism and to locate water entry zone.
2. CHFR log provides deep formation resistivity measurement which highlights the saturation changes and easily detect bypassed zones.
3. CHFR gives more accurate interpretation than pulsed neutron tools TDT or C/O specially in cases of low salinity and low porosity reservoirs.
4. A sharp decline in water production concurrent with sudden increase in oil production after the well intervention job shows that CHFR tool is very essential in managing water production and also as contingency tool.
5. Remedial work over operations based on the cased hole resistivity results have allowed a significant enhancement of the oil production and the implementation of an optimum field management strategy.

References

1. Reynolds RR (2003) Produced Water and Associated Issues. A Manual for Independent Operator. PHC, Oklahoma Geological Survey.
2. Hamada GM (2017) TDT and CHFR Logs Monitoring of Water Production and Bypassed Oil Layers and Water Production management in Matured Sandstone Reservoirs. Am J Eng Res 696: 192-203.
3. Claverie M, Malek NA, Goh KF (2006) Practical Steps for successful Identification and Production of Remaining Hydrocarbons Reserves in a Mature Field-Case Study from Tinggi, Malaysia, SPE 101140. SPE Asia Pacific Oil & Gas Conference, 11-13 September, Adelaide, Australia.
4. Ma SM, Al-Ajmi FA, Al-Shehri AM, Al-Behair AM (2004) Looking Behind Casing: Evaluation and Application of Cased-Hole Resistivity in Saudi Arabia, SPE-88467, Presented at SPE Asia Pacific Oil and Gas Conference, Perth, Australia, 18 -20 October.
5. Tchambaz M, Belhaj B (2003) Reservoir Monitoring with The CHFR-Plus In Water Injection Oil Fields, Libya Examples SPE 84598. SPE Annual Technical Conference, 5-8October, Colorado, USA.
6. Bekheit B, Mohamed Gh, Mahgoub Sh (2010) Effective Use of Resistivity behind Casing to Improve Oil Recovery from A Brown Oil Field: A Case Study from The Western Desert, Egypt", SPE-127995, Presented at North Africa Technical Conference and Exhibition, 14-17 February, Caro Egypt.
7. Aulia K, Beguin P, Boyd A, Farag Sh, Ferraris P et al. (2001) Resistivity behind Casing, Oil Field Review, Schlumberger.