Formation evaluation for Mishrif formation in Nassiriya oil field

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Abstract— **formation evaluation is used to determine the ability of a borehole to produce petroleum. Essentially, it is the process of "recognizing a commercial well when you drill one". The formation evaluation problem is a matter of answering two questions: -What are the lower limits for porosity, permeability and upper limits for water saturation that permit profitable production from a particular formation or pay zone; in a particular geographic area; in a particular economic climate. -Do any of the formations in the well under consideration exceed these lower limits. It is complicated by the impossibility of directly examining the formation. It is, in short, the problem of looking at the formation indirectly by the following methods (mud logging, wireline logging, coring, well testing).this research focused on well logging, Well logging is the process of recording physical, chemical, electrical and other properties of rock/fluid mixture penetrated by drilling a borehole into the earth crust. Many of these logs are electrical in measurements. Hydrocarbon may exist in a porous and clean formation. That is, gamma ray and spontaneous potential can identify shaly/clean zones while neutron, density, sonic logs or even NMR logs may be used for porosity estimation. Resistivity logging is used to differentiate between formation filled with salty water (low resistivity) and with those filled with hydrocarbons (high resistivity).**

The petrophysical evaluation was based on well logs data to delineate the reservoir characteristics of Mishrif formations. The available well logs such as (Gamma ray, SP, Resistivity (MSF, ILL), Sonic, Density and Neutron logs) were uploaded to Geolog7 software. The petrophysical parameters such as porosity, water saturation, hydrocarbon saturation and shale volume were computed and interpreted using Geolog7 software. Petrophysical properties were determined and plotted as computer processing interpretation (CPI) using the same software above.

The Mishrif Formation considered as main reservoir products in Nassiriya oil Field, south of Iraq. The well- Ns was selected to study the characterization of carbonate reservoirs and calculate petrophysical properties for the Mishrif Formation in Nassiriya oil field. The upper and lower contact boundaries of Mishrif formation were determined using electrical porosities, and Gamma ray logs. The Formation is subdivided into two main lithological units (upper Mishrif and lower Mishrif) separated by impermeable unit depending on Gamma ray logs. Lower lithological unit is also subdivided into two reservoir units which is (mB1 and mB2) separating by barrier rocks. The

results of calculating the volume of shale show an increase in volume in (CR11) cap rock unit more than (80%), this unit is impermeable zone, Also this show that Units mA and mB2 have poor reservoir properties, while unit mB1 has good reservoir properties and it was considered the best reservoir units where The water saturation value in this unit between (20-30%), while porosity between (13-28%). The total net pay in this unit about 66m. while the average water saturation in mB2 about (80%) and average porosity about (14%). Unit mA is water bearing zone with high water saturation value and low porosity value. The oil water contact depth is 2052m .

Keywords- formation evaluation; water saturation; porosity; Well logging

I. INTRODUCTION

Wire line logging is a conventional form of logging that employs a measurement tool suspended on a cable or wire that suspends the tool and carries the data back to the surface. The wire line logs are providing continuous measurement of data as a function of depth, but they are used as a supplementary method to cores.

Wire line logs consist of these types of logs which are mechanical logs (e.g., calipers), electrical logs (e.g., laterologs, induction logs, SP logs), natural radiation logs (e.g., simple and spectral gamma ray logs), acoustic logs (e.g., sonic logs), pressure and temperature logs, artificial radiation logs (e.g., density and neutron logs), imaging logs (e.g., dipmeter and various other types) and special logs (e.g., NMR logs)[1]. Petrophysical interpretation is essential for understanding subsurface reservoir rock. Well Logging is a process of recording a detail for the geological formations have penetrated by borehole. Well logging represents as an integrated process in the measuring the reservoir.

Wireline logs represent one of the most important data types available to a reservoir geoscientist or petrophysicist because they provide a continuous record of borehole measurements that can be used to interpret the petrophysical properties and also the fluid distribution in the reservoir[2].

A. Gamma Ray log

Gamma ray (GR) logs used to calculate the natural radioactivity in formations, specify lithology and for correlation zones. Gamma ray tool detects gamma-ray emissions from radioactive isotopes. Gamma ray logs imply the presence of shale when there is a high gamma ray response. Clean (shale free) sands or carbonates tend to have a low gamma ray response [3]. The gamma ray log uses a scintillation counter to measure the natural radioactivity of formation as the sonde is drawn up the borehole. The main radioactive element in rocks is potassium, which is commonly found in illitic clays and to a lesser extent in feldspars, mica, and glauconite. Therefore, the gamma ray log uses a scintillation counter for calculating the natural radioactivity of formation as the sonde is drawn up the borehole [4].

B. Density log

The density log calculates formation density from emitting gamma radiation from the tool and recording that the amount of gamma radiation returning from the formation. A density logging tool uses intermediate energy gamma rays emitted from a radioactive source in the tool to induce Compton scattering in the formation. In this process, gamma ray photons from the tool collide with electrons in the formation and transfer some of their energy to the electrons[5]. The remainder of the energy is scattered as lower energy gamma ray photons. The density logging tool then detects some of these scattered photons. The gamma ray count rate at the tool depends on formation electron density, which is proportional to formation bulk density ρb. Combining ρb from the density log with rock matrix density ρma and fluid density ρf yields porosity ϕ [3].

C. Sonic Log

The sonic log is a porosity log that measures interval transit time (Δt ,delta t, or DT) of a compressional sound wave traveling through the formation along the axis of the borehole. The sonic log device consists of one or more ultrasonic transmitters and two or more receivers ([6].

D. Neutron log

Neutron logs measure the hydrogen concentration in a Formation, the hydrogen index (HI); the commonest source of hydrogen in the formation will be hydrocarbons. Or water In shale-free where the pore space is filled with water or oil, the neutron log directly measures liquid-filled

porosity Symbolizes (ϕn,PHIN, or NPHI) [3]. Neutrons are produced from a chemical source in the neutron logging tool. The chemical source is usually a mixture of americium and beryllium which continuously emit neutrons. When these neutrons collide with the nuclei of the formation the neutron loses some of its energy. With enough collisions, the neutron is absorbed by a nucleus and a gamma ray is emitted. Because the hydrogen atom is almost equal in mass to the neutron, maximum energy loss occurs when the neutron collides with hydrogen atoms. Therefore, the energy loss is dominated by the formation’s hydrogen concentration. Because hydrogen in a porous formation is concentrated in the fluid-filled pores, energy loss can be related to the formation’s porosity [6].

E. RESISTIVITY LOG

Resistivity logs are electrical well logs that record the resistivity of a formation. Resistivity is usually recorded in ohm meters (Ωm). Three depths of resistivity can be logged (shallow, medium, and deep) that record the resistivity of the formation with increasing distance away from the borehole. Resistivity logs can be interpreted to infer information about the porosity of a formation, the water saturation, and the presence of hydrocarbons.

II. THE CASE STUDY AREA

Nasiriya Oil Field is located in Thi-Qar governorate about (38 km) north-west of Nasiriya city. Include an anticline structure with NW-SE trend. The exploration operation and the exploratory drilling had discovered the major reservoir in Mishrif, Yamama and Nahr Umr formations [7]. The field latitudes is 34 80' -34 60' N and longitudes 57 50' -60 10' E, as The Mishrif formation is considered heterogeneous formation described as organic detrital limestone with beds of algal, rudist, and coral-reef limestone, capped by limonitic fresh water limestone [8]. Mishrif formation had divided into two main units (upper Mishrif, MA & lower Mishrif, MB). They are separated by thin shale unit within 10 m thickness and lower Mishrif is subdivided into MB1 and MB2 with barrier rocks in some areas of the field [9]. Figure (1).

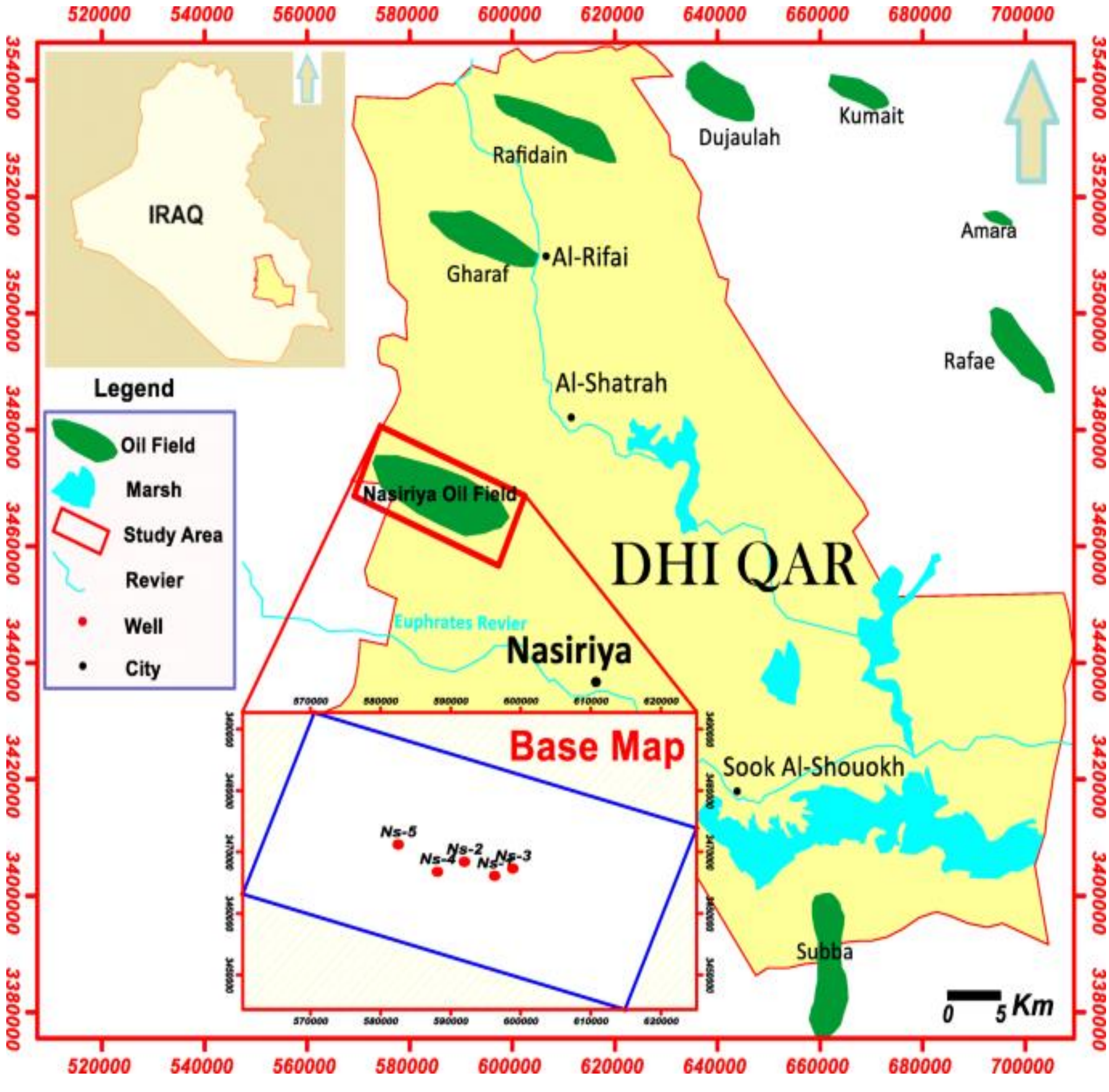

Figure 1. Nassiriya oil field location map [10]

III. METHODOLOGY

This study was based on data subsurface provided by the Thi-Qar Oil company. LAS file for well-Ns in Nassiriya oil field was used to achieved the study aims. The LAS file for well-Ns containing (gamma-ray, sonic, density, neutron, and resistivities logs).

The methodology was using in this study as following:

A . Gathering primary information: Includes viewing the final geological report, previous reservoir and geological studies that made on the Nassiriya field.

B – Using Paradigm Geolog7 software: This program was developed by petrophysicists to obtain fast, accurate, versatile and portable results. It is a log analysis tool, ideal for both geologists who may wish to check quality of their log data, and it is also used experienced petrophysicists who are able to carry out multi-zone, multi-wells by using mathematical equations in order to calculate the (volume of shale, the porosity total and effective porosity, water saturation).

1. Calculation of Shale Volume (Vsh)

To derive Vsh from gamma ray log, it is imperative that the gamma ray index (IGR), determined by using equation of Schlumberger (1974)[11]:

IGR= (GRlog - GRmin)/(GRmax –Grmin) (1)

When: IGR= gamma ray index; GRlog= gamma ray reading of formation; GRmin= minimum gamma ray (clean sand or carbonate); GRmax= maximum gamma ray (shale). figure (2) shows the shale volume of Mishrif Formation.

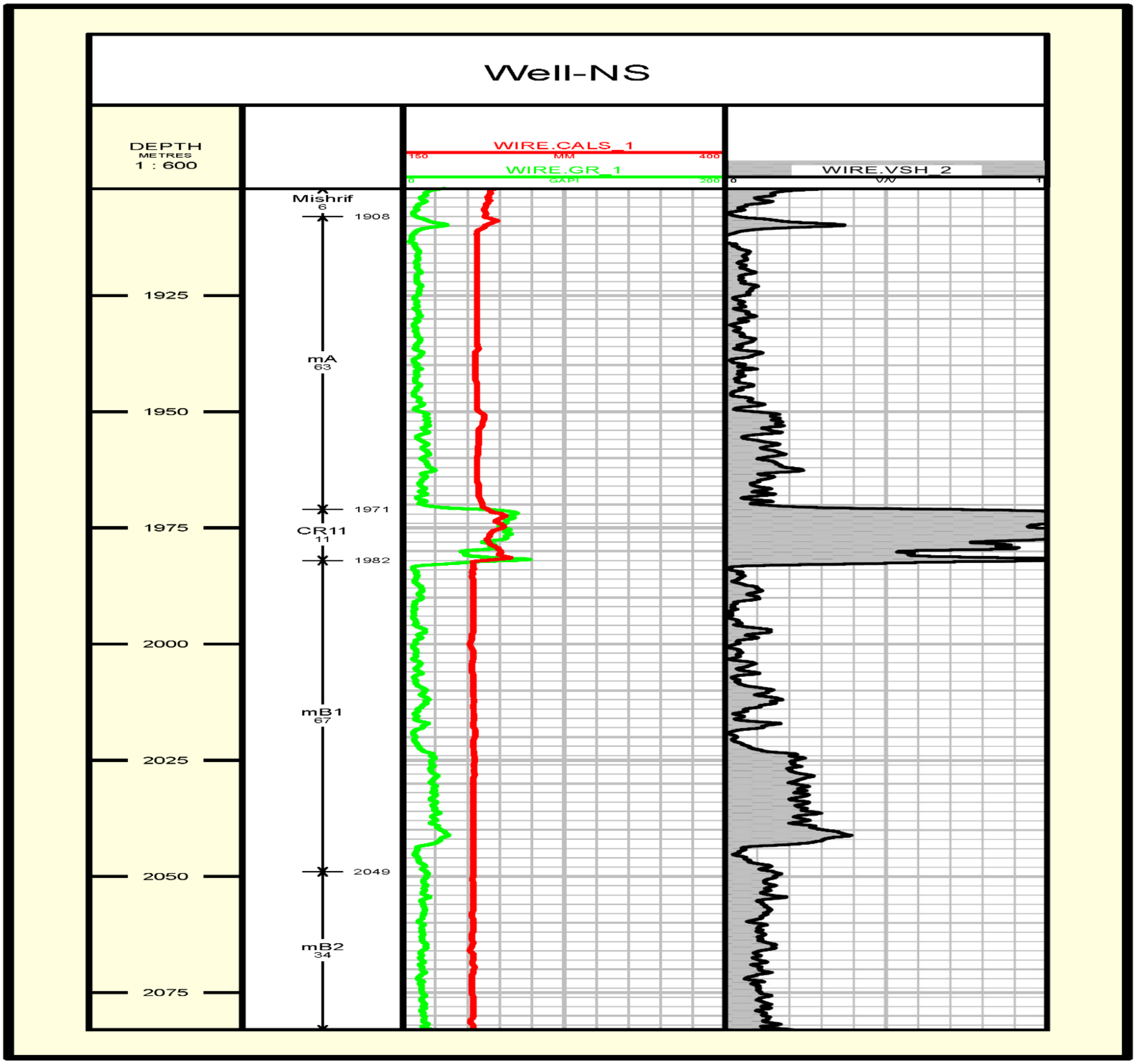

Figure 2. The Shale Volume of Mishrif Formation

2. Calculation of Total and Secondary Porosity

Neutron log measure the direct porosity and Density porosity is derived from the bulk density of clean liquid filled formations when the matrix density (ρma) and the density of the saturating fluids (ρf) are known, using Wyllie et al., [12] equation:

ØD= (ρma - ρb) / (ρma - ρf) (2)

Where: ρma= density of matrix (2.71 gm/cm3 for limestone); ρf= density of fluid (1 gm/cm). In intervals, whose shale volume is more than 10%, we used equation (1) to remove shale effect from porosity calculation:

To calculate Total porosity (Øt), equation (3) is used as follows:

Øt= (ØN + ØD) / 2 (3)

The effective porosity (Øe) is then calculated, using equation of Schlumberger [13] after total porosity corrected from shale volume:

Øe= Øt * (1-Vsh) (4)

Figure (3) below shows total and effective porosity of Mishrif formation.

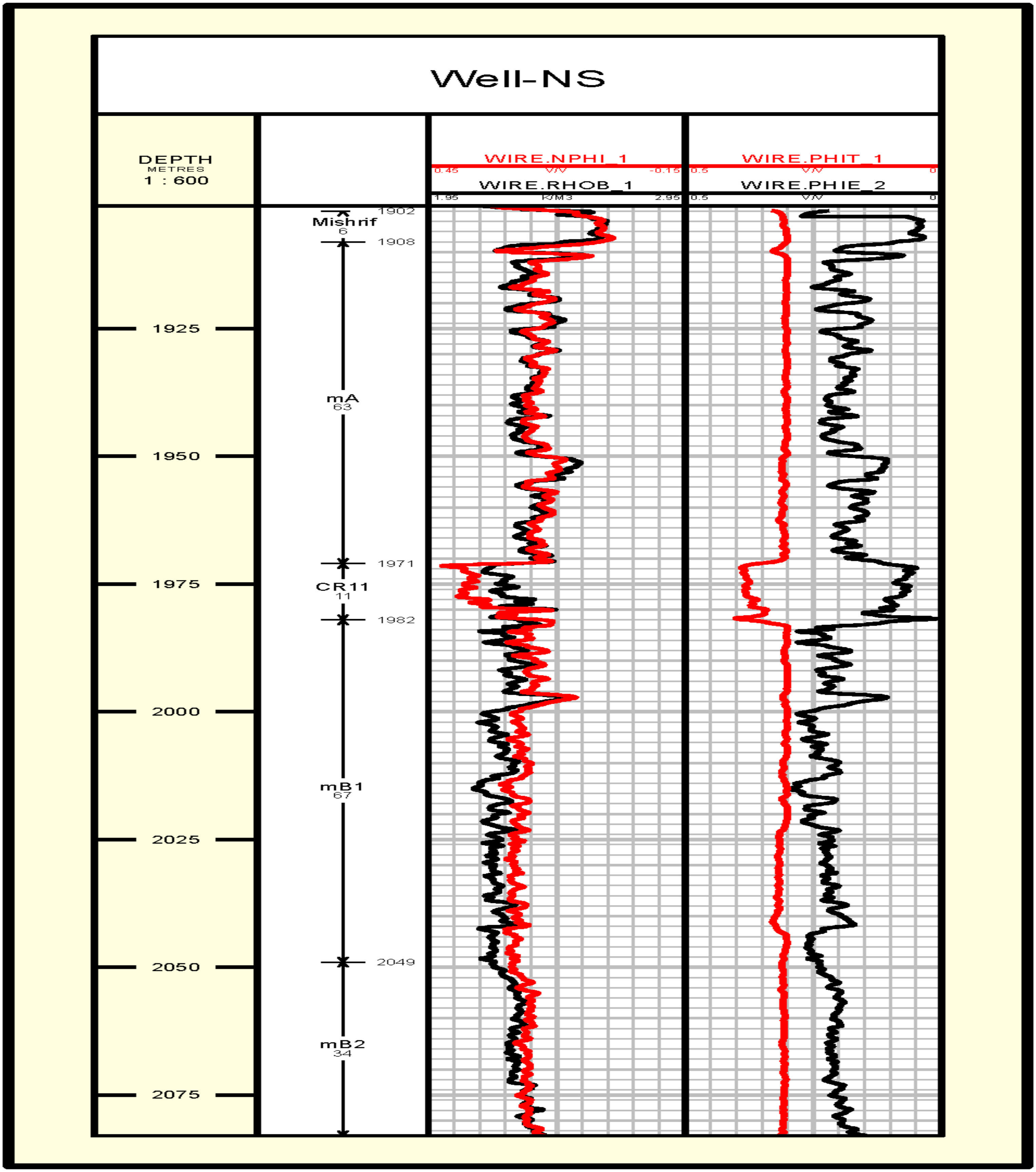

Figure 3. total and effective porosity

3. *Calculation of Water Saturation*

Water saturation for the uninvaded zone was calculated according to Archie [14]:

Sw = [(a * Rw) / (Rt * _m)]^1/n (5)

Where: Sw= the water saturation (fraction); Rw=Resistivity of water formation which is =0.022 ohmm; Rt= formation resistivity (ohm-m);

a=tortuosity factor; m= cementation factor; n=saturation exponent (Archie's parameters).

IV . RESULTS AND DISCUSSION

A. Identify the Mishrif formation top and sub-units

One of the most important direct applications for well logs is definition of formation boundaries. In this study, the upper and lower contacts of the Mishrif Formation are defined by changing in log curves reading. The Gamma ray log was used to determine the upper contact with Kifl Formation and the lower contact with Rumaila Formation. The gamma ray log recorded low values in the tops which mean the appearance of clean chalky limestone at the top of Mishrif formation, and high gamma ray reading in lower contact with Rumaila formation

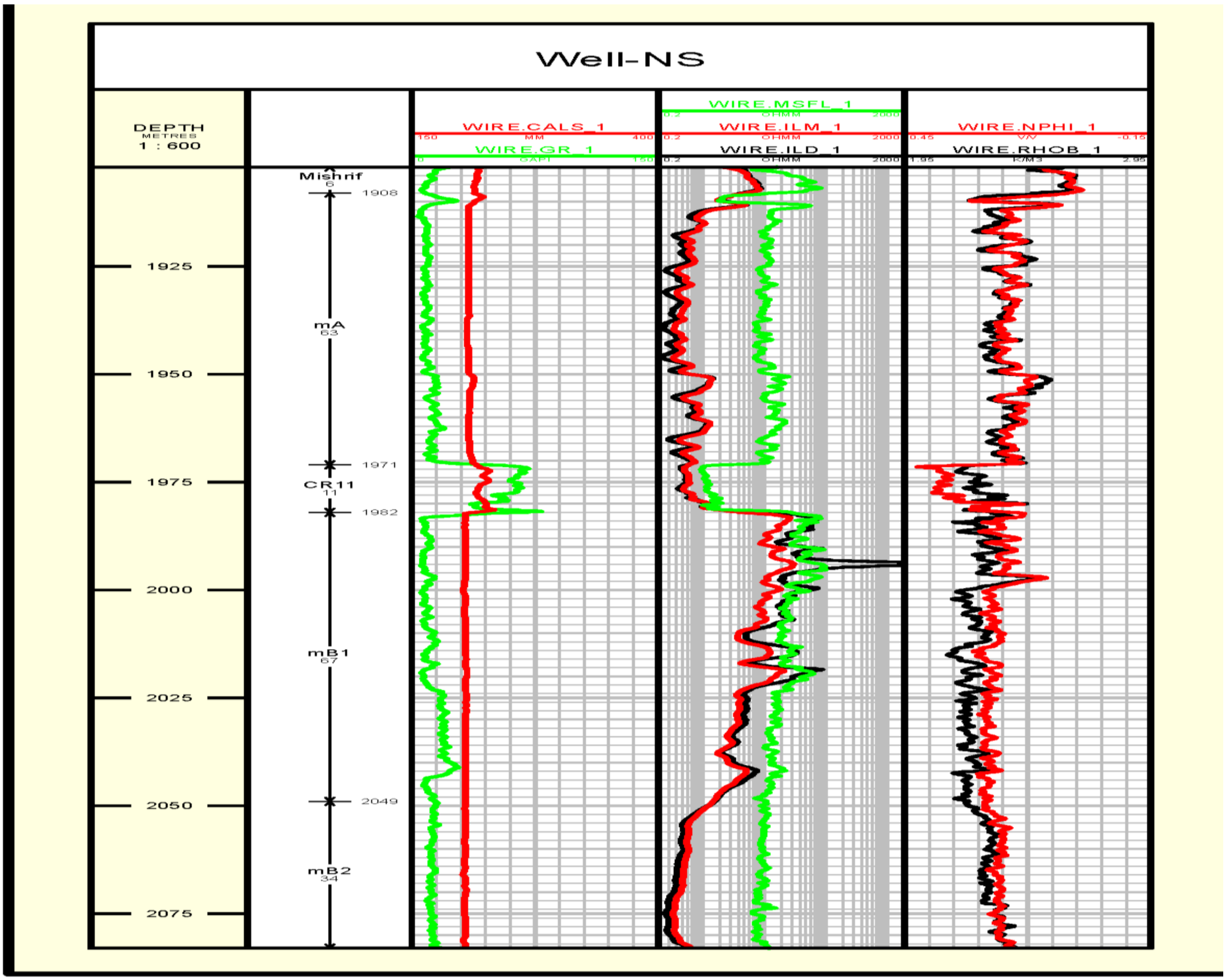

Figure 4. Mishrif tops and sub-Units

The Mishrif formation is subdivided into two main lithological sub units (upper Mishrif and lower Mishrif) separated by impermeable unit depending on Gamma ray logs. Lower lithological unit is also subdivided into two reservoir units which is (mB1 and mB2) separating by barrier rocks. The figure (4) below showing the Mishrif tops and sub-units.

In this study, the shale volume has been calculated by using (Geolog7) program. The results of calculating the volume of shale show an increase in volume in (CR11) cap rock unit more than (80%), this unit is impermeable zone and the lithology of this zone is Shale according to final geological report.

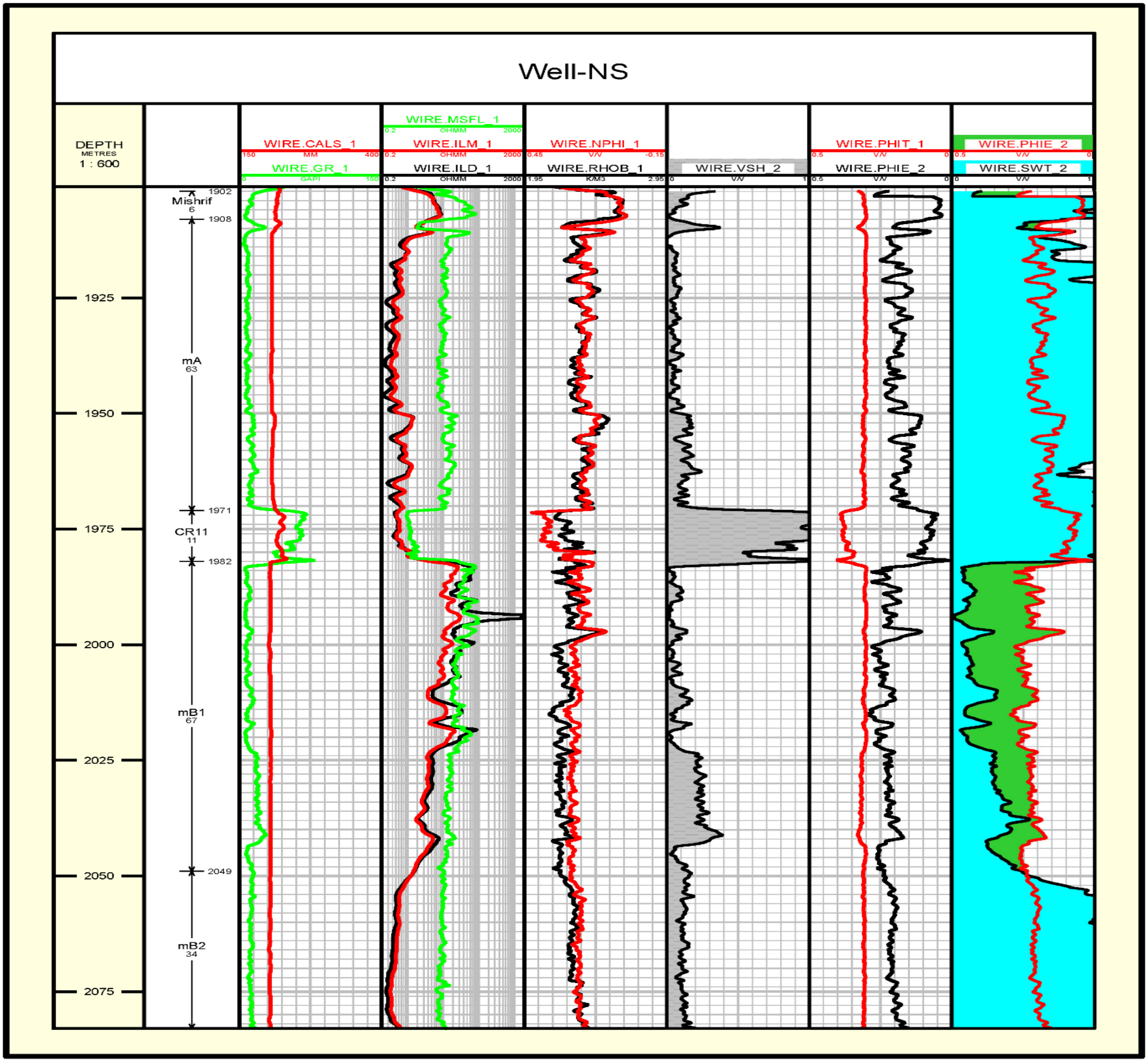

Figure 4. The petrophysical Properties of Mishrif Formation

Porosity of the Mishrif formations have been calculated by using porosity logs, it has been observed that unit mB1 have high effective porosity values, while the unit CR11 have high total porosity but the effective porosity is very low.

B. Petrophysical evaluation

In the Mishrif Formation, Units mA and mB2 have poor reservoir properties, while unit mB1 has good reservoir properties and it was considered the best reservoir units for oil in Nassiriya oil field. The unit mB1 has recorded lowest water saturation and highest porosity value. The water saturation value in

this unit between (20-30%), while porosity between (13-28%). The total net pay in this unit about 66m.

Unit mB2 considered as water bearing zone with average water saturation about 80%, while average porosity about 14%. Unit mA is water bearing zone with high water saturation value and low porosity value.

The oil water contact depth is 2052m. The figure (5) below showing the petrophysical properties and well logs data.

V. CONCLUSION

The study aimed to evaluate Mishrif formation in Nassiriya oil field and calculate the petrophysical properties (shale volume, total and effective porosity, and water saturation) using well logs data sets by using Geolog7 software. It can be concluded that:

The Mishrif Formation consists of two main units separated by a shale layer, the upper unit has low reservoir properties, and the lower unit has good reservoir properties.

Based on the petrophysical properties variation with depth, the Mishrif Formation in the Nasiriya Field is divided into four units. These units are from the top mA, CR11, mB1.

The unit Mishrif mB1 is the best unit in Nasiriya field that characterized by the higher reservoir properties and represent the principle oil-bearing zone.

ABBREVIABIONS

Well-Ns = Well Nassiriya
Pb = bulk density
Pf = fluid density
Vsh = Shale Volume
Grmin = minimum gamma ray
IGR = gamma ray index
GRlog = gamma ray reading of formation
GRmax = maximum gamma ray (shale)
ØD = Total porosity from density log
Øt = Total porosity
Øe = effective porosity
ØN = Total porosity from neutron log
Sw = the water saturation
Rw =Resistivity of water formation
Rt = formation resistivity
a = tortuosity factor
m = cementation factor
n=saturation exponent (Archie's parameters).

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