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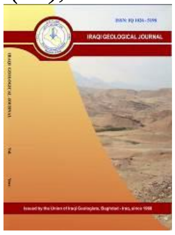

Identification of Tar Mat in Zubair Formation of the X Oilfield, Southern Iraq

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Abstract

The Zubair Formation was selected in the X oilfield to determine the tar zones via core, and wells logs including micro-resistivity and NMR. The study focused mainly on the main pay of the Zubair Formation, which contains a thick variable tar mat interval near the oil-water contact area, and it impacts reservoir productivity. Tar mat zones were distinguished using different paradigms such as descriptions of core and study borehole logs behavior. The result indicated that the tar mat thickness increases in the middle part of the X oil field due to the presence of high amounts of shale volume. Therefore, tar mats create barriers between oil columns and formation water, preventing the production of secondary oil in these regions.

Keywords: Tar mats; Well logging; NMR log; Core analysis

1. Introduction

Tar mat is a general term for both tar mat and bitumen, and its definition differs across authors. According to Jacob (1989), tar mats are solid organic matter zones that fill gaps and fractures in rocks and maybe laterally continuous, acting as fluid flow barriers. Furthermore, he gave another definition of tar mat as concentrations of heavy oil, usually asphalt, occurring near the oil-water contact in an oil reservoir. Its existence in many oil reservoirs is due to rapid pressure declines, low primary oil recovery, and prematurely high gas-oil ratios (Wilhelms and Larter, 1994). Besides, it may affect the reservoir performance by reducing effective porosity by filling pores, reducing permeability by restricting pore throats, and changing wettability the influencing reservoir quality (Shaw et al., 1996). The tar mats are usually contained various quantities of carbon (from 100 to 300 atoms per molecule), oxygen, hydrogen, sulfur, nitrogen components, nickel, and vanadium (Pineda-Flores and Mesta-Howard, 2001). A tar mat extension can either be continuous or discontinuous in the reservoir, and the thickness varies from area to area. Tar mats were detecting in many major oil reservoirs in the world and, particularly, in the Middle East such as south Iraq, Qatar, Saudi Arabic, and Kuwait (Al-Bazzaz and Al-Mansour, 2014).

Numerous studies have been conducted on tar mats in the Zubair Formation. Azim et al. (2006) studied the tar mat origin and distribution in the Raudhatain oilfield of north Kuwait in the Zubair Formation in the upper sand reservoir. The result showed that there is a 100 ft thickness of tar mats near the oil-water interface. Asphaltene content in the tar mat was above 80%. Jedaan (2007) studied the characteristics, origin, and repartition of tar mat in the Bul Hanine field in Qatar. Awadh et al. (2019)

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showed how hydrochemistry controls the brine origin and may be permeability barrier may form. As a result of this study, the tar mat should be removed from the volumetric calculation because it acts as a barrier to permeability. Also, the asphaltene deposited near the paleo oil-water contact (OWC) or over permeability barriers resulting from the filling of the reservoir with light oil or variations in pressure and temperature.

Al-Ameri et al (2011) showed that the main kerogen source in the Zubair reservoir originated from the migration and accumulation of kerogen from Jurassic and Lower Cretaceous source rocks to various Cretaceous reservoir traps in that formation. Assuming a TOC of 0.2–2.6 wt % in the layers of shale, it is thought to be a fair source rock. Al-Mansour (2014) studied the effects of temperature on the chemical and physical properties of oil in deep tar mats. Several reservoirs were found to contain massive layers of tar mat column. With increased temperature, the heavier components of the tar mat decreased, including nitrogen, oxygen, and sulfur.

While Jawad and Handhal (2019) studied the identification of deposits, distribution of tar mat, and forming mechanism in North Rumaila oil field in the main pay of the Zubair Formation. The result showed that tar mats create a barrier between the formation water and oil column, impeding recovery of secondary oil. Further, the thickness of tar increases in the northeast part of the north Rumaila oilfield due to the presence of shale. This study aims to detect tar in the Zubair Formation in the X oilfield using different methods such as Rock-Eval analysis, log data, and visual detection of cores.

2. Geological Setting

Geologically, the X oilfield is one of the giant's oilfields in Iraq, and it is located in the north part of the Arabian Plate southern of Iraq in the Zubair subzone of the Mesopotamian foreland basin (Fouad, 2010), which is a portion of the Unstable Shelf (Jassim and Goff, 2006) (Fig.1). The X oil field structure forms part of the asymmetrical elongated anticline structure. Each flank dips slightly differently; the west flank is steeper than the east, dipping from about 2° to 3.5°, while the east's dip is about 1.6°. The length of the X oil field is 20 km and the width is 17 km without any faults (Ismail and Al-Najam, 2019). The majority of the structure traps in southern Iraq formed as a result of a collision between the Arabian Plate and the Iranian Plate during the Alpine movement (Al-Sakini, 1992).

The Zubair Formation sandstone is a major reservoir in the south of Iraq. The sandstone of the Formation is dominant in the SW margin of the basin and thin towards Iran (Ali and Nasser, 1989). The sediments of this formation were transported into the Basrah area by the Wadi Al-Batin depression (Ali and Aziz, 1993). It covers wide districts of the Arabian Plate, including Kuwait, northern Saudi Arabia, and part of central and southern Iraq. In southern Iraq, the Zubair Formation consists of the following informal members (Fig.2) (from oldest to youngest): The Lower shale member, The Lower sandstone. The Middle shale, The Upper sandstone, The Upper shale (Abbo and Saffar,1967). The main pay member (upper sandstone) is oil productive at the X oilfield, and it subdivides into three informal units (Z2, H, L), they are separated by two shale intervals that are laterally continuous across the field area. The age of the formation was estimated by Bellen et al. (1959) as Hauterivian to Aptian or Barremian to earliest Aptian.

3. Materials and Methods

Numerous samples and wells data are choosing to identify tar mats such as core, micro resistivity logs, and Nuclear Magnetic Resonance (NMR) methods. The micro resistivity logs measure the resistivity of the invaded zone, while NMR is used to detect viscosity and the type of hydrocarbon based on shifting T2 values. In this study, Geolog software is used to process Petro-physical calculations.

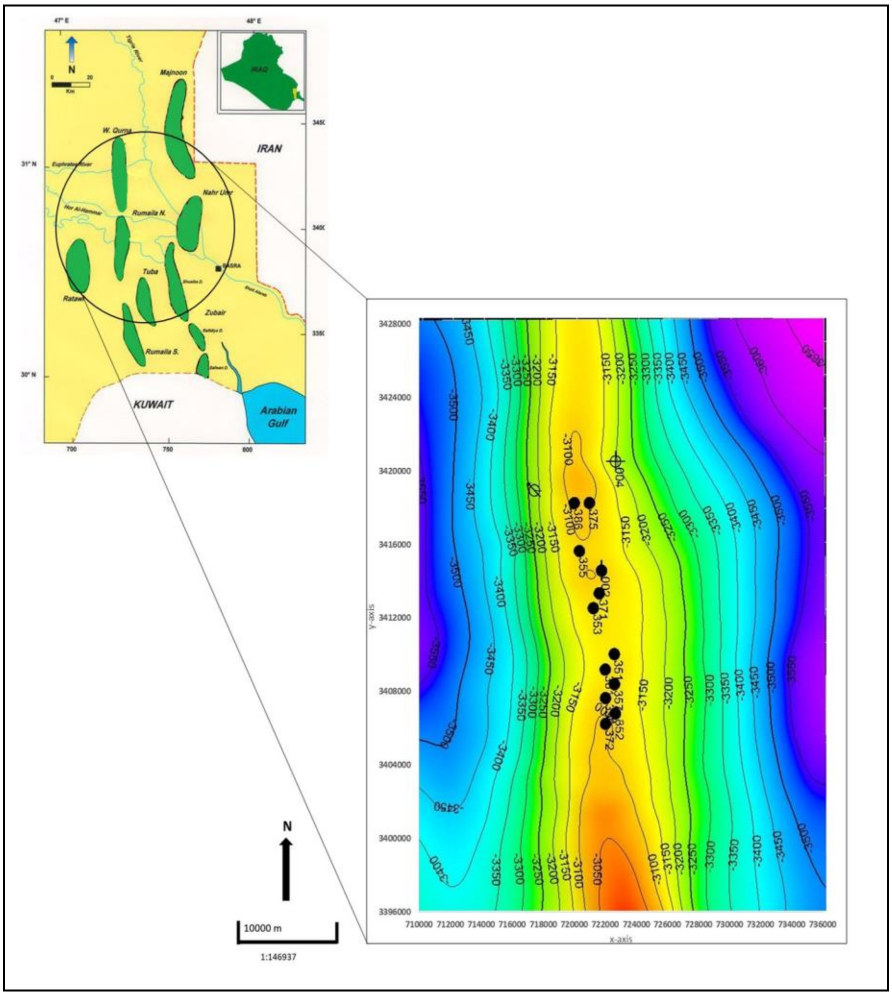

Fig. 1. The location of the X oilfield in relation to neighboring oilfields

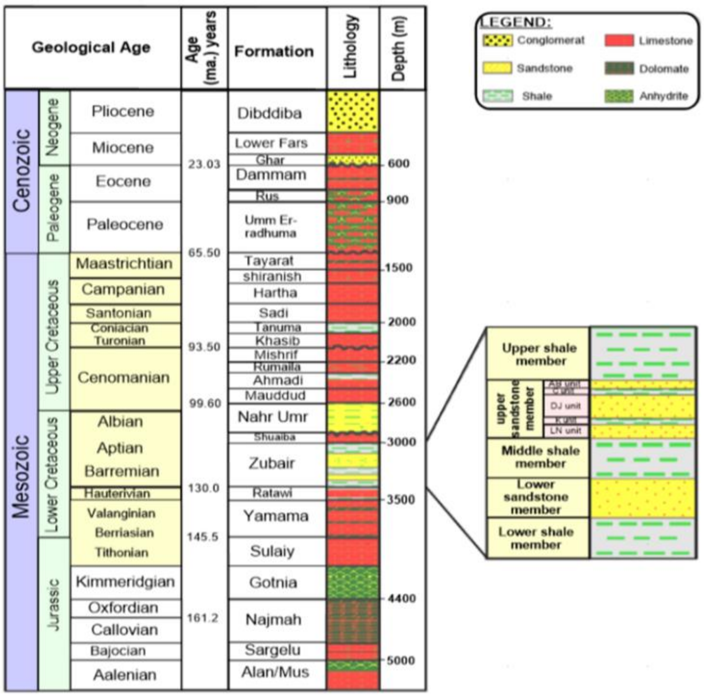

Fig. 2. The stratigraphic column in the Zubair Formation, North Rumaila field (Handhal et al., 2019)

4. Results and Discussion

Several methods were used for detecting tar in studied wells including:

4.1. Core Method

Tar mats can be detected visually from a core that relies on color differences in tar mat zones, rather than oil or water-filled zones. The tar mats appear darker brown or black because dark oil stains abounded in the tar mats. A geologist's experience, as well as geochemical data, is essential for using this method. Thus, X -002 well was selected to detect tar because it is the only well in the X oilfield that has core samples. As a result of observing the dark colors, we could identify the tar mat zones. The tar mats zone thickness of well X -002 was calculated and calibrated with well logging (Table 1 and Fig.3).

Table 1. Thicken of Tar mat zone for well X -002

Well No.	Top of tar zone (m)	Bottom of tar zone (m)	The thickness of tar mat with shale (m)	Zubair zone	Shale thickness within a tar (m)	Tar mats without shale (m)
X -002	3216	3230	14	Z2A	0.43	13.57

Fig.3. Color of tar mat in X-002 well core samples

4.2. Logs

The tar zone was identified by evaluating the behavior of open-hole logs across the formation, such as resistivity log, and NMR.

4.2.1. Micro resistivity logs

A micro-resistivity log is a type of log that records the flushed zone resistivity. The investigation depth of the log is a few millimeters. Micro-resistivity logs typically read a smaller value than deeper resistivity logs for oil zones drilled by mud filtrate, which had a lower salinity than formation water. In the tar zone, no mud filtrate can invade the formation around the borehole, so the micro-resistivity logs should have close or even greater resistivity than deeper resistivity logs (Azim et al., 2006). The thickness of tar mats was measured using this method for many wells in the X oil field oilfield showed in (Table 2) (Figs. 4 to 6).

Table 2. Thickness of tar is measured by resistivity logs

Well No.	Tar zone's top(m)	Tar zone at the bottom (m)	Tar mat with shale (m)	Zubair	The thickness of shale within a tar (m)	Tar mats without shale (m)
X -386	3225	3227	2	H3b sst	0.031	1.969
X -375	3244	3247	3	H7b sst	0.781	2.219
X -372	3207	3209	2	H shale	0.288	1.712
X -371	3238	3239	1	H3a sst	0.029	0.971
X -361	3259	3262	3	H3b sst	0.561	2.439
X -357	3249	3250	1	H3a sst	0.445	0.555
X -352	3245	3247	2	H3b sst	0.347	1.653
X -002	3216	3230	14	Z2A	0.43	13.57

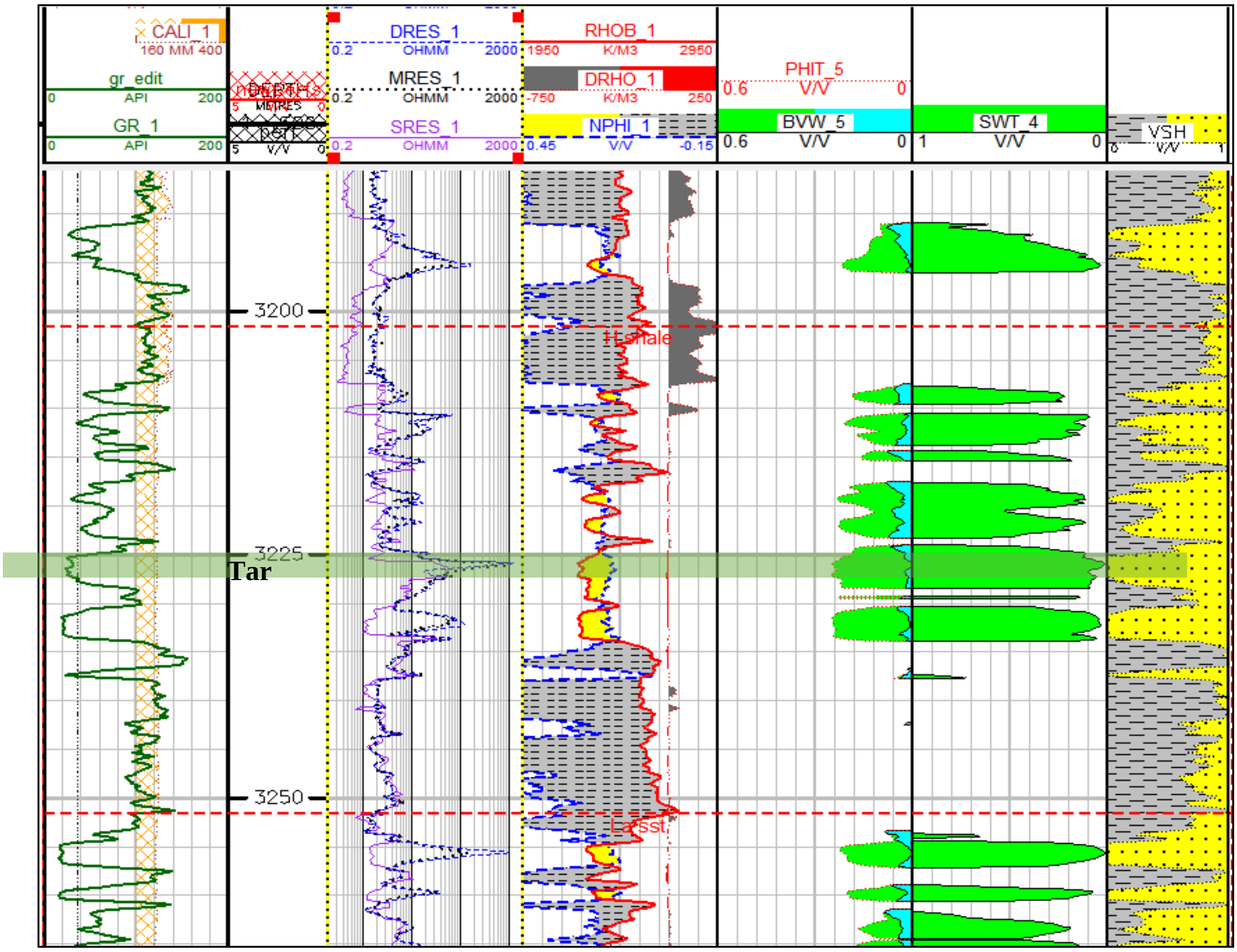

Fig. 4. Petrophysical characteristics for well X -386 showing Tar mat zone.

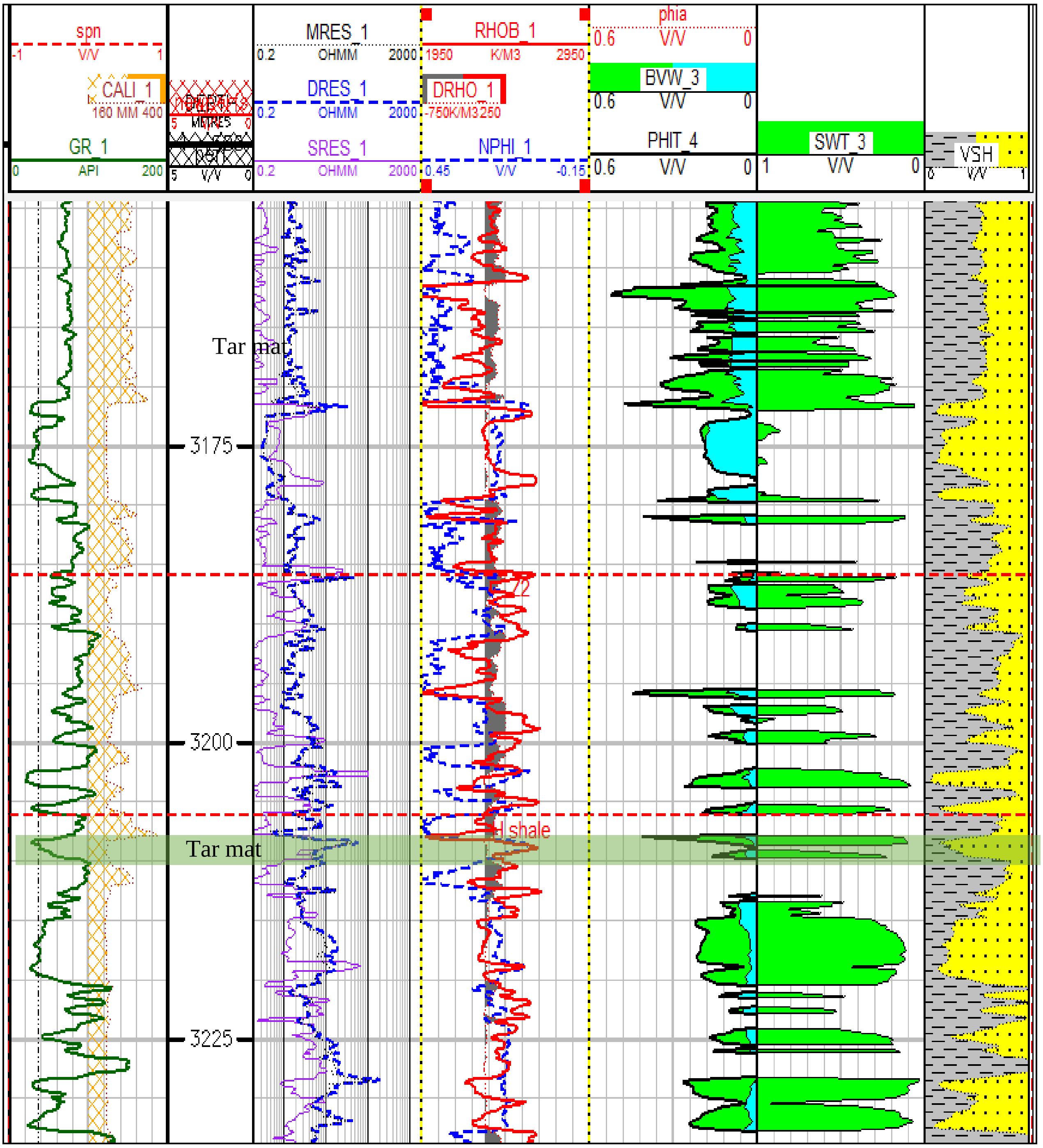

Fig. 5. Petrophysical characteristics for well X -372 showing Tar mat zone

4.2.2. NMR logs

Nuclear magnetic resonance (NMR) is a technique that indicates the response of atomic nuclei to magnetic fields. NMR measurements in tar zones showed a short T2 and low diffusion coefficient, as well as a lower hydrogen index (Nascimento and Gomes, 2004).

Geolog software has been used to process the NMR data from the X -352 well in the X oil field, (Fig. 7). Based on this figure, the tar zone is found at depths (3245 - 3247) m in the H unite of the main pay of the Zubair formation. Because Sandstone's default cut-off value is 33 ms (Ge et al., 2015), the T2 distribution on the left shows high viscosity and immovable hydrocarbons.

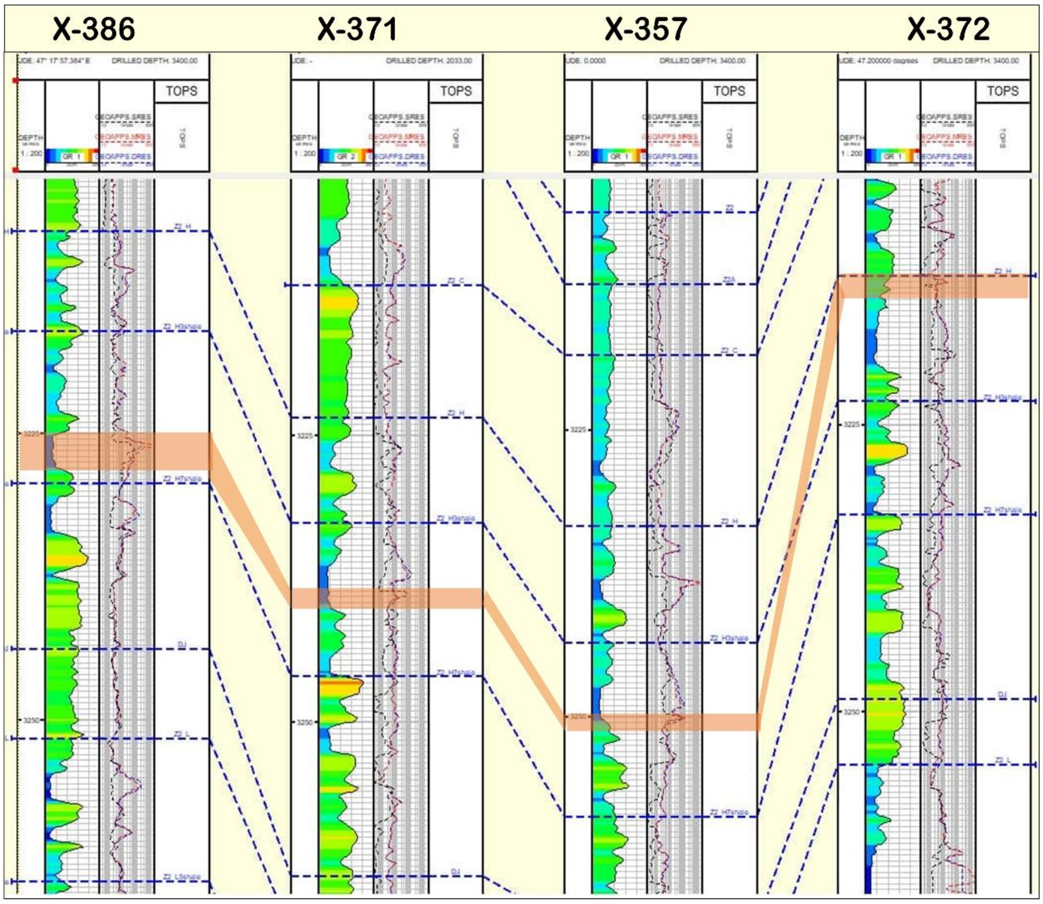

Fig. 6. Illustrate the tar mat zones extend along the X oilfield from north to south

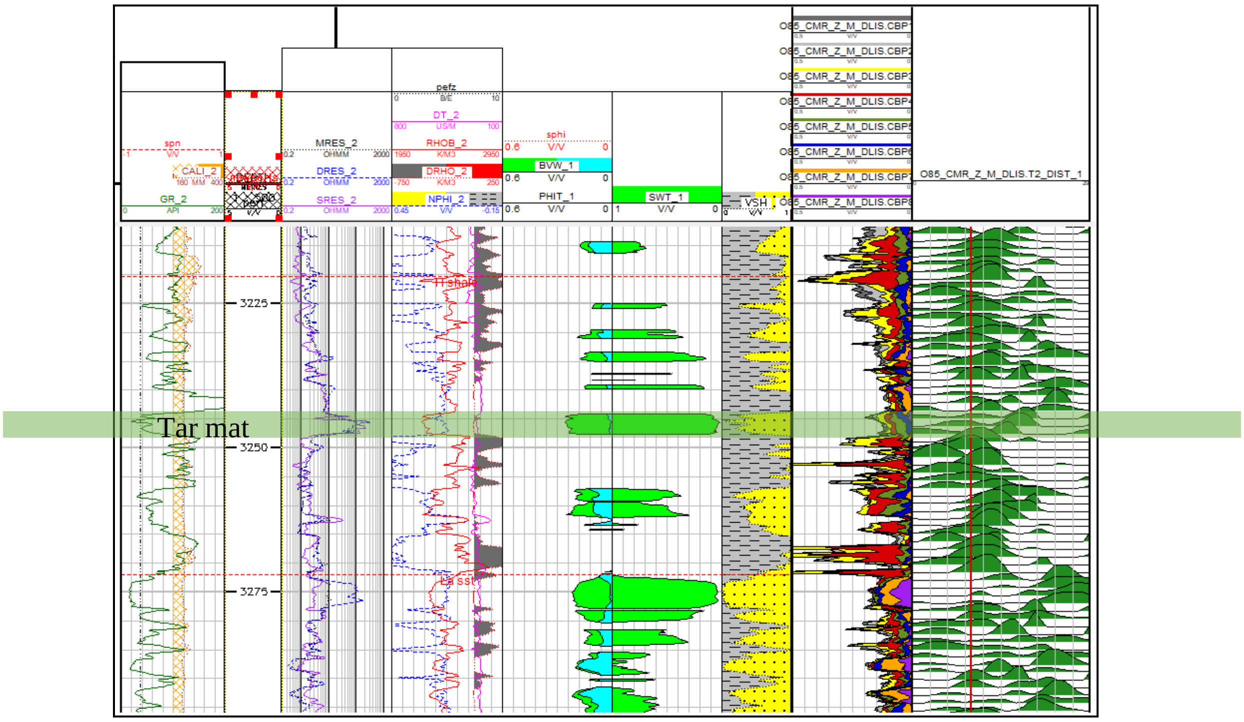

Fig.7. Applied NMR for well X -352 to exhibiting tar mat zone

5. Conclusions

- Tar mat was detected in the X oilfield depending on a description of the core samples and study borehole log behavior (Resistivity and NMR logs).
- Tar mat thickness is determined in 9 wells. In the north, the range is from 1.96 to 2.23 m, and in the south, it ranges from 0.56 to 2.44 m. While tar mat thickness ranges between 0.97 and 13.6 m in the saddle, among the north to the south of the X oilfield.
- The middle part of the X oilfield has a greater concentration of shale, which increases the thickness of tar.
- In these regions, tar mats prevent secondary oil recovery because they create a barrier between the formation water and the oil column.

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