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Characteristics of the Oil Water Contact Zone of Nhar Umr and Mishrif Reservoirs in Kumait and Dujaila Oil Fields, Southern Iraq, Using Vp/Vs Ratio and Porosity Logs Data

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Abstract

The detailed data of the Vp/Vs ratio and porosity logs were used to detect the Oil-Water Contact Zone (OWCZ) of Nahr Umr sandstone and Mishrif limestone reservoir formations in Kumiat (Kt) and Dujaila (Du) oil fields, southeastern Iraq. The results of OWC were confirmed using P-wave, Resistivity, and Water Saturation (Sw) logs of Kt-1 and Du-1 wells. It was found that the values of the oil-water contact zone thickness in Nahr Umr sandstone and Mishrif limestone were approximately one meter and eight meters, respectively. These results suggest that the OWCZ is possibly thicker in the carbonate rock than clastic rock formations. The thickness of OWCZ in the clastic rocks changed from one part to another, depending on several factors including mineral composition, grain size, porosity, pore shape, and fluid type.

Keywords: Vp/Vs ratio, Porosity, Oil-water contact, Nahr Umr, Mishrif

دراسة الخصائص المكمنية لحدود انطقة النفط والماء لتكويني نهر عمر والمشرف في حقول كميت–دجيلة باستخدام نسبة Vp/Vs وبيانات مجسات المسامية في جنوب العراق

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الخلاصه

تم استخدام البيانات التفصيلية لمجسات نسبة Vp/Vs والمسامية للكشف عن حدود منطقة التلامس النفطي بالماء (OWCZ) لتكويني نهرعمر والمشرف ضمن حقول كميت والدجيلة في جنوب شرق العراق وكانت نتائج الكشف عن حدود انطقة النفط مع الماء في هذه التكاوين من خلال دراسة مجسات P–wave ، المقاومية ، والتشبع المائي والواقعة ضمن أبار كميت–1 و دجيلة–1، حيث وجد أن سمك منطقة تلامس النفط لتكويني نهر عمر الرملي والمشرف الجيري حوالي متر وثمانية أمتار على التوالي. يعتقد المؤلفون أن النطاق السمكي الواقع من بداية حدود تلامس النفط بالماء(OWCZ) الى حد نهاية النفط وبداية التشبع بالماء O.W.C قد تكون أقل سمكا في الصخور الفتاتية من التكوينات في الصخور الكربونية . وان سمك

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OWCZ يتغير في الصخور الفتاتية من جزء إلى آخر اعتمادًا على العديد من العوامل بما في ذلك التركيب المعدني وحجم الحبيبات والمسامية وشكل المسامات وأنواع السوائل ضمن المكمن .

1. Introduction

The oil-water contact (OWC) is an important parameter to evaluate the petrophysical properties and calculate the volume of oil in the reservoir. The OWC does not reflect a sharp surface boundary, but it is a transition zone. The resistivity log is usually used to determine OWC and water saturation (Sw) [1]. The OWC identification depends on low resistivity contrast. Akbar and Permadi [2] believe that OWC which is determined using electrical logs is occasionally uncertain. The capillary transition zone in reservoirs depends on the pressure difference across the fluid contact [3]. Some authors believe that the thickness of the OWCZ changes during the production process [4]. Therefore, it is important to monitor the OWC continuously. The thickness of the OWCZ may vary among the different parts, ranging from 1 to 15 meters. OWC is parallel to the tectonic stress, but the actual situation shows that this contact is more complicated. Han and Batzle [5] found that the Vp/Vs ratio is more sensitive to the change in fluid type. Thus, it can be used to identify the hydrocarbon contact. The Vp/Vs ratio is used by many authors in lithology discrimination, degree of consolidation determination, and pore fluid identification [6, 7]. The porosity of rocks is usually decreased with the increase of compaction, which is accompanied by an increase of burial depth. However, for sandstone rocks, the mineralogical and chemical factors are more significant than the physical forces [8]. Temperature and time influence porosity variation with the depth, mostly at shallow and moderate depths, whereas chemical agents and composition of the grains are more effective at depths more than three kilometers [9]. This study is concerned with the identification of OWCZ in Nahr Umr and Mishrif formations (Cretaceous age), particularly in Kt-1 and Du-1 wells, southern Iraq.

2. Location and geology of the oil fields

Kumait and Dujaila oil fields are located in Maysan governorate and northeast of Nasiriyah City, southeastern Iraq, as shown in Figure -1.

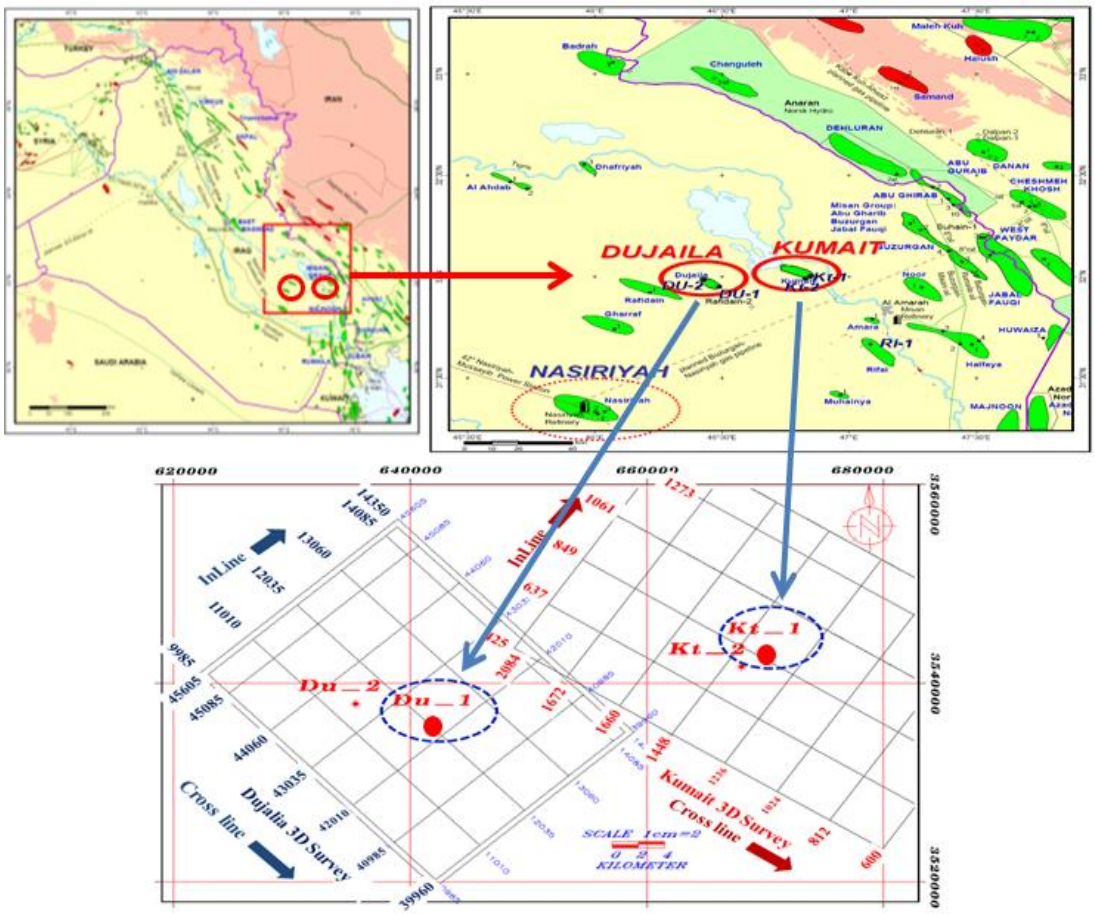

Figure1- Location and base map of the study area [10].

Tectonically, this area belongs to the Mesopotamian unstable subzone [11-13]. The Tertiary and Cretaceous stratigraphy columns in the study area are shown in Figures-(2) and (3), respectively. The Kt-1 well penetrated to a depth of 4410 m. Nahr Umr sandstone formation (lower Cretaceous) is the main reservoir in Kumait Oil Field. This formation extended in depth from 3700 to 3840 m in Kt-1 well. The Du-1 well is penetrating to a depth of 4124 m. The main reservoir in Dujaila oil field is Mishrif Limestone Formation (upper cretaceous). The upper contact depth of Mishrif Formation in Du-1 well is 2835 m and the lower contact depth is 3162 m.

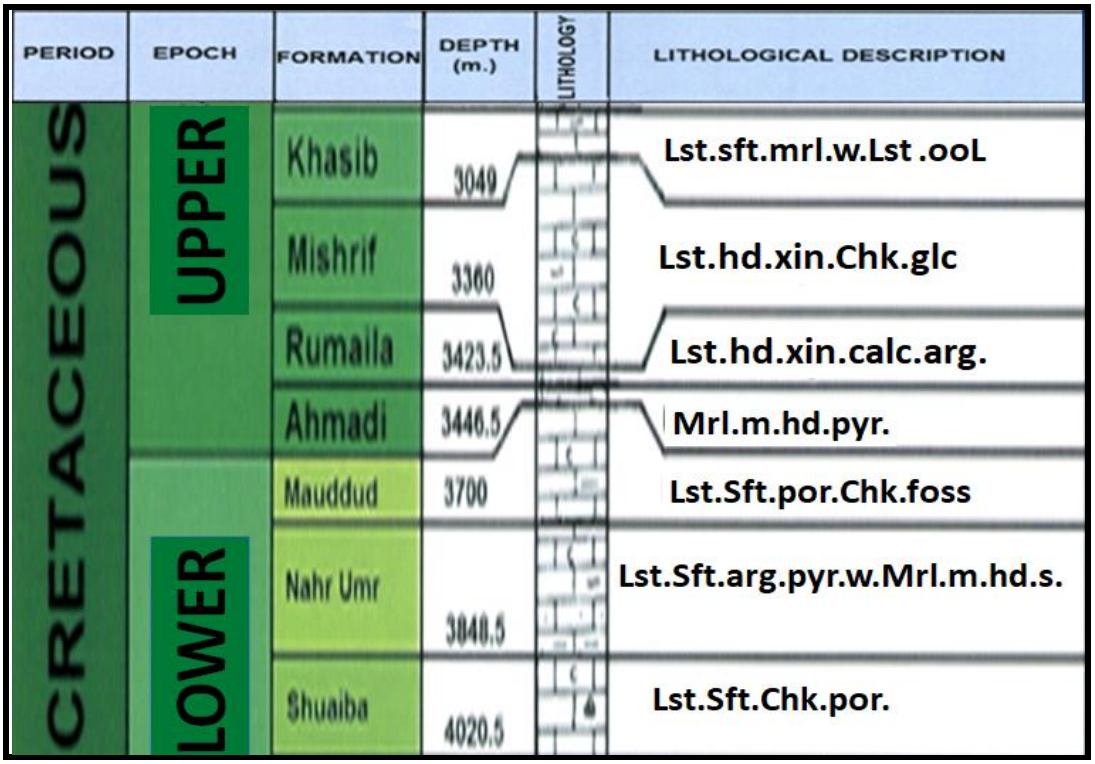

Figure 2- Geological column in Kt-1 well [14].

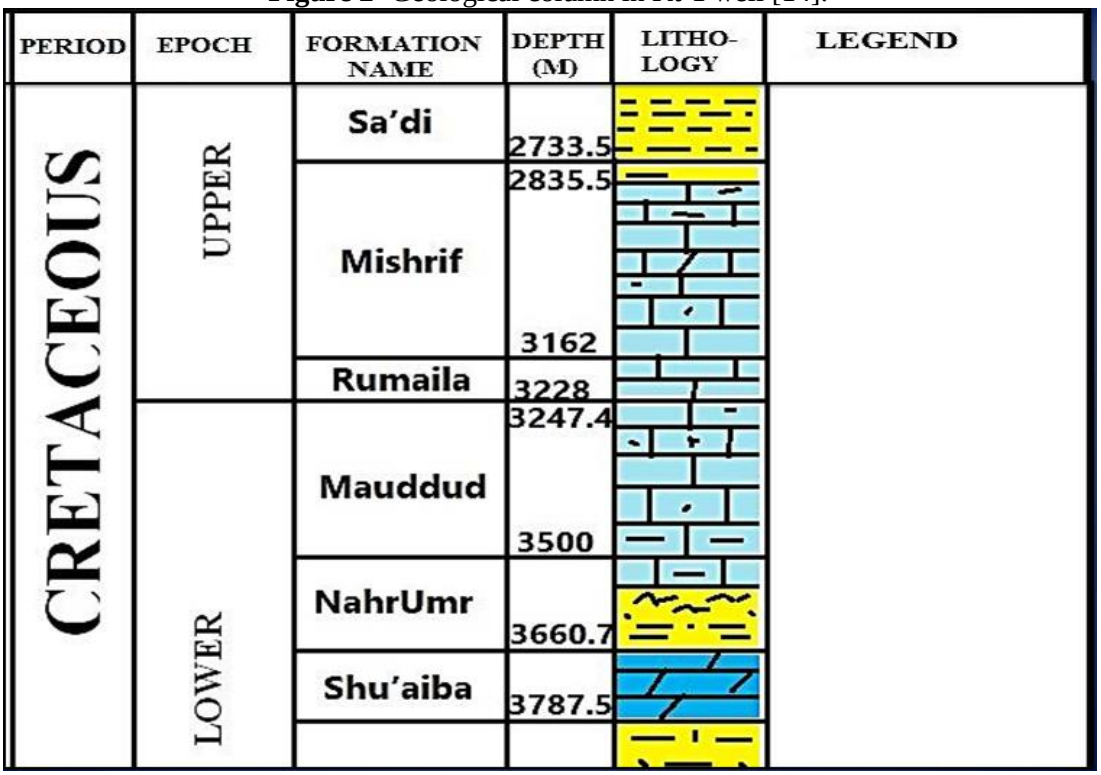

Figure 3 - Geological column in Du-1 well [15].

3. Hydrocarbon-Water Contact analysis of Nahr Umr and Mishrif formations in both oil fields

The resistivity logs are used to determine OWC and Sw. High contrast significant increase in the Sw values indicates the OWC [16]. Nahr Umr (Sand-2 layer) Sandstone Formation is the main reservoir in Kt-1 well. The well logs show that the sand-2 unit of this Formation is approximately 11 m in thickness at a depth between 3804 and 3815 m. The values of P-wave and S-wave, obtained using Castagna's equation, density, Poisson's ratio, Vp/ Vs ratio and Sw logs of Nahr Umr Formation, are shown in Figure-4. The well logs of P-wave, S-wave, water saturation, volumetric shale, Vp/Vs ratio, and effective porosity of the lower part of the reservoir of Mishrif Formation between the depths 2860-2900 are shown in Figure-5.

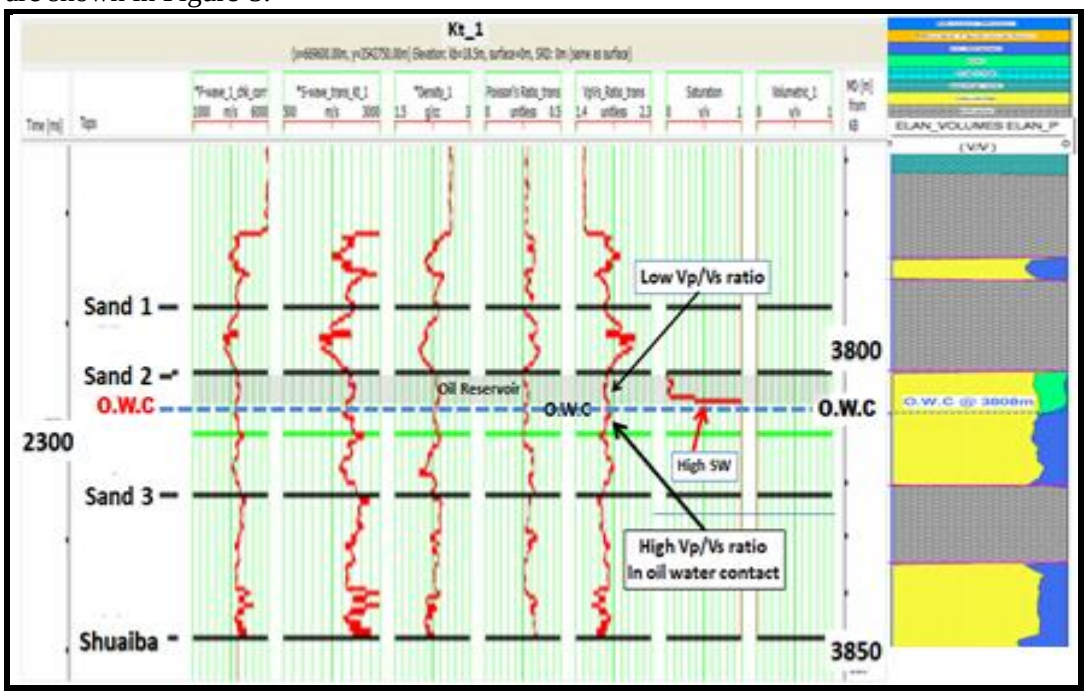

Figure 4- From left to right: Results of P-wave, S-wave, density, Poisson's ratio, Vp/Vs ratio, saturation, and volumetric logs for the Well Kt-1 and the level of Oil-Water contact in Sand-2 Unit within Nahr Umr Formation of Kumait Oil Field.

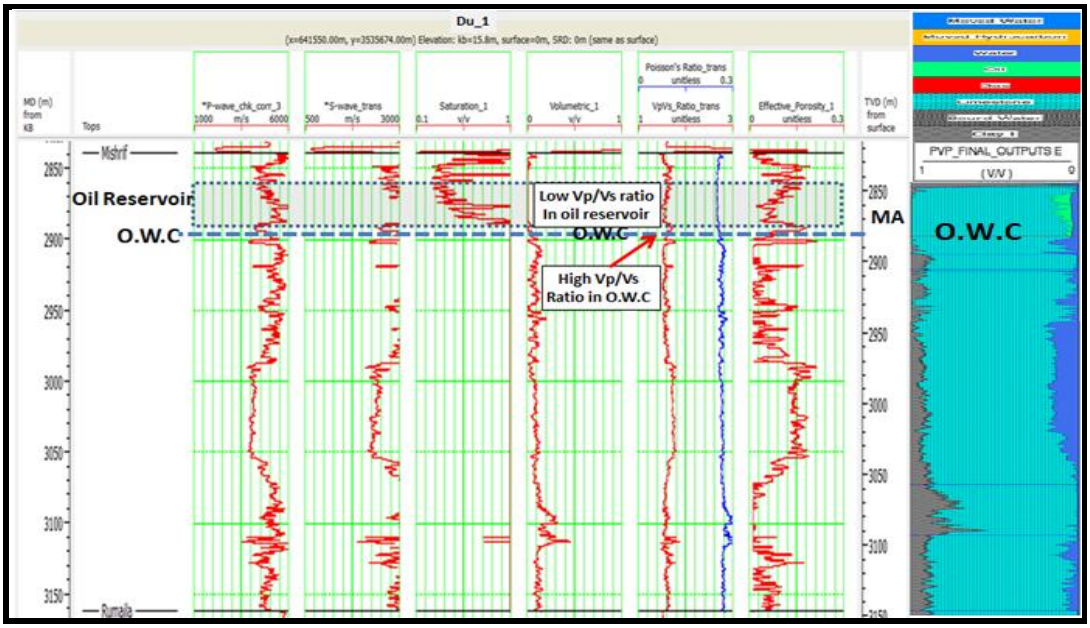

Figure 5- From left to right: Results of P- wave, S-wave, saturation, Vp/Vs ratio, Poisson's ratio, effective porosity, and volumetric Logs for Well Du-1 and the level of Oil-Water Contact in MA Limestone unit within Mishrif Formation of Dujaila Oil Field.

4. The usage of Vp/Vs ratio and porosity logs to detect the OWC Zone

The Vp/Vs ratio was reported to be changed at the OWC [6]. The Vp/Vs and porosity logs are used in the present study to detect the OWCZ in the two selected wells. Three boundaries are established and shown in Figure-6. The first is the upper boundary (Green), at the level of 3804- 3807 m depth, indicates the starting oil zone (only oil). The second boundary (Red) at the level of 3807- 3808 m depth, represents the top of the OWCZ. The third boundary (Blue) at the level of 3808 m depth, indicates the lower boundary (the actual boundary) of the OWCZ. The three boundaries, which were traced by Vp/ Vs ratio log, were also traced by the porosity log, as demonstrated Figure-7. The location of the detected boundaries coincides with the P-wave, resistivity, and Sw logs of Nahr Umr in Kt-1 well (Figure -8). The same above procedure is used for Mishrif Limestone Formation in Du-1 well of Dujaila oil field. The OWCZ was traced using the Vp/ Vs ratio and porosity logs, as illustrated in Figures-(9) and (10), respectively. The P-wave, resistivity, and Sw logs were employed to support the results obtained using Vp/ Vs ratio and porosity logs and confirm the detection of the OWCZ in Mishrif Formation (Figure-11).

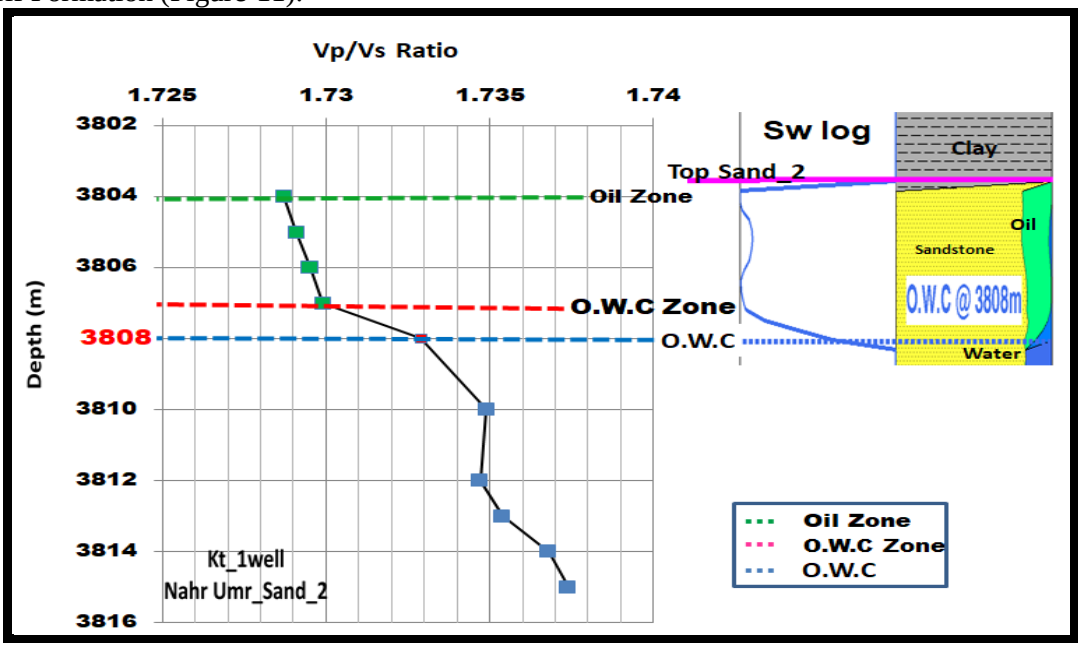

Figure 6 - Vp/Vs ratio log values in Sand_2 reservoir unit within Nahr Umr Formation.

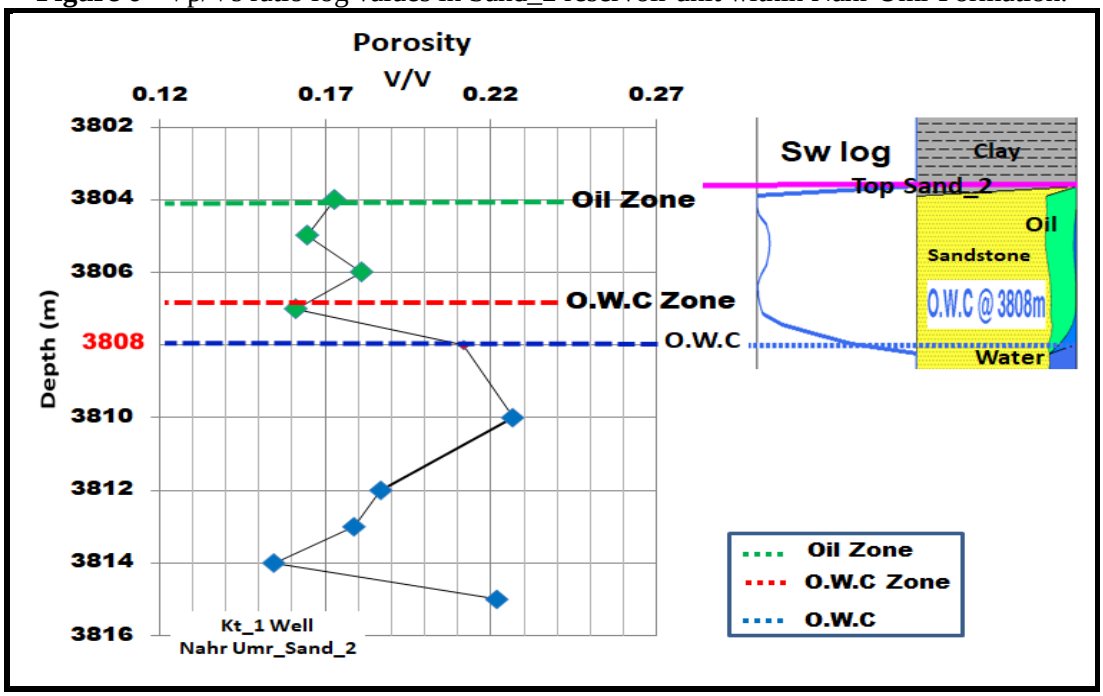

Figure 7- Porosity log values in Sand-2 reservoir unit within Nahr Umr Formation.

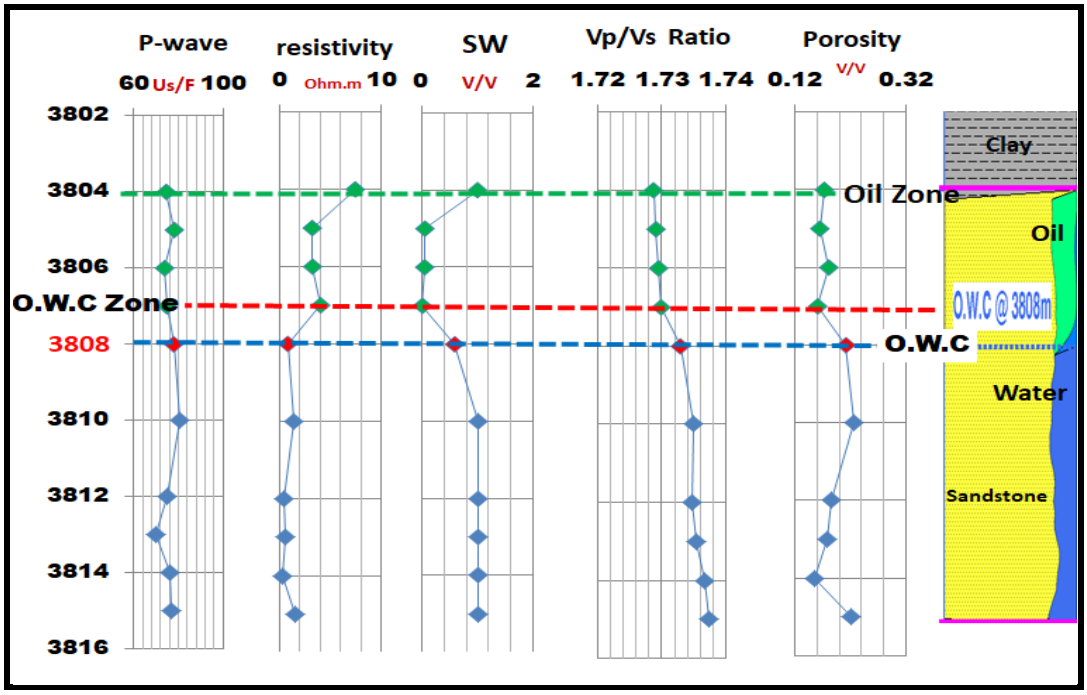

Figure 8- The relation between depth with P-wave, resistivity, Sw, Vp/Vs ratio, and porosity in Sand-2 reservoir unit within Nahr Umr Formation.

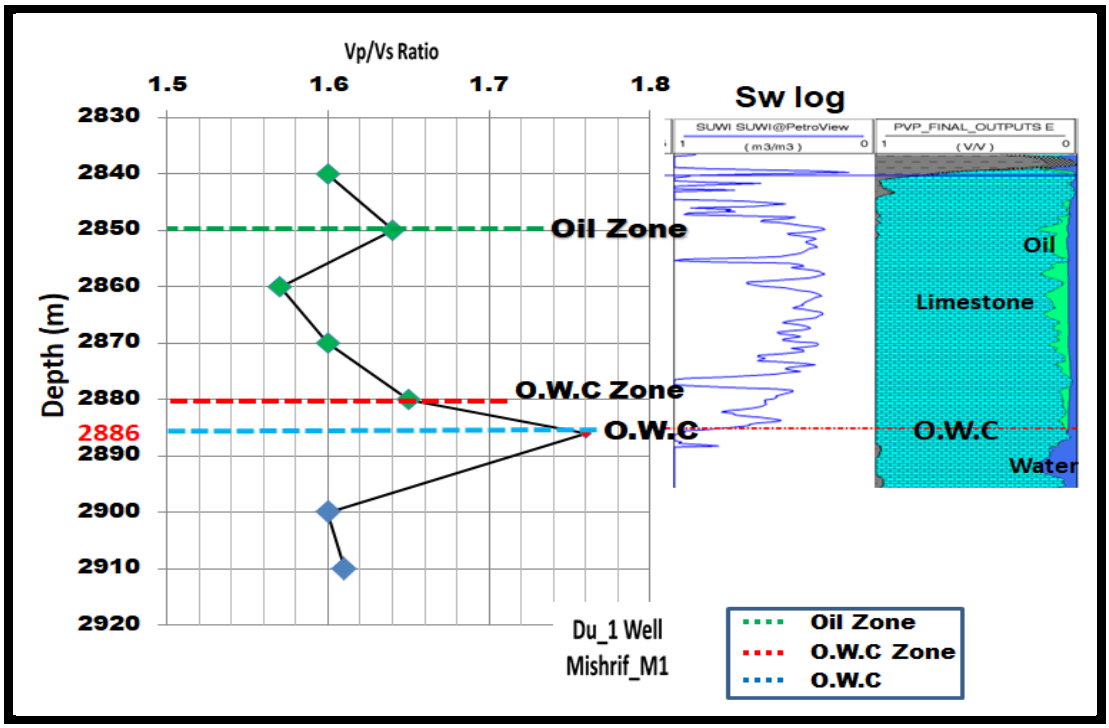

Figure 9- Vp/Vs ratio log values in MA (Limestone) reservoir unit within Mishrif Formation.

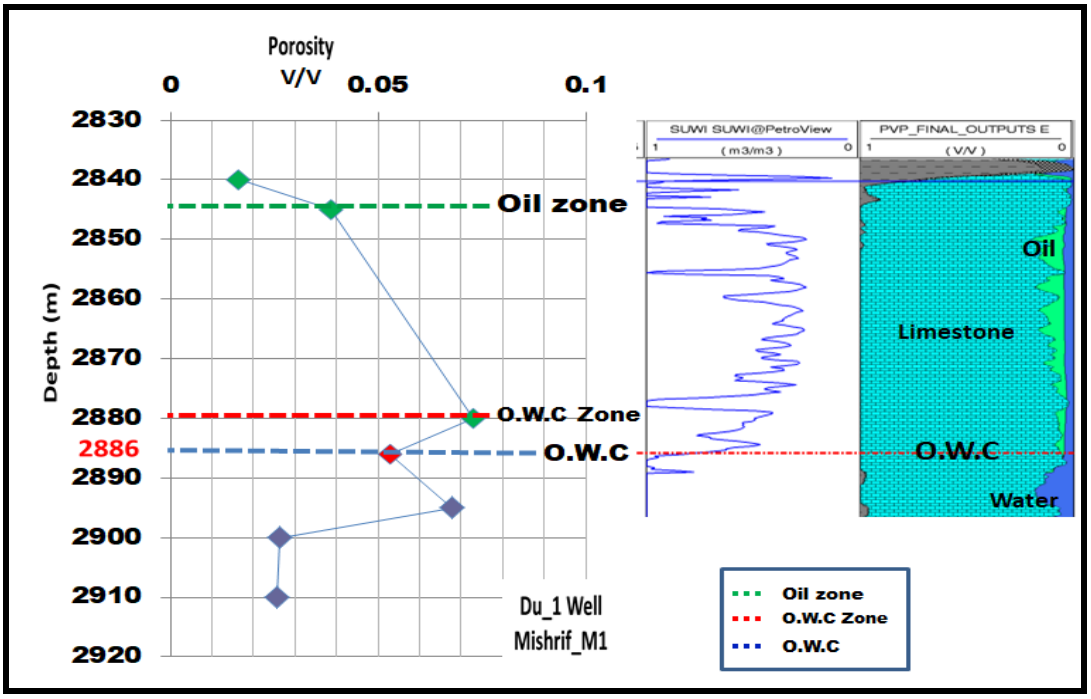

Figure 10- Porosity log values in MA (Limestone) reservoir unit within Mishrif Formation.

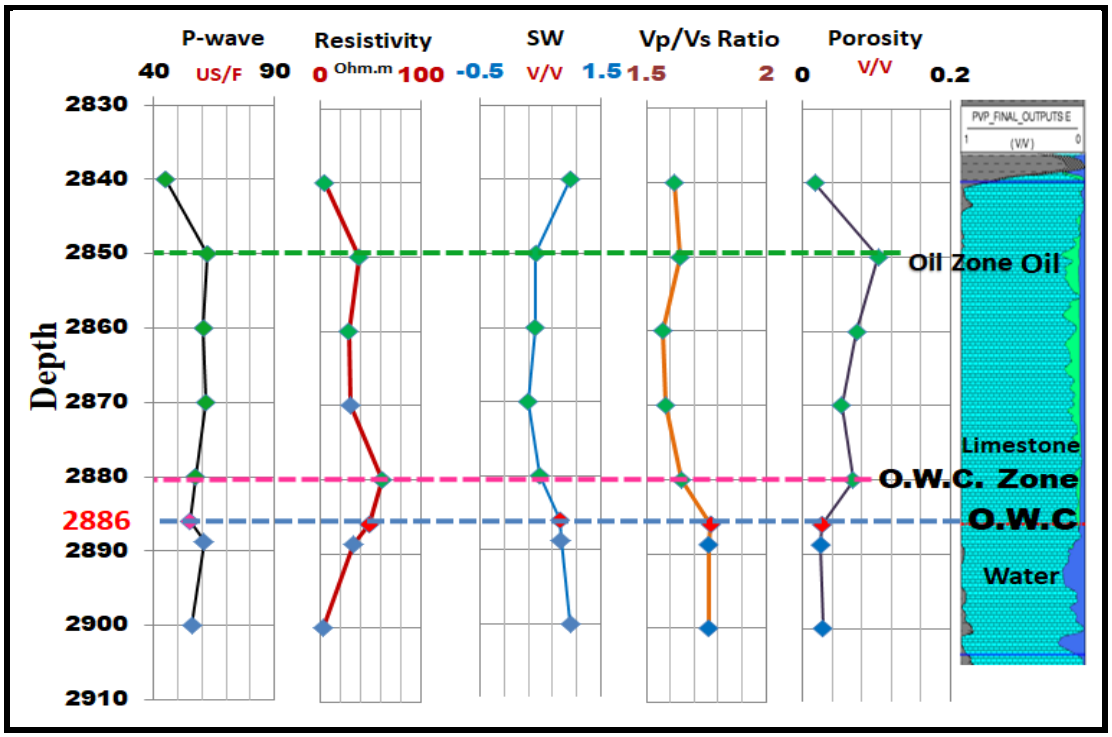

Figure 11- The relation between depth with P-wave, resistivity, Sw, Vp/Vs Ratio, and porosity in MA (Limestone) reservoir unit within Mishrif Formation.

5. Conclusions

It is concluded that the detailed study of the Vp/Vs and porosity logs can be used to detect the actual location of the oil-water contact zone. Studying the logs data of Nahr Umr and Mishrif formations in Kt-1 and Du -1 wells of Kumait and Dujaila oil fields resulted in obtaining some important characteristics concerning the oil-water contact zone. It was found that the thickness of this zone in Nahr Umr sandstone Formation in Kt-1 well is approximately one meter. While the thickness of the oil-water contact zone in Mishrif Formation in Du-1 well reached eight meters. The authors believe that the oil-water contact zone may be thicker in carbonate rocks than clastic rocks. The

difference in the thickness of this zone in clastic rocks may be dependent on mineral composition, grain sizes pore shape, and porosity.

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