

Well log Sequence Stratigraphy and Petrophysical Properties of the Shiranish Formation in the Kirkuk Oil Field (K-260 and K-229)**Aiad Ali Hussien Al-Zaidy****Well log Sequence Stratigraphy and Petrophysical Properties of the Shiranish Formation in the Kirkuk Oil Field (K-260 and K-229)****Aiad Ali Hussien Al-Zaidy**

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aiadgeo@yahoo.com**Received: 7 December 2016****Accepted: 12 February 2017****Abstract**

The Shiranish Formation comprises the globigerinal marls and limestones of the Upper Senonian (Upper Campanian-Maestrichtian). The present study has been discussed the petrophysical properties of this marly rocks in Kirkuk oil field (K-260 and K-229). The study area is located in northeastern Iraq (Kirkuk areas). This area lies within the Zagros foreland basin, bordered on the northeast by the Zagros Mountains and on the southeast by the Arabian Shield, and consists of linear and high amplitude folds that trend in a northwest-southeast direction. The Shiranish Formation was deposited during the transgression period after the sea level fall marked by the glauconitic contact (SBI) with the Kometan Formation. According to the general facies observation with the gamma ray and resistivity logs patterns, there are two major units in this Formation. The first unit is represented by six cycles of transgressive system tracts (TST) which bounded the upper unit by maximum flooding surface; the second unit is represented by three cycles of high system tracts which unconformably underlying of Aaliji Formation. According to the porosity type and the conductivity properties in addition to decreasing and increasing of shale effect (Gamma Ray) for the Shiranish Formation within K-260 and K-229 there are five petrophysical zones. These zones may be divided in to two

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Groups:-

- A. Low petrophysical properties rocks, this include the zones II and IV.
- B. Good petrophysical properties rocks, this include the zones I, III and V.

The zones of group B are important rock units because there are shows of fractured porosity and gas effects in the zones three and five. Where, the zone three is represents a gas effect when the neutron and density porosity are extrusive. While the zone five are represent the fractured porosity in addition to present of gas effects. The first zone is different from the previous two types by the type of rock is limestone and the fabric/porous type is moldic and intragranular grainstone. At the last of this study the researcher is suggested that the Shiranish Formation may be a good reservoir rocks (fractured reservoir).

Key words: - Sequence stratigraphy, Petrophysical properties, Shiranish Formation, Kirkuk oil field.

التتابعية الطباقية و الخواص البتروفيزيائية من الجس البئري لتكوين الشيرانش في حقل كركوك النفطي (كركوك-229 و كركوك-260)

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قسم علم الارض - كلية العلوم - جامعة بغداد

الخلاصة

ان تكوين الشيرانش يتكون من صخور المارل الكلوبيجرانية و الحجر الجيري ذي العمر السينوماني (الكامباني الاعلى-الماسترخي). ان الدراسة الحالية قد ناقشت الخواص البتروفيزيائية لتلك الصخور في حقل كركوك النفطي (كركوك-229 و كركوك-260). تقع منطقة الدراسة في شمال شرق العراق (كركوك)، ضمن حوض زاكروس المتقدم والذي يحده من الشمال الشرقي جبال زاكروس ومن الجنوب الغربي الدرع العربي، و يتكون من طيات خطية و عالية الموجة باتجاه عام من الشمال الغربي الى الجنوب الشرقي. ترسب تكوين الشيرانش خلال فترة تقدم بحري اعقت سطح تعرية كلوغونايتي (عدم توافق) يفصل الشيرانش عن التكوين الاقدم (تكوين كوميتان). بالاعتماد على السحنات الصخرية العامة و انماط استجابة مجسات اشعة كاما و المقاومة فقد تم تقسيم التكوين المدروس الى وحدتين صخريتين رئيسيتين:- الاولى تمثل ستة تتابعات لتقدم بحري (TST) والتي تنتهي بخط الطغيان البحري الاعظم (mfs) مع التتابع الاعلى. الوحدة الصخرية الثانية تمثل ثلاث تتابعات صخرية لمرحلة ركود مستوى سطح البحر الاعلى (HST) والذي ينتهي بتراجع بحري يؤشر حد طبقي من النوع الاول (SBI) يفصل التكوين المدروس عن تكوين العليجي.

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بالاعتماد على نوع المسامية و خواص التوصيلية الكهربائية بالإضافة الى زيادة و نقصان تأثير السجيل (اشعة كاما) لصخور تكوين الشيرانش في الابار المدروسة تم تمييز خمسة انطقة بتروفيزيائية. يمكن وضع هذه الانطقة في مجموعتين رئيسيتين:-

- أ- صخور رديئة الخواص البتروفيزيائية، هذه تشمل النطاق الثاني و الرابع.
ب-صخور جيدة الخواص البتروفيزيائية ، هذه تشمل النطاق الاول و الثالث و الخامس.

ان انطقة المجموعة الثانية هي تمثل وحدات صخرية مهمة بسبب وجود شواهد للمسامية الناتجة عن تكسر الصخور اضافة الى وجود تأثير الغاز وهذا في النطاقين الثالث والخامس، حيث ان النطاق الثالث اظهر تأثير متمائل. بينما النطاق الخامس فيمثل تأثير التكرسات اضافة الى تأثير الغاز. بينما النطاق الاول فيختلف عن الانطقة السابقة بنوع الصخور و نوع النسجة/مسامية والتي هي صخور جيرية حبيبية ذات مسامية القالب وبين الحبيبات. اخيرا، فقد اقترح الباحث في هذه الدراسة بان صخور تكوين الشيرانش ممكن ان تكون صخور مكنية جيدة (مكامن صخور متكسرة).
كلمات مفتاحية: التتابعية الطباقية، الخواص البتروفيزيائية، تكوين الشيرانش، حقل كركوك النفطي

Introduction

The Shiranish Formation comprises the globigerinal marls and limestones of the Upper Senonian (Upper Campanian-Maestrichtian), this marly rocks had discussed in the present study as petrophysical properties in Kirkuk oil field (K-260 and K-229). The study area is located in northeastern Iraq (Kirkuk areas) (Fig.1.1). This area lies within the Zagros foreland basin, bordered on the northeast by the Zagros Mountains and on the southeast by the Arabian Shield, and consists of linear and high amplitude folds that trend in a northwest-southeast direction. These folds affect the whole Mesozoic-Cenozoic series [1] [2].

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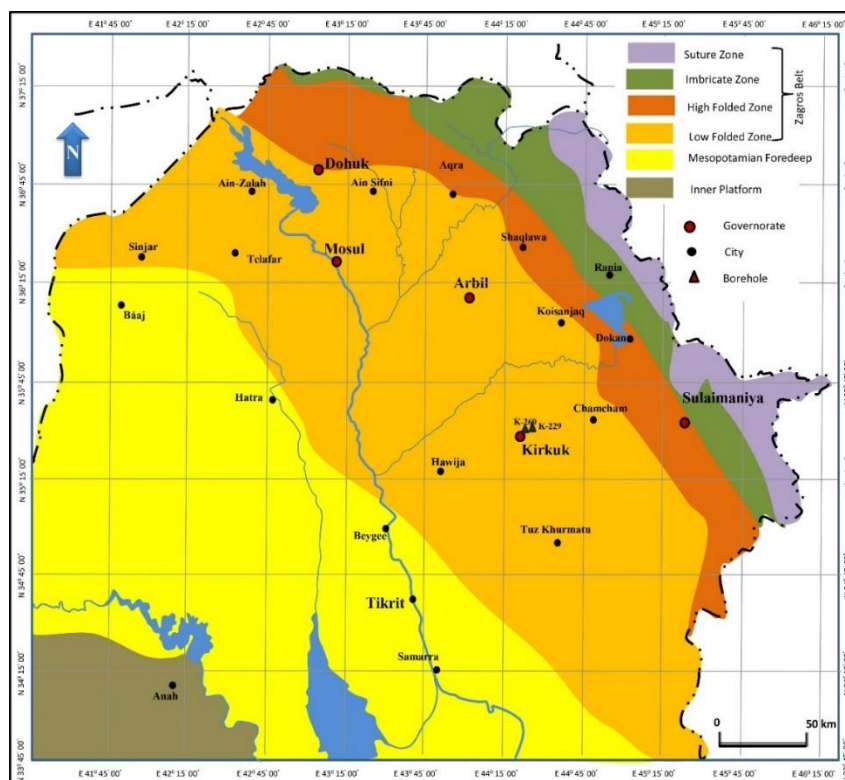


Fig.1 Location map of the study area shows the tectonic subdivisions according to [3].

Methodology

Well-log Sequence Stratigraphic analysis to subdivide a stratigraphic section. And to determine the characters of reservoir units such as lithology, types of porosity, permeability and types of fluids can be deduced from the study of geologic logs. In the present study the primary and secondary porosity as well as water and oil saturation were determined in addition to subdividing the succession.

The parameters of log interpretation are determined directly or inferred indirectly and measured by one of three types of logs:

1. Electric (Resistivity)
2. Radioactive (Gamma Ray, Density, Neutron)

The equations and parameters are used in this procedure (Fig.2) proposed by [4], [5], [6], [7], [8], [9], [10], [11] and [12].

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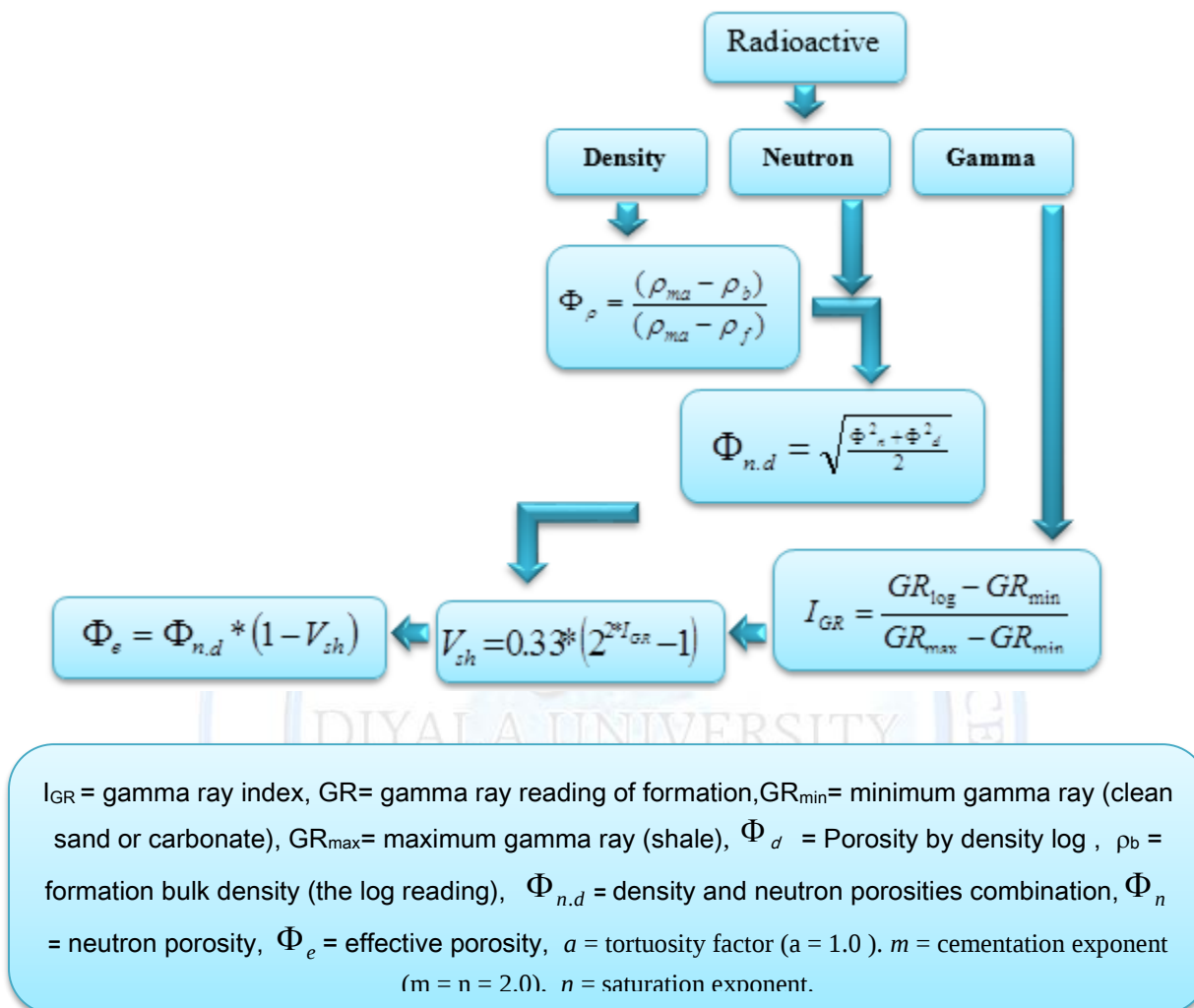


Fig.2 Diagram showing steps and parameters of petrophysical properties which used in the present study.

Sequence Stratigraphy

The Shiranish Formation was defined by Henson (1940) from the High Folded Zone of northern Iraq near the village of Shiranish Islam, northeastern of Zakho [13]. In south of Iraq an almost identical unit, the Qurna Formation, was introduced by Rabanit in 1952 [14]. The Shiranish Formation, in its type area, comprises thin bedded argillaceous limestones (locally dolomitic) overlain by blue pelagic marls [15].

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The Shiranish Formation comprises the globigerinal marls and limestones of the Upper Senonian (Upper Campanian-Maastrichtian) transgressive cycle. It passes northeastwards, diachronously, into the Tanjero Formation, the contact being gradational in most sections. The Shiranish also tongues laterally into contemporaneous reef and fore-reef limestone complexes, developed preferentially at the base of the transgressive sequence, in the Upper Campanian - Lower Maastrichtian (Bekhme limestone) and at the top of the Shiranish, or at the Tanjero - Shiranish transition, generally in the later Maastrichtian (Aqra limestone). The Formation usually conformably and gradationally overlies the Shiranish Formation. An unconformable lower contact was reported in the Ranyia area [16]; however, the Upper Cretaceous elastics here may belong to the basal unit of the Suwais Red Beds [13]. In the Dokan area the lower contact is unconformable with the underlying Kometan Formation, while the upper contact is conformable with the overlain Tanjero Formation [17]. In the present study, the Shiranish Formation is underlying of the Aaliji Formation and overlaying of the Kometan Formation, therefore the Shiranish Formation is bounded by two unconformable surfaces (SBI). According to well logging sequence stratigraphic analysis for Wagoner *et al.*, 1988; Vail and Wornardt, 1992 and Catuneanu, 2006 [18], [19], [20]; the Shiranish Formation divided into two major units:-

1. The first unit is appeared in the lower part of the Formation which characterized by six cycles of bell shaped gamma ray-resistivity logs for alternative of basinal shale with marls. These cycles represent the transgressive system tracts (TST) (Fig.3) where bounded with the upper part (limestone unit) by the maximum flooding surface (mfs).
2. The upper part of the Shiranish Formation is characterized by three cycles of high system tract (HST) which appeared as a funnel shape of gamma ray and resistivity log patterns. The low gamma ray values refer to the low shale volume with the main composition of limestone and marly limestone. The third cycle of this part was ended with the fall of the sea level to mark a sequence boundary type I (SBI) (Fig.3).

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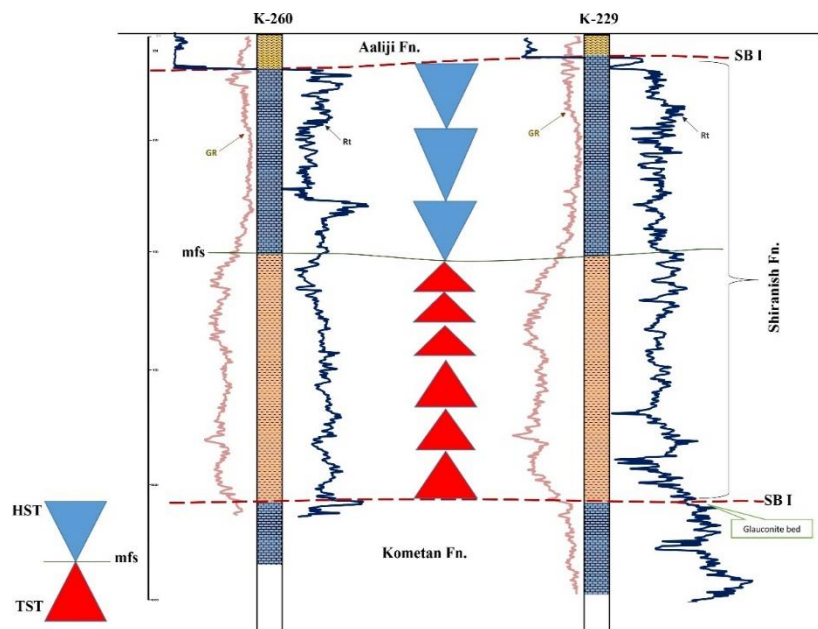


Fig.3 Stratigraphic cross section shows the different parts of the studied succession.

Petrophysical properties of the Shiranish Rocks:

For fractured reservoirs, obtaining the right data and forecasting the reservoir performance is much more difficult than for conventional reservoirs. This statement is very well supported by a reservoir modeling study reported by [21]. Furthermore, just finding fractures or mapping fractures is not good enough for developing a fractured reservoir. Indeed, these data, in addition to the conventional reservoir data, should be used to design production schemes that utilize fractures as an aid [22] rather than a detriment to production. But, to design a viable plan of development, one needs a credible reservoir description that includes mapping fractures in terms of aperture size, length, height, connectivity, conductivity, and frequency distribution. In the present study, the researcher discussed the Shiranish Formation as a reservoir rocks contrary to what is known (impermeable rocks). According to the porosity type and the conductivity properties in addition to decreasing and increasing of shale effect (Gamma Ray) for the Shiranish Formation within K-260 and K-229 there are five petrophysical zones:-

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Zone I

This zone is characterized by low Gamma ray value approximate (25%) which referred to compose of Shelley limestone. The porosity logs shown high porous zone where the total porosity (N-D porosity) value ranging between 15-30% in borehole Kirkuk-260. While in the borehole Kirkuk-229 the gamma ray was less from K-260 and the total porosity value ranging from 20 to 40% (Fig.4 & 5).

Zone II

The second zone represents a low porosity unit, where all types of porosity ranging from 3 to 8% by volume of shale less than 10% in the two studied bore holes (Fig.4 & 5). There are many peaks (increasing in value) within the density, porosity curve in the K-260.

Zone III

This zone is characterized by low volume shale and high density, porosity unit with porous value ranging from 20 to 40%. In the borehole K-229 the high porous unit appeared in the upper part of the zone three without any effect of neutron logs (Fig.4), while in the borehole K-260 this unit appears in the lower part with increasing of neutron log (Fig.5).

Zone IV

The zone four is characterized by increasing volume of shale downward with a slight increasing downward of porosity logs within two studied borehole. But in the borehole K-229 appears many reflections in the neutron and density log (increasing of porosity) (Fig.4 & 5).

Zone V

This zone is characterized by high volume of shale (increasing downward) with three porous parts (increasing neutron and density logs) (Fig.4 & 5).

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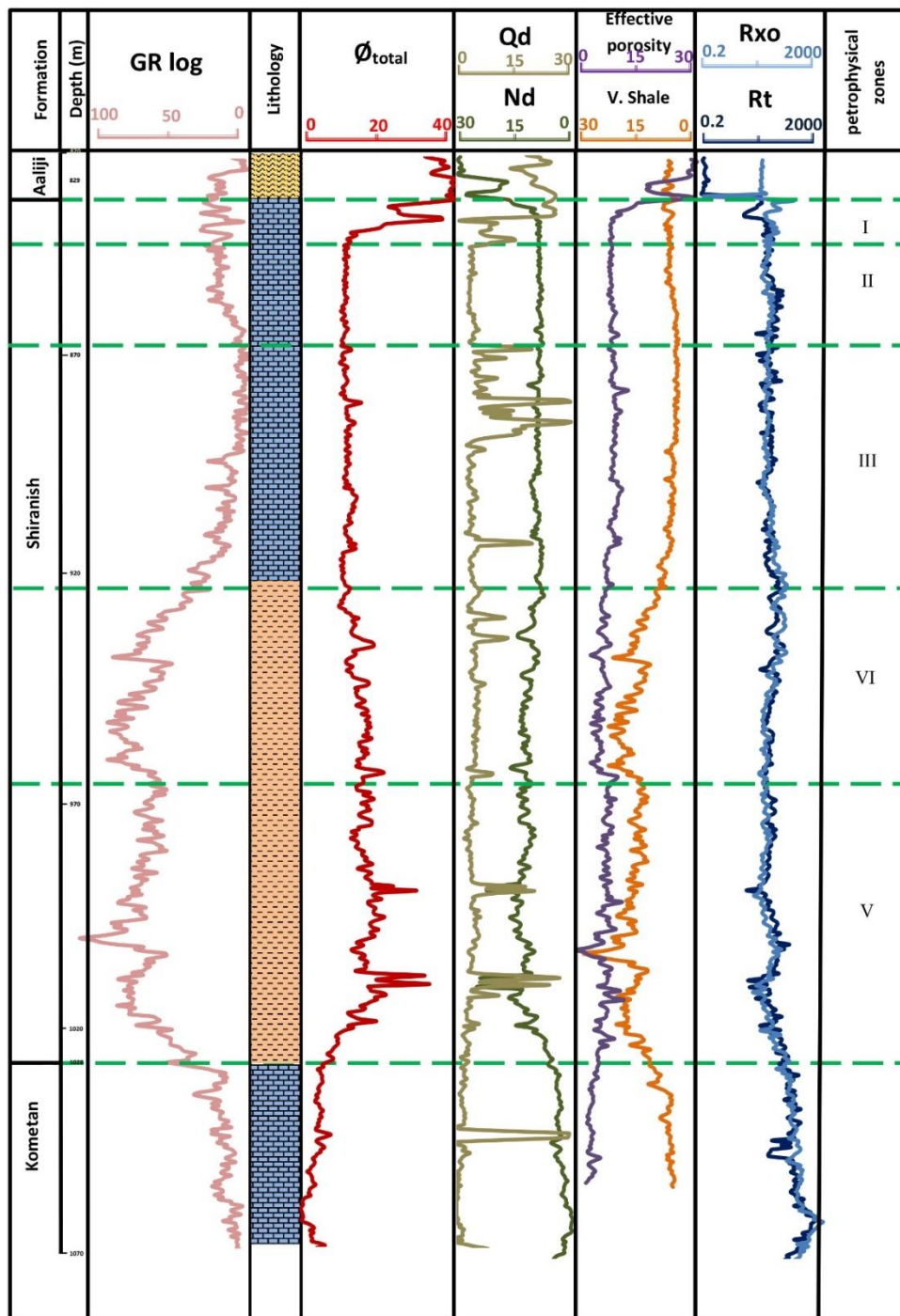


Fig.4 Geologic section for the Shiranish Formation in the Kirkuk-229 borehole showing the petrophysical properties.

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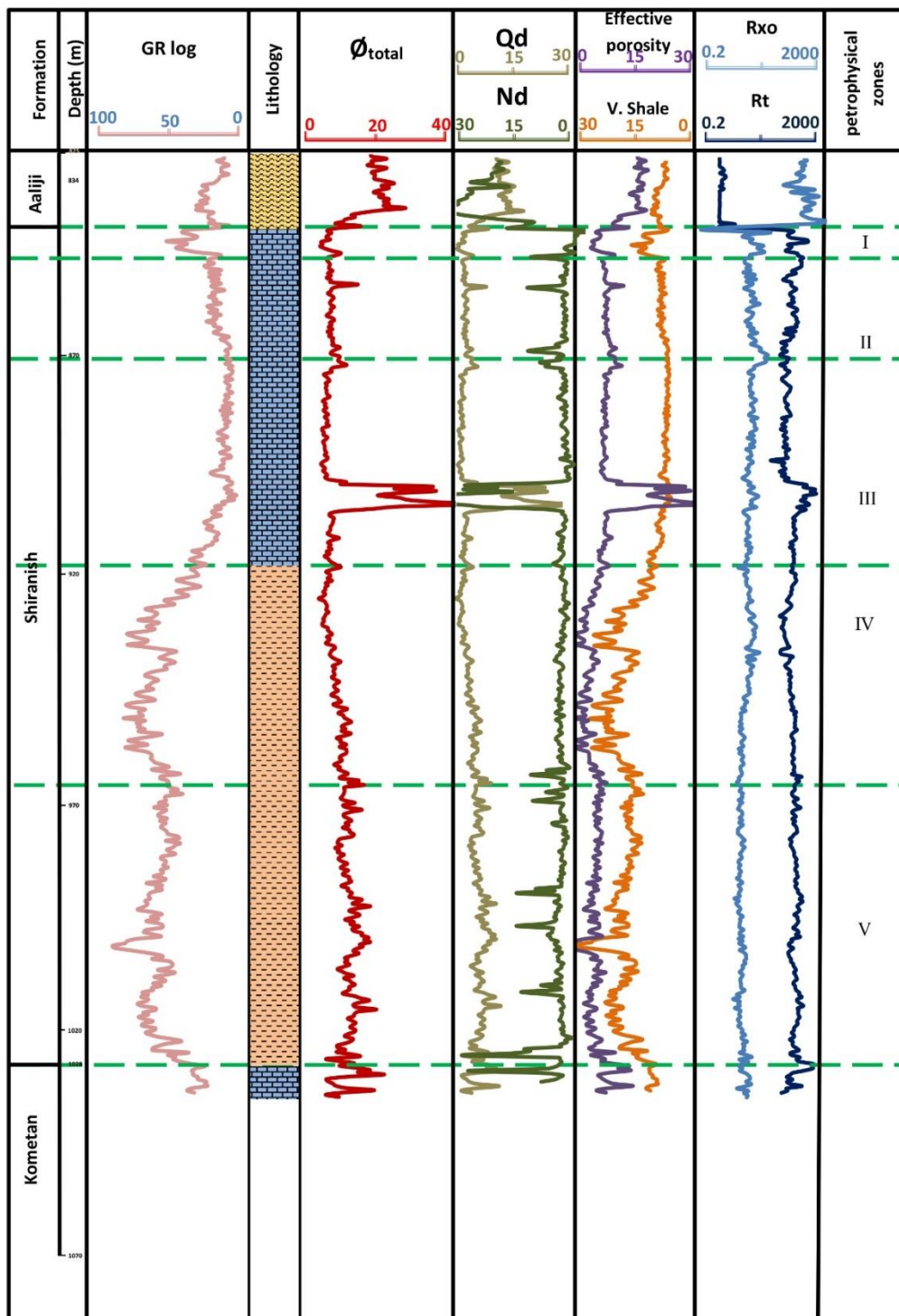


Fig.5 Geologic section for the Shiranish Formation in the Kirkuk-260 borehole showing the petrophysical properties.

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Permeability and porosity relationship:

The permeabilities of average reservoir rocks generally range between 5 and 1000 millidarcys [23] (Halliburton, 2001). A reservoir rock whose permeability is 5 md or less is called tight sand or dense limestone, according to composition. A rough field appraisal of reservoir permeabilities is:

Fair	1-10 md
Good	10-100 md
Very good	100-1,000 md

Log-derived permeability formulas are only valid for estimating permeability in formations at irreducible water saturation [12]. Before calculating the permeability, we must first determine whether or not a formation is at irreducible water saturation.

The permeability values are calculated by using the Coates and Dumanoir method [8], this method is a complex method for calculating permeability.

$$C = 23 + 465 * \rho_h - 188 * \rho_h$$

$$W = \left\{ (3.75 - \Phi) + \left[\frac{(\log(R_w / R_{tirr}) + 2.2)^2}{2.0} \right]^{0.5} \right\}$$

$$K = \left[\frac{C * \Phi^{2W}}{W^4 * (R_w / R_{tirr})} \right]^2$$

Where:-

C = constant based on hydrocarbon density

ρ_h = hydrocarbon density in g/cm³

W = constant in Coates and Dumanoir permeability formula

Φ = porosity

R_w = formation water resistivity at formation temperature

R_{tirr} = deep resistivity from a zone at irreducible water saturation (S_{wirr})

K = permeability in millidarcys (md)

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After using this equations to calculate the permeability compared these values with the porosity values by using Nelson plot [24] and Akbar plot [25], to introduced the permeability-porosity relationship in the carbonate and shale rocks showing the different types of carbonate and fractured fabric and porous (Fig.6), as follow:-

1. The first zone shows two type of carbonate fabric, the first is moldic grainstone and intergranular porous grainstone with leaching processes.
2. The third zone shows two different trend for this relationship, the first is fractured rocks and the second is coccolith chalk pore.
3. The fifth zone is appeared two type of fabric, the first is leaching unit but the second is fractured unit.

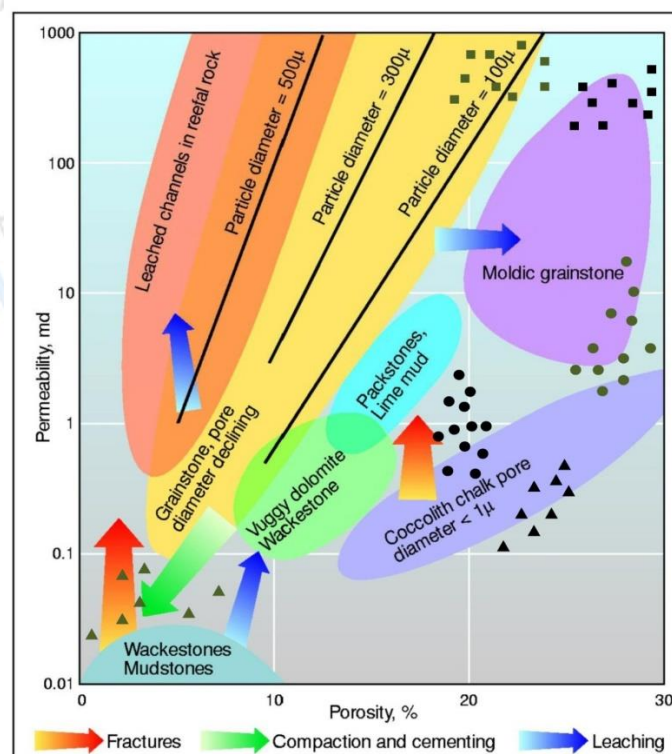


Fig.6 Schematic poro-perm plots for carbonate and fractured rocks, based on Nelson [24] and Akbar [25], showing the types of studied rocks. Where the black shapes (K-229) and green (K-260), and the shapes (■, ● and ▲) are the zone I, III, and V.

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Conclusions

The Shiranish Formation was deposited during the transgression period after the sea level fall marked by the glauconitic contact (SBI) with the Kometan Formation. According to the general facies observation with the gamma ray and resistivity logs patterns, there are two major units in this Formation: -

- I.** Six cycles of transgressive system tracts as a succession of alternative of shale and marls. This succession is bounded with the upper unit by the maximum flooding surface (mfs).
- II.** Three cycles of high system tracts as a succession of alternative of limestone and marly limestone. This unit is underlying unconformably of the Aaliji Formation to mark the sequence boundary type I.

There are five different zones according to petrophysical properties within the Shiranish Formation, these zones may be divided in to two groups: -

- A.** Low petrophysical properties rocks, this include the zones II and IV.
- B.** Good petrophysical properties rocks, this include the zones I , III and V.

The zones of group B are important rock units because there are shows of fractured porosity and gas effects in the zones three and five. Where, the zone three is represents a gas effect when the neutron and density porosity reflect. While the zone five is represent the fractured porosity addition to present of gas effects. The first zone is different from the previous two types because the type of rock is limestone and the fabric/porous type is moldic and intragranular grainstone. at the last of this study the researcher is suggested that the Shiranish Formation may be a good reservoir rocks (fractured reservoir) Besides being source rocks.

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