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Petrophysical Properties Distribution in The Framework of Electrofacies for Khasib Formation in Nasiriya Field, South of Iraq

Mohammed K. Dhaidan [1], Abbas K. A. Mohammed [2*], Amjad A. Farhood [3], Yasser A. Kazar [4]

[1,3,4] Geology Department, Fields Division, Ministry of Oil, Thi-Qar Oil Company, Nasiriya, Iraq.
[2] Institute of Exploration Geosciences, University of Miskolc, Miskolc, 3515, Hungary. and Geology Department, Fields Division, Ministry of Oil, Missan Oil Company, Misan, Iraq.

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Correspondence:
Name: Abbas Mohammed

Email: goldengeo.87@gmail.com

ABSTRACT

Determining petrophysical properties remains a paramount concern for oil companies, encompassing crucial properties such as porosity, permeability, and water saturation. Constructing accurate models requires an in-depth understanding of sedimentary facies within reservoirs. Despite the challenge posed by the absence of core samples, this study integrates fifteen well logs, borehole data, and seismic maps of the Late Turonian-Early Coniacian Khasib Formation from Nasiriya Oilfield, south of Iraq. The Khasib Formation is grouped into electrofacies by the integration of cluster analysis technique provided by Geology software using well logs and the borehole data. Electrofacies models are constrained using Petrel software. The porosity and water saturation models were built based on the electrofacies models. The property modeling including electrofacies, effective porosity and water saturation is stochastically distributed within the constructed 3D grid using Truncated Gaussian and Sequential Gaussian Simulation algorithms. Five different electrofacies (shale, marly limestone, argillaceous limestone, chalky limestone, and porous limestone) are recognized. The Khasib Formation is subdivided into 5 zones (A-E). The zone (Khasib E) is promising, and accumulates a considerable amount of oil with higher porosity and lower water saturation in the northwestern part of the field compared to the southeastern part. The area between the wells Ns-14, Ns-15, Ns-16 and Ns-18 can be the targeted area for production. Zones A and B are water-bearing, and they can be used for water injection purposes. This electrofacies-driven approach provides a detailed and accurate understanding of hydrocarbon accumulation and subsurface reservoir heterogeneity, offering valuable insights for Oilfield operations.

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محمد ضيدان [1] ، عباس محمد [2*] ، امجد فرهود [3] ، ياسر كزار [4]

[1,3,4] *قسم الجيولوجيا، هياة الحقول، شركة نفط ذي قار، ذي قار، العراق.*

[2] *معهد علوم الأرض الاستكشافية، جامعة مشكولتس، مشكولتس، هنغاريا . وقسم الجيولوجيا، هيأة الحقول، شركة نفط ميسان، ميسان، العراق.*

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المراسلة:

الاسم: عباس كريم عبدالصاحب محمد

Email: goldengeo.87@gmail.com

الملخص

ان حساب الخصائص البتروفيزيائية للصخور المكمنية مثل المسامية والنفاذية والتشبع المائي يعد واحداً من اهم الحسابات الأساسية للشركات النفطية. يتطلب بناء الموديل الجيولوجي وتوزيع هذه الصفات فهماً عميقاً للبيئة الترسيبية والسحنات الدقيقة للصخور المكمنية في الحقول النفطية. على الرغم من التحدي الذي يسببه عدم توفر عينات اللباب الصخري على بناء الموديل الجيولوجي، تدمج هذه الدراسة بيانات التسجيل البئري لخمسة عشر بئرًا، وصف الفتات الصخري، وخرائط تركيبية عميقة لتكوين الخصيب في حقل ناصرية النفطي، جنوبي العراق. تم استخدام طريقة Cluster Analysis باستخدام برنامج Geolog لغرض تفسير السحنات الإلكترونية لتكوين الخصيب، حيث تم تقسيمه الى خمس سحنات عن طريق تجميع بيانات التسجيل البئري المتشابهة ودمجها مع وصف الفتات الصخري. وتم تحميلها الى برنامج Petrel لغرض بناء النموذج السحني الذي يعتبر الاساس في توزيع الصفات البتروفيزيائية كالمسامية والتشبع المائي. واستخدمت طريقة TGS and SGS الاحصائية لغرض توزيع كل من السحنات الإلكترونية والمسامية والتشبع المائي على طول خلايا النموذج الجيولوجي ثلاثي الابعاد. وبينت نتائج التحليل السحني الكهربائي ان تكوين الخصيب ينقسم الى خمس سحنات هي (السجيل، الحجر الجيري المارلي، الحجر الجيري الطيني، الحجر الجيري الطباشيري، والحجر الجيري المسامي). وعلى الصعيد الطباقي، فأن تكوين الخصيب قد قسم إلى 5 وحدات (A-E). وبينت نتائج النموذج الجيولوجي ان وحدة خصيب E تعتبر طبقة نفطية وتتراكم فيها كمية واعدة من النفط وبخواص مكمنية جيدة حيث سجلت أعلى مسامية وتشبع مائي أقل ولاسيما في الجزء الشمالي الغربي للحقل مقارنة بالجزء الجنوبي الشرقي. لذا، فإن المنطقة بين الآبار Ns-14 وNs-15 و Ns-16 و Ns-18 يمكن أن تكون المنطقة المستهدفة للإنتاج. الوحدات A وB تعتبر وحدات مائية غير حاوية على النفط، لهذا يمكن استخدامها لأغراض حقن المياه. ان استخدام السحنات الكهربائية في حال عدم توفر اللباب الصخري اعطت نتائج جيدة وفهماً جيدا لطريقة توزيع الخصائص المكمنية وجود الهايدروكربونات، مما يقدم رؤى قيمة لعمليات حقول النفط.

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Introduction

The Turonian-Lower Campanian sedimentary cycle in southern and central Iraq constitutes around14% of the Cretaceous hydrocarbon reserve, and about 10% of the total Iraqi reserve (Alsakini, 1992). The Khasib Formation has the greatest amount of these reserves which reaches up to 90% of the entire hydrocarbon cycle (Sadooni, 2004). The Khasib Formation is an important hydrocarbon-bearing formation and extends in several Oilfields in southern and central Iraq (Mohammed, 2018). There are no obvious studies carried out on the Khasib Formation at the Nasiriya province's Oilfield considering the reservoir potential and its distribution within the formation. Some studies were conducted to evaluate the Khasib

Formation in southern, central, and western Iraq (Sadooni, 2004; Al-Ameri and Al-Obaydi, 2010; Al-Qayim, 2010; Mohammed, 2018; Mohammed *et al.,* 2021).

Khasib Formation was deposited in a basinal to sub-basinal setting and gradually turning to an open marine shelf (Sadooni, 2004; Al-Qayim, 2010). The formation was deposited in a ramp ranging from inner ramp in the form of shoal, middle ramp, and outer ramp with a transgression event caused by the increase of the sea level (Mohammed, 2018). The Chia Gara Formation of the Upper Jurassic-Lower Cretaceous sourced the Upper Cretaceous strata including the Khasib (Ameri and Al-Obaydi, 2010). Mohammed (2018) stated that the upper part of the Khasib Formation in Amara Oilfield (about 180 Km to the NE of Nasiriya (Fig. 1) mainly consists of mudstone – wackestone facies and contains hydrocarbon accumulations, while the lower part consists of packstone and some grainstone facies, the lower part contains the best petrophysical properties. Many diagenetic processes were observed within the Khasib in the East Baghdad and Amara Oilfields including cementation, dolomitization, dissolution, stylolitization and bioturbation, which whether have enhanced or destroyed the reservoir properties in the formation (Al-Qayim at al., 1993, Mohammed, 2018). This interval is important in the hydrocarbon potentiality in Iraq and other countries such as Egypt and Arabian Gulf countries (Farouk *et al.*, 2022; 2023).

Understanding the distribution of the porosity, permeability, the volume of shale, and water saturation within the reservoirs is crucial for the effective exploration and production of hydrocarbons (Davis, 2018). There has been a growing trend toward the use of 3D modeling techniques for studying the spatial distribution of these properties. However, applying 3D models requires the best knowledge about the sedimentary facies and their distribution within the targeted formation. This can be gained by the sedimentological and petrographical studies of the carbonate rocks. The missing subsurface core samples make it difficult to obtain the sedimentary facies of the reservoirs because the core operations are expensive and time-consuming for petroleum-based companies. The well logs data are essential and accessible when core and seismic data are missing (Mohammed *et al.,* 2021). Well logs are used for evaluating the reservoir characterizations of subsurface layers (Towfiqul *et al.,* 2017). Electrofacies analysis is a powerful tool that allows the characterization of rock properties based on well logs data. The cluster analysis can be used to group the electrofacies from well logs (Ye *et al.,* 2000; Kadkhodaie-Ilkhchi *et al.,* 2013; Davis, 2018).

It is a rapid and cost-effective approach that can be used to obtain the different electrofacies from well logs which are essential for modeling the reservoir characterizations and determining the oil-bearing intervals (Torghabeh *et al.*, 2014). By applying this technique to the Khasib Formation, 3D models of the petrophysical properties can be generated within the formation. This will provide valuable insights into the distribution of hydrocarbons and other important resources within the formation. It will support improved exploration and production strategies and identify areas of the formation that may be particularly promising for hydrocarbon exploration and production. One of the main advantages of using the electrofacies models is to obtain a better understanding of the heterogeneities and complexities of the subsurface reservoirs which is critical for optimizing exploration and production efforts.

3D petrophysical distribution in the framework of electrofacies is a valuable tool for understanding the distribution of fluids within subsurface reservoirs and for optimizing exploration and production stages. Using advanced technologies such as machine learning and artificial intelligence are possible to improve the accuracy and efficiency of this approach and to gain valuable insights into the subsurface environment. Since there were no core samples for Khasib Formation in Nasiriya Oilfield, the approach of Mohammed et al. (2021) is followed in this study. We use cluster analysis to group logs data into electrofacies and to distribute petrophysical properties based on it.

Aim of study

This study aims to distribute the petrophysical properties of the Khasib Formation in Nasiriya Oilfield in 3D models, these properties include the effective porosity, the volume of shale and water saturation. The cluster analysis and electrofacies approach then applied to understand the heterogeneity of the formation and to evaluate the best oil-bearing zones within the formation.

Area of Study

The Nasiriya Oilfield is located in Thi-Qar Province, 40 km northwest Nasiriya City, approximately 300 km southeast of the Capital Baghdad, and 180 km northwest Basra City (Fig. 1a).

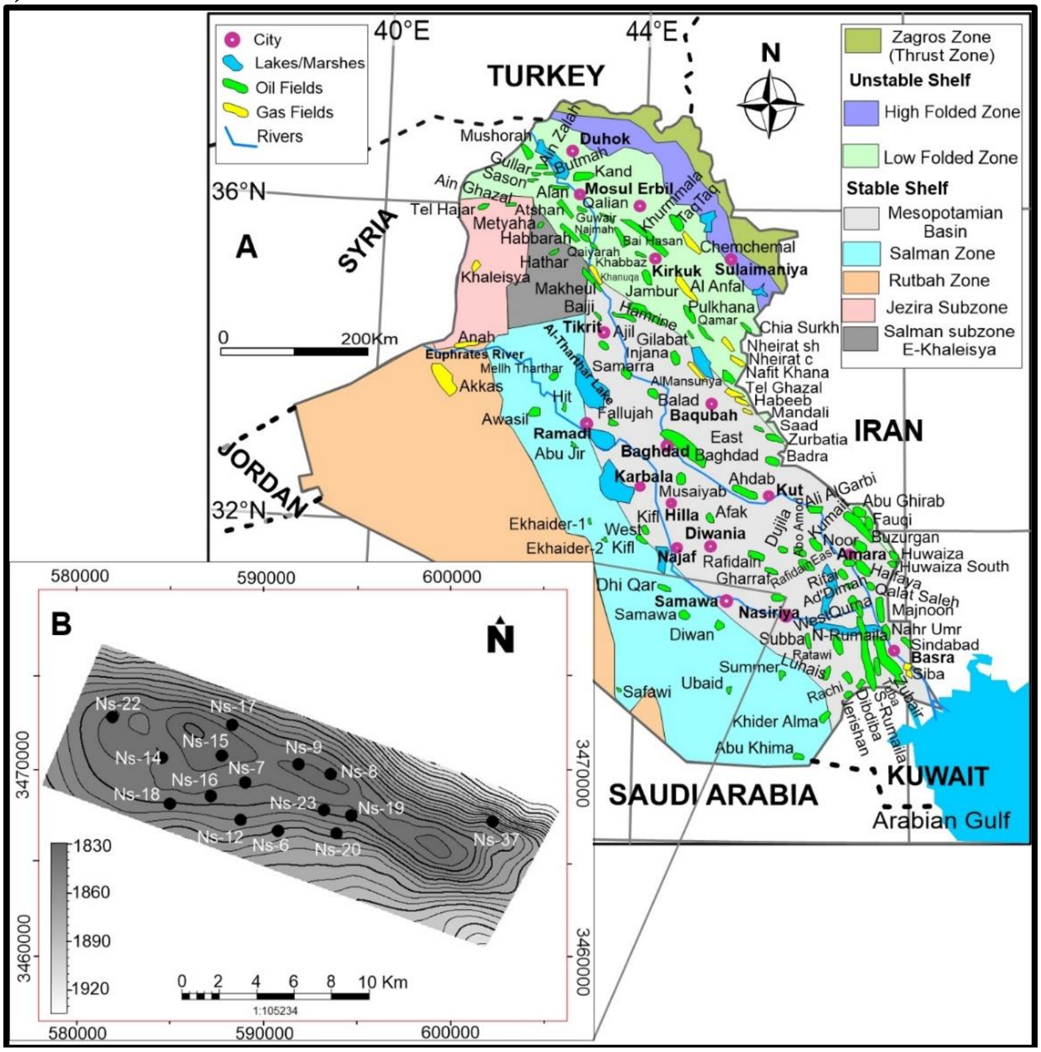

Fig. 1. (A) The Iraqi tectonic map showing the oil/gas fields (from Mohammed, 2020). (B) The Nasiriya Oilfield's structural map showing the top of the Khasib Formation and the locations of the studied wells.

The field lies on the Euphrates subzone, on the Mesopotamian Foredeep Basin (MFB) of the stable shelf. The structural contour maps of the Khasib show that the field consists of two anticlinal structural (dooms) with a general NW-SE trend. The larger one in the northwest extends from the well Ns-8 to Ns-22, while the smaller one is located in the southeast part, between the wells Ns-37 and Ns-19 (Fig. 1b). In 1973, the Iraqi National Oil Company (INOC) discovered the field. Their survey had shown a shallow convex enclosure in the northwestern part of the field (Mohammed and Dhaidan, 2023).

The initial company's reports had shown that the oil is mainly accumulated in the Lower and Middle Cretaceous reservoirs. These include the carbonate Mishrif Formation, the sandstone Nahr Umr Formation, and the carbonate Yamama Formation. However, the final geological reports of Nasiriya Oilfield further showed some evidence of the presence of oil in the Late Turonian-Early Coniacian Khasib in all the drilled wells. The reports showed that the oil accumulates mainly at the lower Khasib. The average thickness of the formation exceeds 50 m in the Nasiriya Oilfield.

Owen and Nasr (1958) were the first who described the Khasib Formation in the Zubair-3 well. They noted that the formation has a thickness that ranges from 50 - 240 m in Basra, in the MFB, which is also extending to Kuwait, whereas it is absent in Saudi Arabia and Qatar (Mohammed, 2018). In northern Iraq, the Kometan is equivalent to the Khasib, Tanuma and Sa'di formations. The Khasib Formation is unconformably overlying the Mishrif Formation, and is conformably underling the Tanuma (Van Bellen *et al.*, 1959). Whereas in the Nasiriya area, the Khasib Formation is unconformably overlying the Kifl Formation (Fig. 2). The upper part of the formation (30-35 m thick) mainly consists of chalky limestone intercalated with argillaceous limestone. While the lower part (15-18 m thick) mainly consists of light brown to brown, porous limestone, with medium to good oil shows (TOC, unpublished reports).

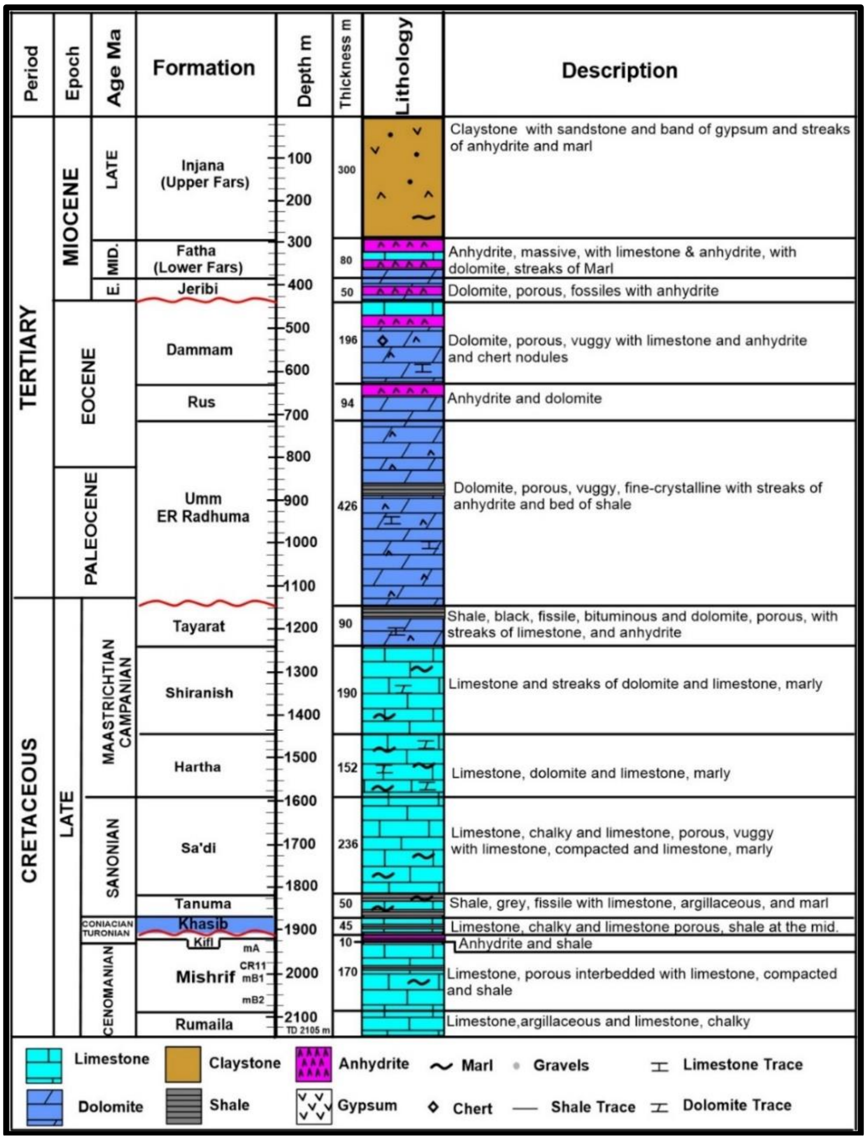

Fig. 2. General stratigraphic column of the Nasiriya Oilfield (Mohammed and Dhaidan, 2023), the Khasib Formation of this study is highlighted with blue recangle.

Materials and Methods

Sets of well logs including sonic, gamma ray, neutron, density, and resistivity logs, proposal, and final geological technical reports of fifteen wells in Nasiriya Oilfield are surveyed and for data collection in this study. Then, the petrophysical characteristics such as the shale volume (V_{sh}), effective porosity (PHI_{eff}), and the water saturation (S_w) are empirically calculated as follows (Asquith and Krygowski, 2004).

$$PHI_{total} = \left(\frac{PHI_D + PHI_N}{2}\right) \text{ ---------- (1)}$$

where: PHI_{total} is the total porosity, PHI_D is the porosity derived from density, and PHI_N is the porosity of neutron. PHI_D is calculated as below (Eq. 2) (Asquith and Krygowski, 2004):

$$PHI_D = \left(\frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}}\right) \text{ ---------- (2)}$$

where: ρ_{ma} is the density of matrix, presumed to be 2.71 g/cm^3, which is the density of calcite. ρ_b is the density log, and ρ_{fl} is the density of fluid, presumed the density of oil (0.95 g/cm^3). PHI_{total} is then amended from the effect of shale to obtain the effective porosity $PHI_{eff.}$ (Eq. 3) (Schlumberger, 1998).

$$PHI_{eff.} = (PHI_{total}) * (1 - Vsh) \text{ ---------- (3)}$$

where: Vsh is the shale volume obtained using the equation (4) bellow:

$$Vsh = 0.33(2^{2\times GRI} - 1) \text{ ----------- (4)}$$

where: GRI is the Gamma-ray Index obtained from gamma ray log as follows (Eq. 5) (Schlumberger, 1974).

$$GRI = \frac{GRlog - GRsand}{GRshale - GRsand} \text{ ---------- (5)}$$

where: GR_{log} is the reading from gamma-ray log, GR_{sand} and GR_{shale} are the lowest and highest gamma-ray readings, respectively.

The water saturation Sw is computed based on Archie's equation (1942) (Eq. 6):

$$Sw = \left(\frac{a * Rw}{Rt * (PHI_{eff.})^m}\right)^{1/n} \text{ ---------- (6)}$$

where: The constant values (a, m and n) are assumed to be 1, 2 and 2 respectively, **Rw** is the resistivity of formation water, and **Rt** is the true resistivity log (deep resistivity).

Supervised dynamic clustering is used to obtain different electrofacies from the well logs. Input logs are gamma ray (GR), sonic (DT), density (RHOB), and neutron porosity (NPHI). Petrel software is used to build the geological model including electrofacies models with the reservoir properties such as effective porosity and water saturation.

The structural model of the Khasib Formation is built using the surface map of the tops and bases of the formation in each selected well as there are no faults that have been captured in the areas. A simple grid is used with a grid increment dimension of 100*100, seventeen geological layers are found, and the total number of grid cells is 755412. The electrofacies models are distributed based on the Truncated Gaussian. Effective porosity and water saturation derived logs are scaled up into the cellular model and modeled using Sequential Gaussian Simulation (SGS) conditioned to the facies model. Property modeling processes are used to fill the gridded cells with discrete (for electrofacies) and continuous (for porosity and water saturation) properties.

Results and Discussion

Electrofacies Analysis and Identification

Lithofacies/facies refers to a rock unit with distinctive characteristics. The term can be used in descriptive and interpretive senses (Walker, 2006). It may highlight a specific distinctive feature of the rocks and may include a key interpretation of the depositional environment from which the deposits originated. The term electrofacies refers to groups of well logs set that respond differently, therefore facies (since well logs are used to group the facies, we use the term electrofacies). The electrofacies that are characterized by unique petrophysical well logs responding that in turn, represent different sedimentary facies (Davis, 2018). Determining electrofacies in reservoir rocks is important role in evaluating the hydrocarbon-bearing intervals in sedimentary basins (Torghabeh *et al.*, 2014). The cluster analysis technique is used to group the well logs into electrofacies (Ye *et al.*, 2000). Consequently, data in each group share some common characters (well log readings) (Ye *et al.*, 2000; Euzen and Power, 2014). To capture all the heterogeneity levels in the reservoir, a lithofacies model can be built to help geoscientists to understand the distribution of the lithofacies and thus to constrain the different depositional environments (Mikes and Geel, 2006). Mohammed et al. (2021) have integrated the well logs, petrographic and core data to determine the electrofacies type, to build the sequence stratigraphy and to identify the best hydrocarbon bearing zone within the Khasib Formation in Amara and Noor Oilfields. However, there is no core data available from Khasib Formation in Nasiriya Field of this study. Therefore, cluster analysis technique and electrofacies approaches are applied in this study from the available well logs data.

In this study, five different electrofacies are identified within the Khasib Formation. The petrophysical responses of each electrofacies are shown in Table (1).

Table 1: The electrofacies clustering, color codes, log readings ranges of each electrofacies (GR, DT, NPHI, RHOB). The table also shows the average of each petrophysical property such as shale volume V_{sh}, effective porosity PHIE, and total porosity PHIT.

Cluster code	GR API	DT *us*/ft	NPHI %	RHOB g/cc	Vsh %	PHIE %	PHIT %	Lithology
EFC-1	35-81	73-111	27-37	2.19-2.22	76	3	25	Shale
EFC-2	30-40	73-81	6-10	2.56-2.62	24	8	10	Marly limestone
EFC-3	25-36	77-82	15-19	2.32-2.37	26	17	20	Argillaceous limestone
EFC-4	21-27	68-72	12-16	2.45-2.53	19	13	17	Chalky limestone
EFC-5	12-22	78-82	19-25	2.30-2.35	6	20	22	Porous limestone

The integration of cluster analysis and boreholes data include information from the cuttings of the drilled wells showed that:

EFC-1 consists of light grey to grey shale. Logs response for these facies shows a high gamma-ray reflected in the volume of V_{sh} with low density log reading. This electrofacies type has recorded high total porosity. However, they are seemingly unconnected; thus, the effective porosity is low in this type of facies.

EFC-2 consists of light grey marly limestone. It records medium to high gamma-ray log readings, high density log readings and low neutron log readings. These types of electrofacies are dominantly observed in zone F, D and C (Fig. 3).

EFC-3 consists of light grey, finely crystalline argillaceous limestone. Gamma-ray log response is from medium to high readings. This shows good effective porosity. However, most pores are filled with water as will be discussed later. These types of facies are found mainly in the upper part of Khasib Formation, in the zone Khasib A.

EFC-4 consists of white, soft, finely crystalline chalky limestone. The main characteristics of this lithofacies are the low gamma-ray log reading and moderate effective porosity.

EFC-5 consists of beige and light brown to brown, medium crystalline porous limestone. It has shown a low gamma-ray log reading, high porosity and moderate water content at the lower part turning to high-water content at the upper part of Khasib Formation. This electrofacies is dominated in zones B and E.

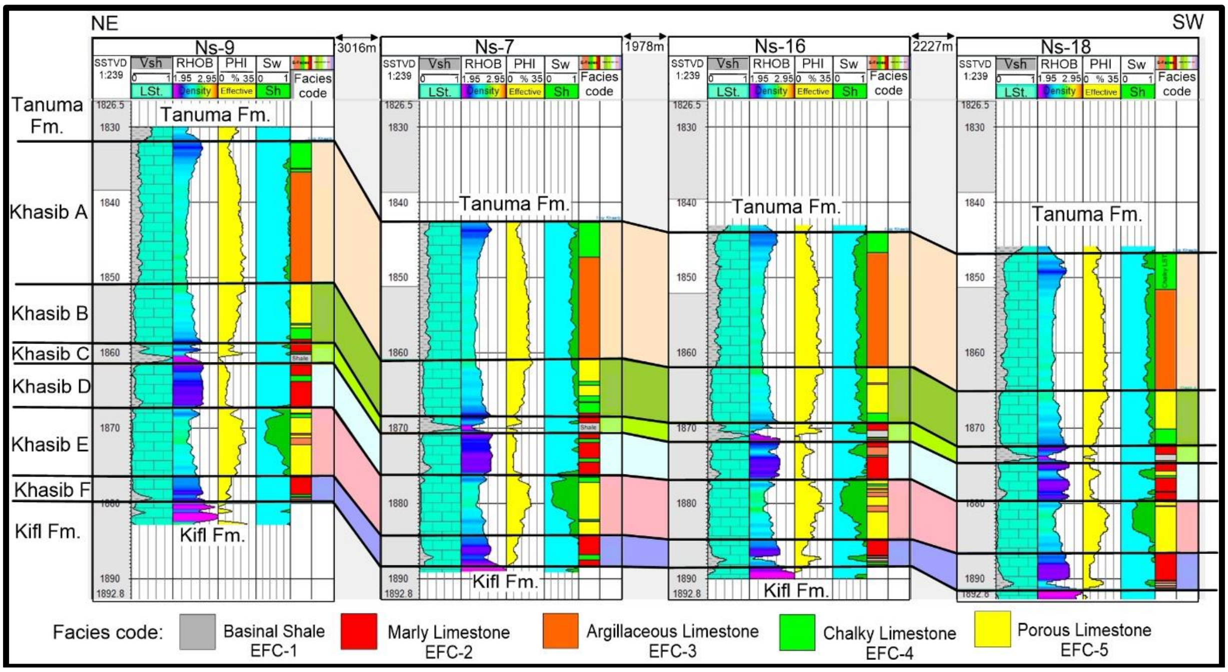

Fig. 3. Well logs cross-section showing the correlation of some petrophysical properties such as the volume of shale (V_{sh}), density log (RHOB g/cc), effective porosity (PHI), water saturation (S_w) for wells Ns-9, 7, 16, and 18.

Khasib Petrophysical Zones

The Khasib Formation is vertically subdivided into six zones based on the petrophysical properties such as PHIE, PHIT, V_{sh} and S_w. These are Khasib (A, B, C, D, E and F) (Fig. 3). The description of each zone is shown in Table (2). Zone F starts from the top of the Kifl Formation and represents the bottom of the Khasib Formation. Zone E contains the major reservoir unit characterized by a high effective porosity and low water content. Zone D mainly comprises the light grey to grey marly limestone and shows poor reservoir characteristics; therefore, it forms the main seal rock of the main reservoir unit (E) of the Khasib Formation, where it displays a low porosity, high water content and high to medium shale content. Zone C contains dark grey and fissile shale with marly limestone. Zone B contains medium crystalline porous limestone interbedded with chalky limestone. Zone A mainly consists of chalky limestone intercalated with argillaceous limestone having a high-water content. This zone has recorded a larger thickness than other zones. These electrofacies integrated with the petrophysical results show that zones E with the dominated EFC-5 have the best petrophysical properties (Table 1 and Fig. 3). The results show that the cluster analysis technique can provide an accurate, rapid, and cost-effective method to subdivide the reservoirs and identifying electrofacies in the reservoirs.

Table 2: The petrophysical description of each zone, the ranges, and averages of each shown petrophysical property, shale volume V_{sh}, effective porosity PHIE, water saturation S_w, in all studied wells. The zones are ordered from the lower to the upper part of the Khasib Formation.

Zone	Lithological description	Thick m	V_{sh} % Range (Average)	PHIE % Range (Average)	S_w % Range (Average)	Reservoir Description
F	Light grey to dark grey colored, marly, fine crystalline limestone interbedded with argillaceous limestone	3.7	5 - 36 (20)	4 - 10 (7)	88 - 100 (94)	Moderate /Water bearing
E	Light brown to brown, porous limestone with chalky limestone	7.9	3 - 7 (5)	12 - 22 (17)	24 - 79 (51)	Good/Oil bearing
D	Light grey to grey marly limestone	5.6	5 - 30 (17)	5 - 8 (7)	81 - 100 (90)	Sealing
C	Dark grey, fissile shale with marly limestone	2.5	54 - 100 (77)	1 - 4 (2)	95 - 100 (97)	Sealing
B	Beige, medium crystalline, porous limestone, interbedded with chalky limestone.	7.5	4 - 10 (7)	11 - 22 (16)	75 - 100 (87)	Good/Water bearing
A	Chalky limestone interbedded with argillaceous limestone	18.8	11 - 37 (24)	8 - 15 (11)	80 - 100 (90)	Moderate/Water bearing

Geological Modeling

Well correlation is an easy way to gain an initial thought about the subsurface geological layers and grant a simple visualization of the thickness and the petrophysical properties between wells across the fields. The transverse cross-section is drawn across the wells Ns-18, 16, 9 and 7. This cross-section shows that Ns-9 is stratigraphically higher than other wells, and generally, the thickness increases toward southeast (Fig. 3). The unit Khasib E shows the highest averaged effective porosity with the lowest averaged water content, and therefore, it is recognized as the main horizon bearing hydrocarbon. While the porous units of Khasib A and B have also recorded a high porosity. However, most of the porosity is filled with water; therefore, forming water-bearing horizons (Fig. 3 and Table 2). It is further observed that unit Khasib A has a higher volume of shale recording argillaceous limestone as the dominated electrofacies in this zone. The marly limestone is dominated in units of Khasib D and F, showing a reduction in the effective porosity, and increasing in the water content in these units (Table 2 and Fig. 3). Khasib C is the main shale layer across the entire Nasiriya Field (Figs. 3 and 7), while zone D shows a low porosity. It is therefore, Khasib C and D are possibly sealing the main reservoir unit of Khasib E.

Electrofacies are built for each zone to understand the facies distribution and the geometry in the formation across the Nasiriya Oilfield. The facies models are constructed based on the electrofacies and thicknesses that have been defined from the fifteen studied wells (Fig. 4). It is possible to observe the sea level change and the evolution of the Khasib Formation over time. The Khasib Formation was deposited in a carbonate ramp slopping forward NE the seaward, where the deeper facies are likely deposited at the NE and the shoreline where the porous facies are deposited at the SW (Fig. 4d).

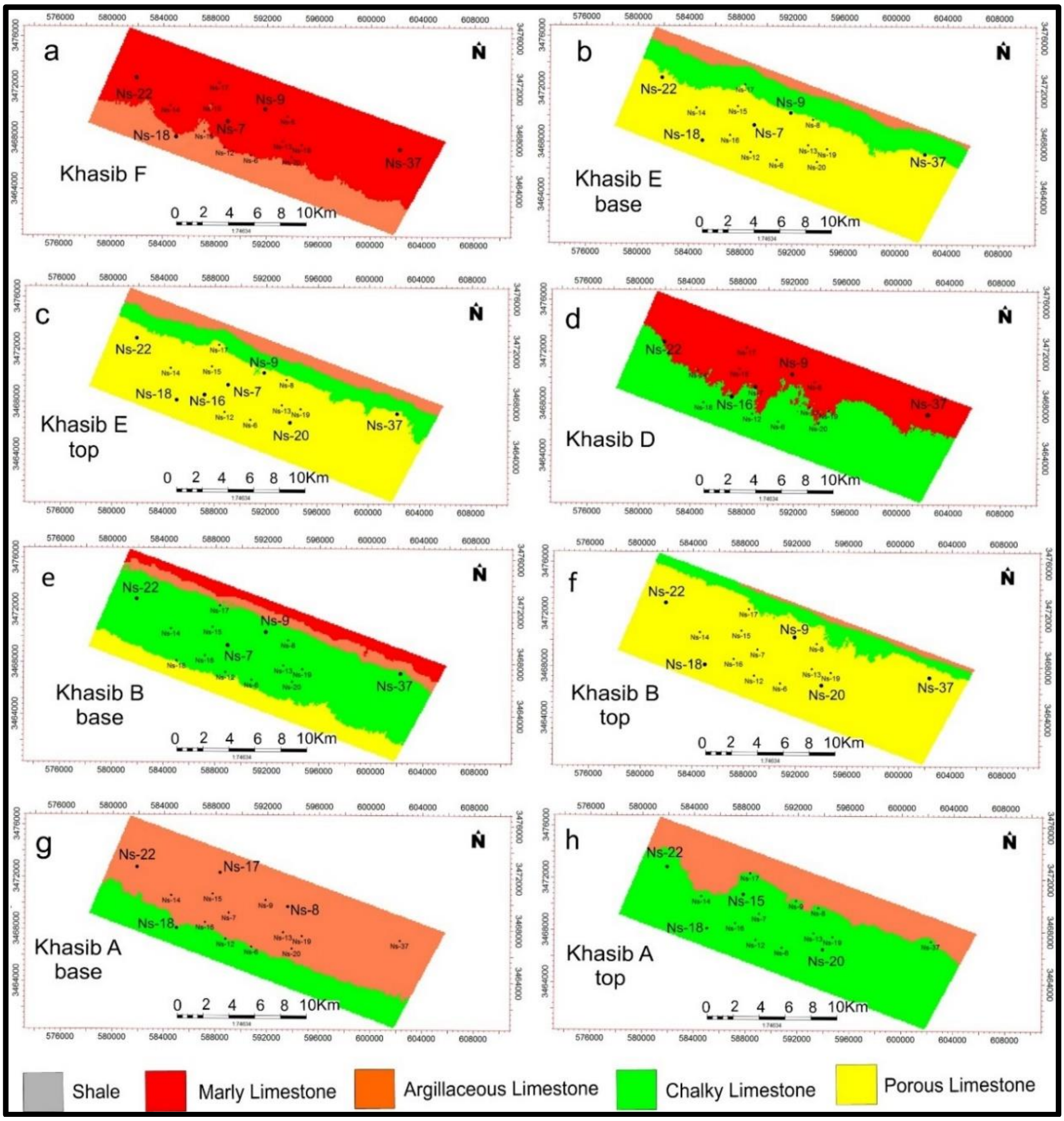

Fig. 4. Lithofacies maps of Khasib Formation in each zone, (a) corresponds to the bottom of the formation (represented by zone Khasib E) while (h) represents the top of the Khasib Formation (representing zone Khasib A).

Distributing of the petrophysical parameters such as the effective porosity and water saturation between the studied wells, shows the reservoir heterogeneity across the entire Nasiriya Field. Petrophysical modeling is the interpolation or simulation of continuous data (porosity, water saturation) throughout the model's grids. Deterministic and stochastic methods are available for the distribution of continuous characteristic in the reservoir modelling. The results of the property models show that the unit Khasib E has the best petrophysical properties (Fig. 5, 6 and 7).

The porosity models have shown that the highest porosity readings dominated in zone Khasib E. The porosity increases in the NW (larger doom) between the wells Ns-18, Ns-16, Ns-15, and Ns-14. The SE part (the smallest doom, between Ns-37 and Ns-19) of the field also shows high porosity distribution (Fig. 4c, and Fig. 7). However, the NW part of the field has low water content, whereas the SE part shows higher water saturation (Fig. 5c).

The area between the wells Ns-18, Ns-16, Ns-15 and Ns-14 is of interest when targeting Khasib Formation. The volumetric calculations of Khasib zones show that the Khasib E unit contains a commercial hydrocarbon accumulation, while Khasib A and B are water-bearing zones and contain promising water amounts that can be used for water injection purposes. The shale in the lower part of the Tanuma Formation representing a good seal for those units.

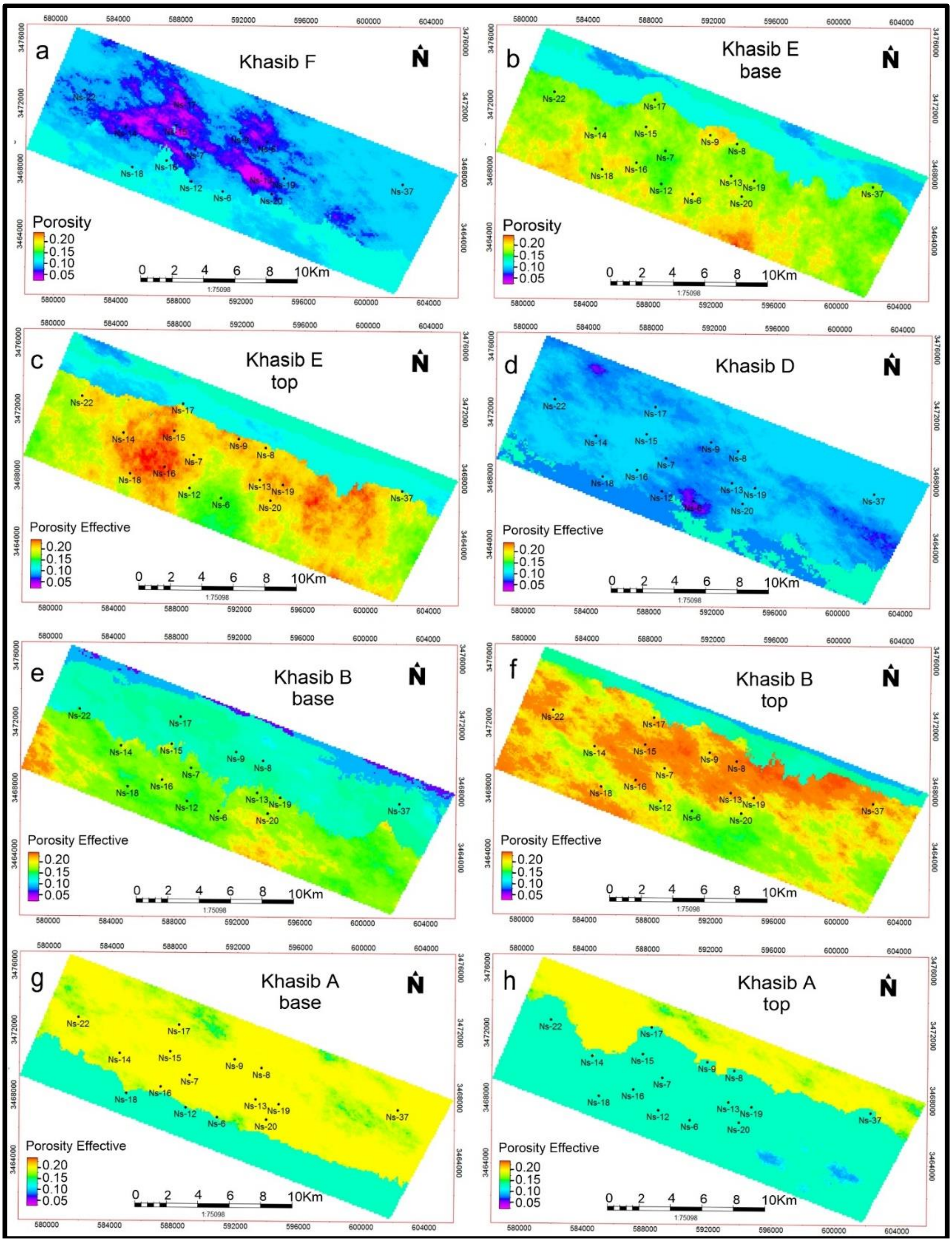

Fig. 5. Porosity distribution models of the Khasib Formation in each zone.

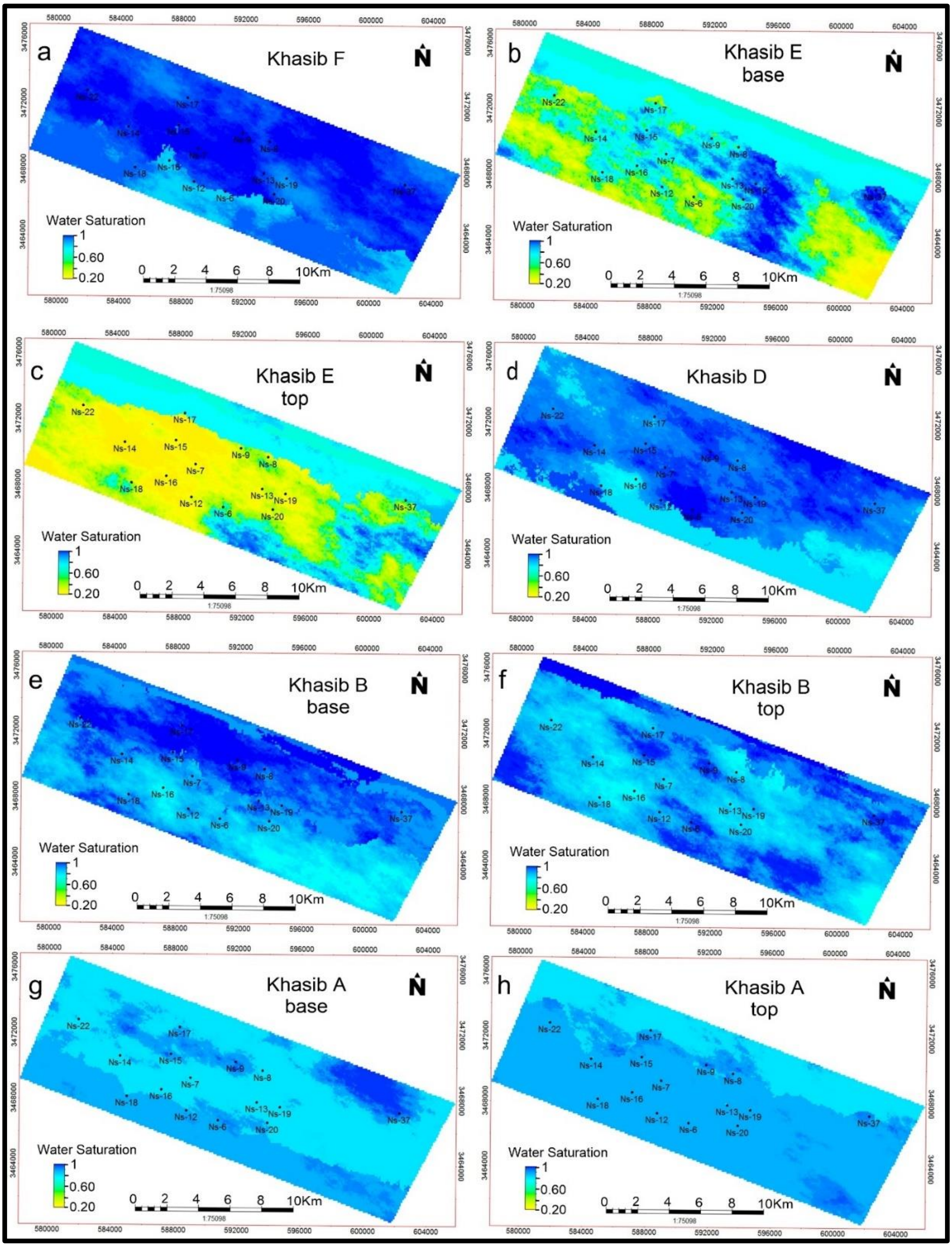

Fig. 6. Water saturation distribution models of the Khasib Formation in each zone.

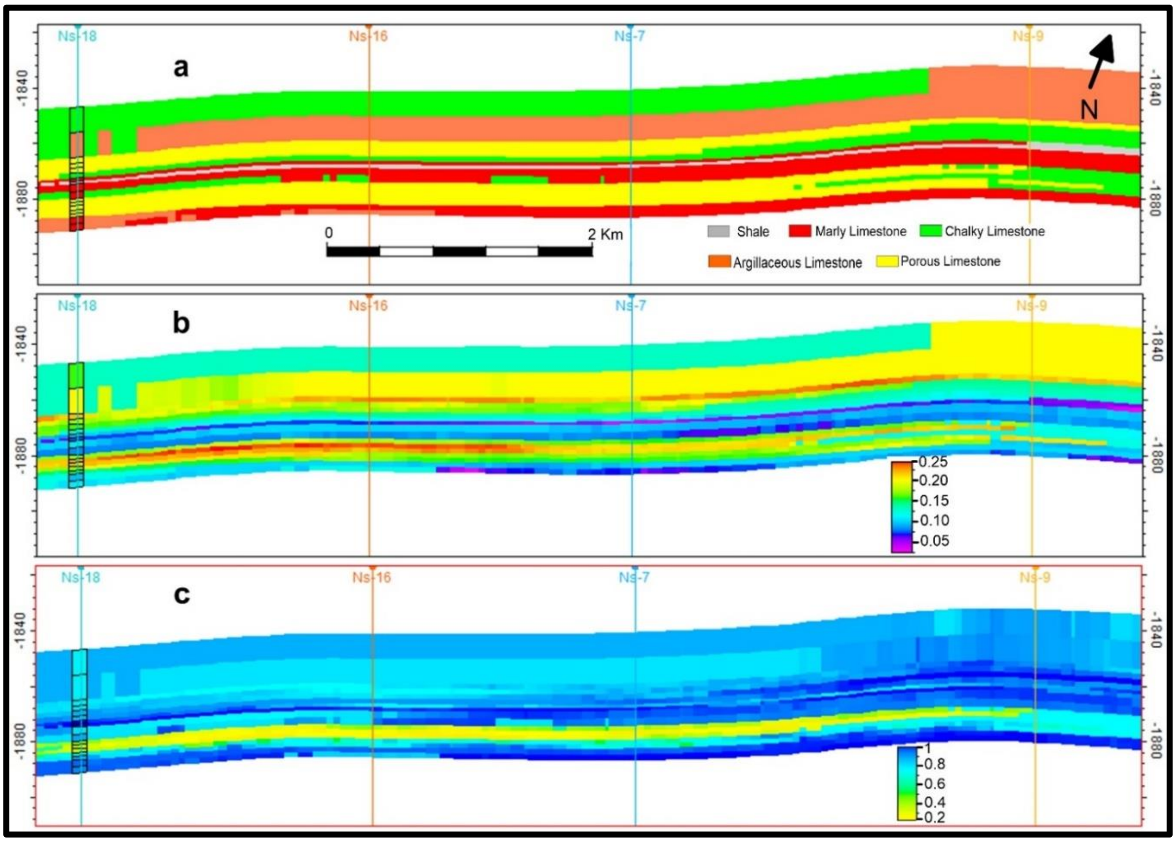

Fig. 7. Inter-cross sections showing the variation of (a) the electrofacies, (b) effective porosity, (c) water saturation across the wells Ns-18, Ns-16, Ns-7, and Ns-9.

Conclusion

The study aims to model and distribute the reservoir properties (lithofacies/ electrofacies, effective porosity, and water saturation) in the Khasib Formation in Nasiriya Oilfield based on well logs data using a combination of Geology and Petrel softwares. It can be concluded that:

1. The structural contour maps of the Khasib Formation show that the Nasiriya Oilfield consists of two anticlinal structural (dooms) with a general NW-SE trend, 24 km long, and 5km wide. The larger one at northwest extends from well Ns-8 to Ns-22, while the smaller one at southeast is situated between wells Ns-37 and Ns-19.
2. Dynamic clustering is used to group the formation into electrofacies. Truncated Gaussian with trends is used to distribute electrofacies. Five different electrofacies are recognized, they are: shale (EFC1), marly limestone (EFC2), argillaceous limestone (EFC3), chalky limestone (EFC4) and porous limestone (EFC5). The electrofacies EFC5 has the highest effective porosity and lowest shale volumes. The results show that the clustering analysis technique is an accurate, cost-effective, and rapid technique for zoning reservoirs and identifying electrofacies.
3. The Khasib Formation is subdivided into six zones (Khasib A-F). Khasib E is the best zone that encompassed by excellent reservoir properties (low water content and high effective porosity); and therefore, represents the prime oil-bearing zone in Khasib Formation. Zone C is the shale layer and extends across the field; thus, it can be a bed marker layer. Zones C and D are the main sealing layers, while zones A and B are water-bearing horizons, and they can be used for injection purposes for the field development plans.
4. The 3D model distribution of the water saturation and the effective porosity show that in the oil-bearing layer (Khasib E), the northwestern part has a higher effective porosity compared to the southeastern part of the Nasiriya Field. The southeastern part has higher porosity but with higher water saturation. Therefore, the area between wells Ns-18, Ns-16, Ns-15, and Ns-14 is promising when targeting the Khasib Formation.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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