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CONSTRUCTING A THREE-DIMENSIONAL GEOLOGICAL MODEL OF THE HAWAZ FORMATION IN J-OIL FIELD, NC-186, MURZUQ BASIN, LIBYA

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Abstract

This study examines the petrophysical properties of the Hawaz reservoir in the J-Field of Concession NC186, situated in the northern Murzuq Basin. It aims to build a geological and petrophysical model of the Hawaz reservoir using Schlumberger Petrel software and well-logging data to assess reservoir quality. The Hawaz Formation is subdivided into three units: upper, middle, and lower. The petrophysical properties of the Hawaz reservoir were analyzed for six wells: J1-186, J2-NC186, J6-NC186, J7i-NC186, J12-NC186, and J25-NC186. Techlog software was used to calculate additional petrophysical data from digital well logs. Geological and petrophysical models were created using Schlumberger Petrel to assess and understand reservoir quality and petrophysical characteristics, utilizing available wireline data,

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including gamma-ray (GR), neutron (N), density, resistivity (Res), and sonic logs, formation tops, and core studies. The results indicate that the Hawaz reservoir sandstone exhibits good reservoir quality, with an average porosity of 11%, a shale volume of 10.3%, and water saturation of up to 39.6%. Water saturation is higher in the southeast, around well J25-NC186, and decreases towards the northwest, around well J12-NC186. The 3D property model divides the Hawaz reservoir into six distinct units (H1, H2, H3, H4, H5, and H6). Units H2, H3, and H4 are considered active zones with favorable petrophysical properties (Sw, φ) and significant hydrocarbon content, while Units H1, H5, and H6 exhibit high water saturation and low net pay thickness. This trend is reflected in the spatial distribution of water saturation, with high values around well J25-NC186 in the southeast and decreasing values around well J12-NC186 in the northwest. Based on the 3D property model, Units H2, H3, and H4 are identified as the most promising zones due to their superior petrophysical properties and hydrocarbon saturation, while Units H1, H5, and H6 are less prospective due to their low net pay and high water saturation.
Keywords: Hawaz Reservoir, Petrophysical Properties, 3D Property Model, Reservoir Quality, Murzuq Basin.

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بناء نموذج ثلاثي الأبعاد لحقل جي النفطي بحوض مرزق- ليبيا

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الملخص

تتناول هذه الدراسة الخصائص البتروفيزيائية لمكمن هواز في الامتياز (J) لحقل (NC186) الواقع في الجزء الشمالي من حوض مرزق.تدرس هذه الدراسة الخصائص البتروفيزيائية لخزان هواز وتهدف إلى بناء نموذج جيولوجي وبتروفيزيائي باستخدام برنامج بيترل لشركة شلمبرجير وبيانات تسجيل الآبار لتقييم جودة الخزان. ينقسم تكوين هواز إلى ثلاث وحدات: علوية، ووسطى، وسفلية. وقد حُللت الخصائص البتروفيزيائية لخزان هواز لستة آبار: J1-186، وJ2-NC186، وJ6-NC186، وJ7i-NC186، وJ12-NC186، وJ25-NC186. واستُخدم برنامج Techlog لحساب بيانات بتروفيزيائية إضافية من سجلات الآبار الرقمية. أُنشئت نماذج جيولوجية وبتروفيزيائية باستخدام برنامج بيترل لتقييم وفهم جودة المكمن وخصائصه البتروفيزيائية، بالاستفادة من بيانات خطوط المسح السلكية المتاحة، بما في ذلك سجلات أشعة غاما (GR)، والنيوترون (N)، والكثافة، والمقاومة (Res)، وسجلات الموجات الصوتية، وقمم التكوين، ودراسات اللب. تشير النتائج إلى أن الحجر الرملي في خزان هواز يتميز بجودة جيدة، بمتوسط مسامية 11%، وحجم صخر 10.3%، وتشبع مائي يصل إلى 39.6%. يرتفع تشبع الماء في الجنوب الشرقي، حول البئر J25-NC186، وينخفض باتجاه الشمال الغربي، حول البئر J12-NC186. يُقسّم نموذج الخصائص ثلاثي الأبعاد خزان هواز إلى ست وحدات مميزة (H1، H2، H3، H4، H5، وH6). تُعتبر الوحدات H2 وH3 وH4 مناطق نشطة ذات خصائص بتروفيزيائية مواتية (Sw, φ) ومحتوى هيدروكربوني كبير، بينما تتميز الوحدات H1 وH5 وH6 بتشبع مائي مرتفع وسمك منخفض للعائد الصافي.

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ينعكس هذا الاتجاه في التوزيع المكاني لتشبع الماء، حيث ترتفع القيم حول البئر J25-NC186 في الجنوب الشرقي، وتنخفض القيم حول البئر J12-NC186 في الشمال الغربي. بناءً على نموذج الملكية ثلاثي الأبعاد، تُعتبر الوحدات H2 وH3 وH4 أكثر المناطق واعدة نظرًا لخصائصها البتروفيزيائية المتميزة وتشبعها الهيدروكربوني، بينما تُعتبر الوحدات H1 وH5 وH6 أقل واعدة نظرًا لانخفاض العائد الصافي وارتفاع تشبعها المائي.

الكلمات المفتاحية: خزان هواز، الخصائص البتروفيزيائية، نموذج ثلاثي الأبعاد، جودة الخزان، حوض مرزق.

1. Introduction

The J oil field is located within concession NC186, where ten exploratory and development wells have been drilled. The NC186 concession, a prolific 4300 km² area, belongs to Akakus Oil Company and is situated in the northern portion of the Murzuq Basin, approximately 730 kilometers south of Tripoli. Concession NC186 lies northeast of concession NC115 and northwest of NC174 (Figure 1) and is recognized as one of the most petroliferous concessions discovered to date within the Murzuq Basin. Several major oil fields (A, B, C, I, J, H, M) have been discovered, producing from Ordovician sandstone reservoirs.

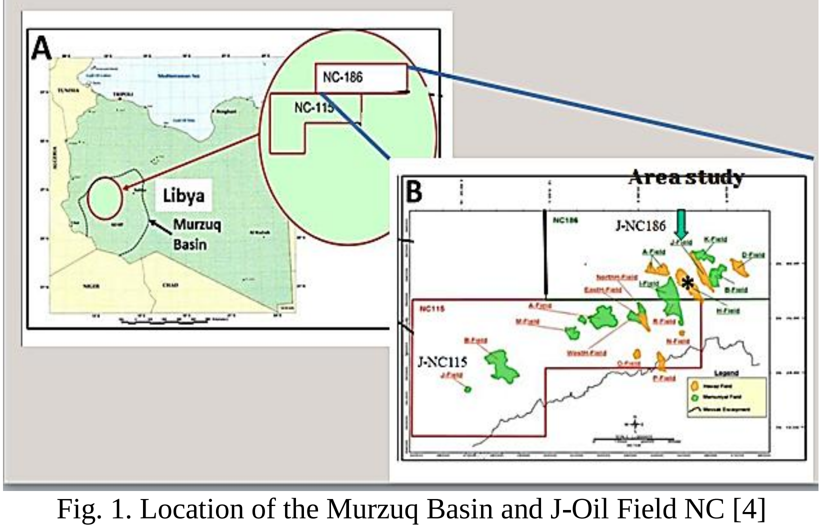

Fig. 1. Location of the Murzuq Basin and J-Oil Field NC [4]

The first significant discovery was made with well J1-NC186, which was drilled to evaluate the hydrocarbon potential of the

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Hawaz paleo-buried hills within concession NC186 [1-3]. The study area, known as the J Oil Field, is located in the central region of concession NC186 in the northern Murzuq Basin, between latitudes 26°40' and 27°00'N and longitudes 12°00' and 13°10'E. This study primarily focuses on the Hawaz Formation within the J oil field, concession NC186.

2. Geological Setting

The Murzuq Basin located on the southwest part of Libya, forms one of several intracratonic sag basins, located on the Saharan Platform of North Africa, it covers more than 350,000 km², lied on four countries, southwestern Libya, northern Niger (Jadu Basin), and a small part in Algeria and Chad. In the north, the Gargaf Uplift separates the Murzuq Basin from the Ghadames Basin. To the west, is bounded by the Tihemboka Arch, which forms the boundary between the northwestern Murzuq and the eastern Illizi Basins. The eastern limit with the Sirte Basin Figure (2).

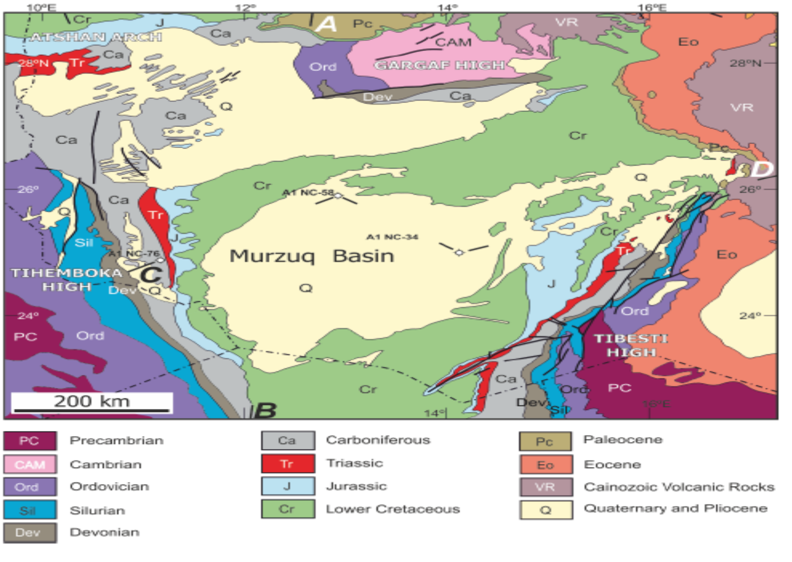

Fig. 2. Location Map of Murzuq Basin and its Boundaries [6]

The south the basin extension in Niger [5]. The present-day structure of the Murzuq Basin can only be determined by subsurface methods since the entire basin center is covered by the Murzuq Sand Sea.

The structural fabric imparted to the North African continental lithosphere during the late Proterozoic, Pan-African event has played an important role in controlling the subsequent structural and stratigraphic evolution of the basin. Early Palaeozoic tectonics

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created a series of NNW trending arches and sub-basins across North Africa, which were filled with clastic continental and shallow marine deposits and transgressive open marine facies.

Early Palaeozoic tectonism effectively controlled the distribution of late Ordovician reservoirs and the distribution of Silurian "Hot Shale," which onlap early-formed fault blocks the structure of the Murzuq basin is quite simple. The sub-horizontal or gently dipping strata are faulted, and the faults are most frequently parallel to the axis. Tectonic movements affected the basin to a greater or lesser degree from the middle Palaeozoic (Caledonian) to post-Oligocene (Alpine) times. Caledonian, Hercynian, and Alpine tectonic events affected this basin's evolution, especially Caledonian and Hercynian orogeny. The Caledonian orogeny started in the Upper Silurian and persisted through the lower part of the Lower Devonian. This has been provided in several localities in the south of the Ghadames Basin, in the Murzuq Basin, and also in the Kufra Basin.

The structure contour map of the top Hawaz Formation in the study area is shown in Figure 3.

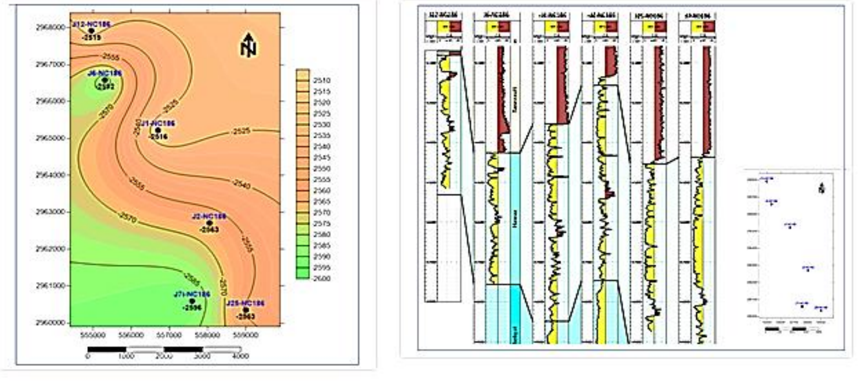

Fig. 3. Structure Contour Map of Top Hawaz Formation in Study Area

The northwest part of the area is high around in the northwest to east part around wells J12-NC186 and J1-NC186, and the structure turns to low in the south-southwest part, the structure cross-section using gamma log form correction between wells was created from the northwest to the southeast part indicate the area in the northwest high structure and the area in the southeast low structure.

3. Stratigraphy of Murzuq Basin

The sedimentary infill of the Murzuq Basin comprises rocks ranging in age from Cambrian to Eocene. The major and thicker sedimentary

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record is mainly attributed to the relatively continuous Paleozoic succession, while the Mesozoic and Cainozoic deposits are characterized by thin and discontinuous sequences. The sedimentary infill of the Murzuq Basin unconformably overlies a Precambrian basement composed of high-grade metamorphic rocks associated with plutonic rocks, as well as low-grade to unmetamorphic rocks of Precambrian age, known as the Mourizide Formation [7]. Both the plutonic and metamorphic rocks are intersected by the pan-African unconformity, which serves as the basal unconformity of the basin (Figure 4). The sedimentary record of the Murzuq Basin has been divided into four sedimentary sequences: Cambrian to Ordovician, Silurian, Devonian to Carboniferous, and Mesozoic.

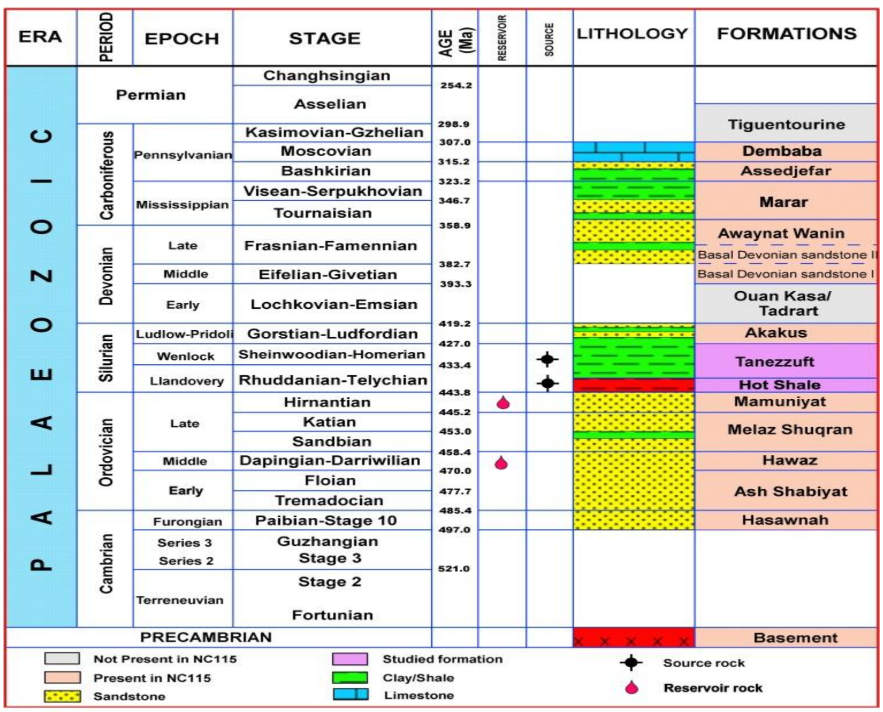

Fig. 4. Lithostratigraphic Chart Murzuq Basin [7]

The Cambrian Ordovician

The sequence, which unconformably overlies the Precambrian basement, corresponds to the lower Paleozoic Gargaf Group, a detrital unit consisting of five formations named, from bottom to top: Hasawnah, Ash Shabiyat, Hawaz, Melaz Shuqran, and Mamuniyat. All of these formations are detrital and are bounded by unconformities of different natures, except for the boundary between the Ash

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Shabiyat and Hawaz formations, which forms an erosive concordant surface[7].

The Silurian Sequence

The sediment is a fine-to-medium-grained detrital sequence that overlies a complex erosive surface resulting from the late Ordovician glaciation. It constitutes a relatively continuous sequence that includes a transgressive and a high sea-level episode followed by a regressive progradation. The lower transgressive and high sea-level deposits are composed of the Bir Tlacsin and Tanzzuft formations, with the latter including the hot shale member. The upper sequence is ubiquitous and shares similar characteristics across North Africa, from Morocco in the west to Arabia in the east [7].

The Devonian-Carboniferous

The sequence unconformably overlies the terminal Silurian Caledonian unconformity. It represents continuous marine deposition locally punctuated by local unconformities that, in some cases, are responsible for major thickness variations. The deposits within the sequence are both detrital and carbonate, and include the Tadrart, Quan Kasa, Awaynat Wanin, Marar, Assedjefar, Dembaba, and Tiguentourine formations. The sequence is capped by the late Carboniferous Hercynian unconformity [7].

4. The Mesozoic Sequence

The sediment is absent in the uplifts bordering the Murzuq basin (Tihemboka, Tibesti, Gargaf, and Atshan highs), and only a partial succession is present in the central part of the basin. The most complete Mesozoic sequence crops out southwards of the basin, in the SE and SW borders, near the Tihemboka and Tibesti highs. This sequence has been drilled in the subsurface only in the southern half of the basin. Towards the north, the Mesozoic sequence is only represented by Cretaceous rocks, which occupy larger extensions of the basin. The Mesozoic sequence is made up of continental detrital sediments and includes the Triassic Zarzaitirnt Formation, the Jurassic Tourantine Formation, and the Cretaceous Mazak Formation.

5. Petrophysical Study

Petrophysics refers to the study of rock properties, such as porosity, permeability, fluid distribution, and more. In this study, a comprehensive set of logs, including neutron, density, and induction logs, has been recorded across the reservoirs. Each log interval was

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measured at 0.5 feet intervals and analyzed in detail for parameters such as porosity, volume of shale, water saturation, net pay thickness, and hydrocarbon pore volume. The petrophysical analysis of the Hawaz Formation in the J oil field Concession NC-186 was conducted to gather the necessary variables for volumetric calculations of the field. Six wells were utilized in this study, and the available well logs include Gamma Ray (GR), Density, Neutron, Sonic, and Resistivity logs. These logs were used to construct maps, cross-sections of the reservoir, determine reservoir interval thickness, water saturation, and Net-pay zone thickness.

5.1. Determination of Volume of Shale

In order to determine the net sand interval within the Hawaz Reservoir, the volume of shale (Vsh) needs to be calculated first. The volume of shale was calculated using new software (Techlog) by relying on the Gamma Ray log. The equation used for the calculation is IGR = (GRlog - GRclean) / (GRsh - GRclean), where: - IGR: is the Gamma-ray index (in API), - GRlog: is the Gamma-ray reading, - GRclean: is the minimum Gamma-ray reading, - GRsh: is the maximum Gamma-ray reading. And then this gamma-ray index is used to calculate the volume of shale by using the Larionov old rock equation**:** Where: VSH =0.33(22*GRI-1) IGR: Gamma-ray index, GRlog: Gamma-ray log reading of formation, Grmin: Minimum gamma ray reading in the clean zone (clean sand or carbonate), GRmax: Maximum gamma ray reading in shale zone, Vsh: Volume of shale. The average shale content ranges from 1% in well J12 to 14.7% in well J2-NC186.

5.2. Porosity Determination

The porosity logs, including neutron and density logs, are both used to determine the total porosity (ØN-D) of the Hawaz Reservoir. To calculate the Net Reservoir, the porosity of the established Net-sand must be determined. Both density and neutron porosity methods are utilized to compute the total porosity of the interval.

5.3. Density Porosity

The density porosity (ØD) of a reservoir rock is determined by the equation ØD = (ρbma - ρblog) / (ρbmax - ρfl), where: - ρb is the bulk density in gm/cc (log). - ρfl is the fluid density, equal to 1 gm/cc. - ρbma is the matrix density, equal to 2.65 gm/cc for Sandstone. - ØD represents the density porosity.

5.4. Neutron Porosity

The neutron porosity has been directly read from the logs and corrected for the shale line.

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5.5. Average Porosity

The average porosity result of each well in the field ranges from 11% to 24%. The porosity map in Figure 5 was constructed to display the distribution of porosity in the Hawaz reservoir. Porosity increased in well J12-NC186 in the northwestern part of the study area, reaching 13%, and decreased towards the southeast part in well J25-NC186, where it reached 9.2%.

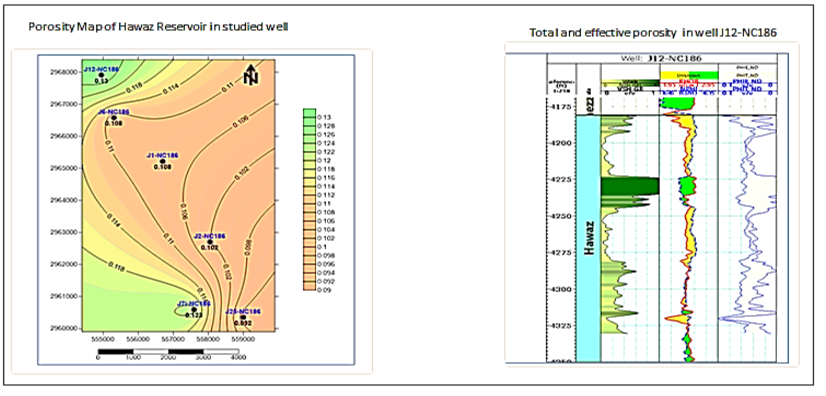

Fig. 5. Porosity Map of Hawaz Reservoir & Total and Effective Porosity in Well J12-NC18

5.6. Water Saturation Calculation

Water saturation. As the presence of shale also affects the water saturation, we compensate for the effect of shale by applying the Indonesian model. This model improves the reliability in shaly formations, as it is based on field observations. The mathematical form of this model is. Following the calculation of the SW of the reservoir interval, the Cut-off criteria of 50% is defined by the software to distinguish the Productive from the Non-productive intervals. The water saturation is calculated using the Indonesian Equation.

The water saturation is calculated using the Indonesian Equation.

$$S_w = \left[\left\{ \left(\frac{V_{sh}^{2-V_{sh}}}{R_{sh}} \right)^{\frac{1}{2}} + \left(\frac{\phi_e^m}{R_w} \right)^{\frac{1}{2}} \right\}^2 R_l \right]^{-\frac{1}{2}}$$

Where: where Sw represents water saturation; Rsh, Rw, and Rt are the shale, water, and true resistivities, respectively; **a** = Tortuosity factor = (1). **ØT** = total porosity ($Ø_{tN-D}$)% m is the cementation factor, and its value is 2. **Rt** = Formation resistivity (Ω.m). **n** = Saturation exponent = (2). **Rw** = Water Resistivity = (0.31 Ω.m). Vsh is the volume of shale, and fe is effective porosity.

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These estimated petrophysical parameters (volume of shale, porosity, and water saturation) are shown in Figure 6. The water saturation map (Figure 6) was constructed to display the water saturation and hydrocarbon distribution in the Hawaz Reservoir in the study area. The average water saturation in the reservoir for each well in the field is depicted on the map, with high water saturation observed in the southern part around well J7i-NC186, reaching 67.6%. This saturation then decreases in the northwest part, with well J12NC186 showing a saturation level of 20.4%.

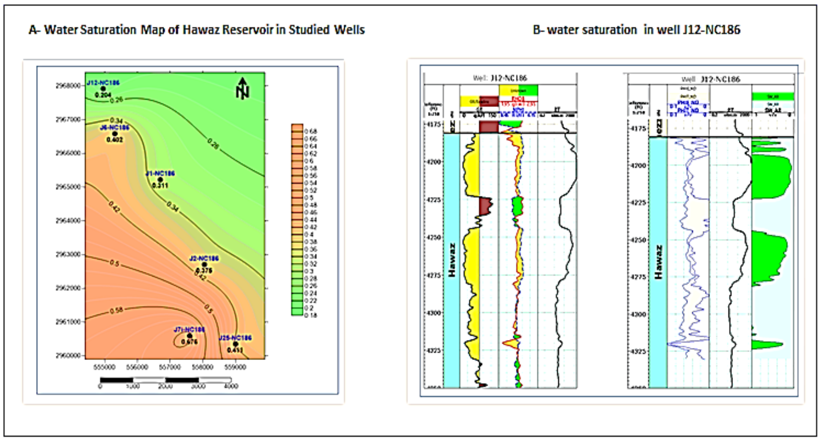

Fig. 6. A Water Saturation Map of Hawaz Reservoir & B Water Saturation in Well J12-NC186

6. 3D Geological Model

The geological model aims to provide the most accurate description of the properties and quantities of reservoirs underground by utilizing information related to various reservoir characteristics. This involves understanding and encompassing key geological features such as porosity, permeability, water saturation, rock types, and structural elements like faults and folds. It is essential to acknowledge the limitations of subsurface data to properly assess the distribution of these features.

The geological model typically consists of four main stages: structure modeling, stratigraphic modeling, Petrophysical modeling, and lithological modeling, each of which requires complex applications and techniques. To accurately delineate hydrocarbon-bearing zones, precision in input data and high-resolution geological models are crucial. In the context of the J-Oil

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Field, constructing a 3D Petrophysical model for the reservoir is vital. Utilizing software like Petrel 2017 aids in creating geological models for specific reservoirs, such as the Hawaz Reservoir. This process involves various steps, starting with gathering essential data such as well heads, well tops, and well logs, which provide crucial information on reservoir zones, formations, and properties like porosity and water saturation.

6.1.1. Import Data: Various types of available data are introduced as input data. This data consists of well logs, which are prepared in a folder, or each data folder is organized and imported files in the Petrel software for constructing geological modelling in J Oil Field-NC186. Different types of data are briefly explained as follows:

1. Well Heads: Represent one of the necessary data for geo-modelling and well head that is 12(TMD) along the path for all wells, the name of wells, and their symbol.

2. Well Tops: Well tops are important points along the well path that represent distinct geological formations. They are crucial for creating a structural model and generating contour maps of all reservoir units.

3. Structure Contour Map: A contour map can be created using data from the landscape and connected drill holes. Maps showing the structure of geological units in tertiary reserves are developed based on information from the tops of wells and the upper boundary of the Mamuniyat formation, which was identified using 2D-seismic data.

6.2. Well Correlation: In simple terms, the focus is on the strong connection between well log data. This process plays a crucial role in creating a detailed 3D geological model using Petrel software. Well correlation helps categorize and organize well log data for easy 2D visualization. It is mainly used to compare new well data with existing correlated wells, specifically to observe variations in thickness and reservoir properties of different geological units within the Hawaz reservoir.

6.3. Pillar Gridding: Pillar gridding is a method used to create a skeleton framework that serves as the surface for determining the (x, y, and z) coordinates to build a 3D structure. This grid-like skeleton is divided into top, mid, and base sections, with connections to specific points established in the initial stages of constructing the 3D model. The process involves building a 3D grid that displays the pillar gridding skeleton for the Hawaz reservoir, where each grid cell represents a space divided into boxes. These

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grid cells, also known as cell properties, contain information on reservoir properties such as porosity, water saturation, rock types, etc. The 3D grid model for the Hawaz reservoir utilized a grid of (100×100 m) on the x and y axes, with pillar gridding implemented to create the 3D structure.

6.4. Layering: The 3D grid cell is divided into multiple vertical layers, serving as the primary horizon for pillar gridding. Each unit within the grid is assigned reservoir properties such as water saturation (SW) and porosity, which are crucial for calculating fluid flow and estimating initial oil in place (IOIP). To determine the vertical direction in the 3D grid based on the number or thickness of cell layers, the horizon and layering operations are the final steps. Identifying the top and base of geological units in the grid cell, as well as the well top, is necessary for representing the Hawaz reservoir units in the field. The Hawaz reservoir units are segmented into multiple layers based on their reservoir properties, as illustrated in Figure 7, showing the distribution of layers and hydrocarbon content in the units. The geological unit with the highest quality Petrophysical properties is divided into more layers than others.

6.5. Scale-up of Well Log: Scale-up of well logs is a process of averaging values of well logs in a grid cell by using statistical approaches. Each cell 3D grid is penetrated by several wells. Each cell has a unity value for each Petrophysical property. Where the results of the final 3D grid are only specified value grid cells through their penetration. The well log can be used in Petrophysical modeling after this operation is scaled up. When reservoir properties are modeled by dividing the area which modeled into a 3D grid. Grid cells are normally much bigger than the density of samples taken from logs. Before any modeling operation, the well log should be scaled up for well log to define 3D grids, which is called blocking of well logs. There are a lot of statistical techniques used to scale up well log, such as harmonic, arithmetic average, and geometric methods. Average Petrophysical, such as porosity and water saturation value, is scaled up by arithmetic average is scaled by geometric method.

6.6.Petrophysical Modelling: Petrophysical modelling is a distribution of reservoir properties in 3D grid cells at the static model. The petrophysical model was constructed by the Sequential Gaussian Simulation Algorithm (SGS) and was performed as a statistical method to agree with the magnitude of data available. These properties consist of:

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6.6.1. Porosity Model: The porosity model was constructed based on effective porosity logs (density, neutron result) that have been corrected to 3D grid cells. One of the famous methods in geo-statistics, which is used as a statistical method to construct a porosity model, is SGS. Upscaling log data to check the accuracy of the final 3D porosity model. Figure 7 shows the 3D map of the upper three units (unit 1, unit 2, and unit 3) representation of the porosity model for active units in the Hawaz reservoir.

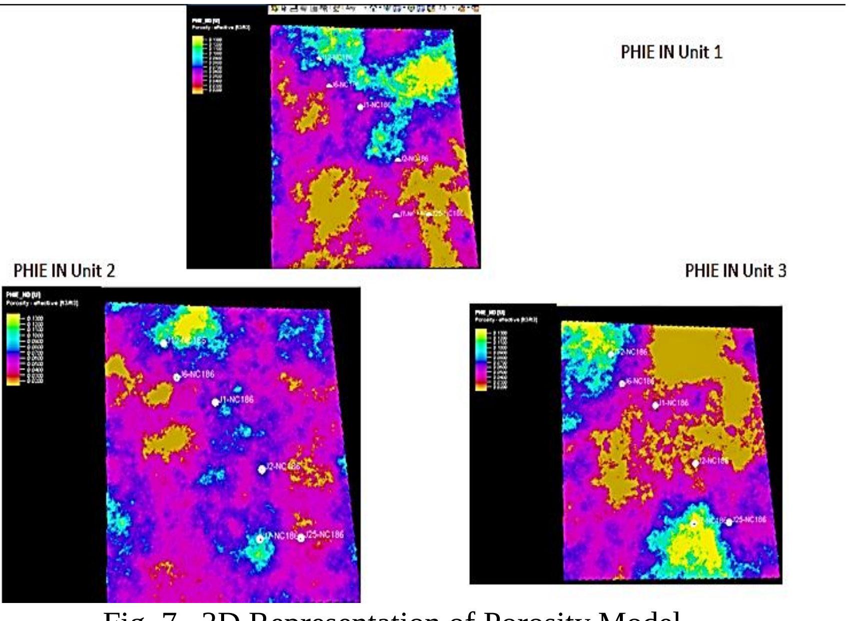

Fig. 7. 3D Representation of Porosity Model

6.6.2. Water Saturation Model: After upscaling well logs for water saturation, a water saturation model has been constructed for the Hawaz reservoir units in the J Oil field. The geostatistical method used is the same as that used in the porosity model (SGS) and the Sw model. The petrophysical properties of the original log data and the upscaled log data were analyzed to verify the accuracy of the water saturation model. Figure 8 (a and b) shows a 3D representation of the water saturation model for the J Oil field, corresponding to the porosity model.

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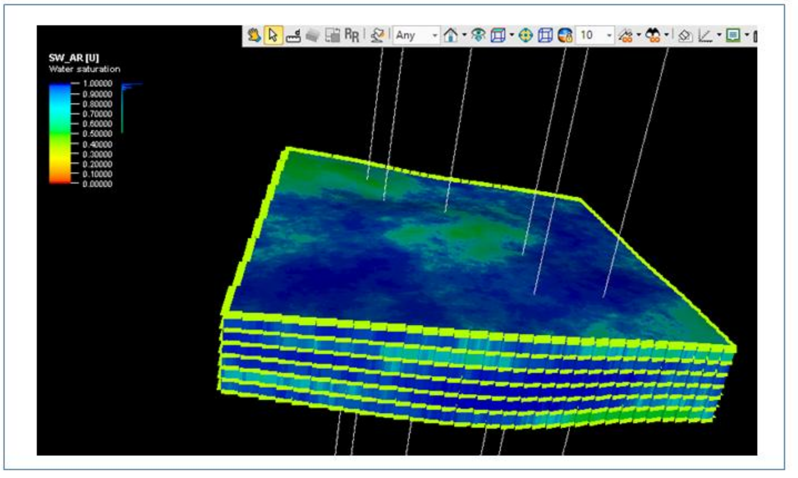

Fig. 8a. A 3D Representation of the SW Model

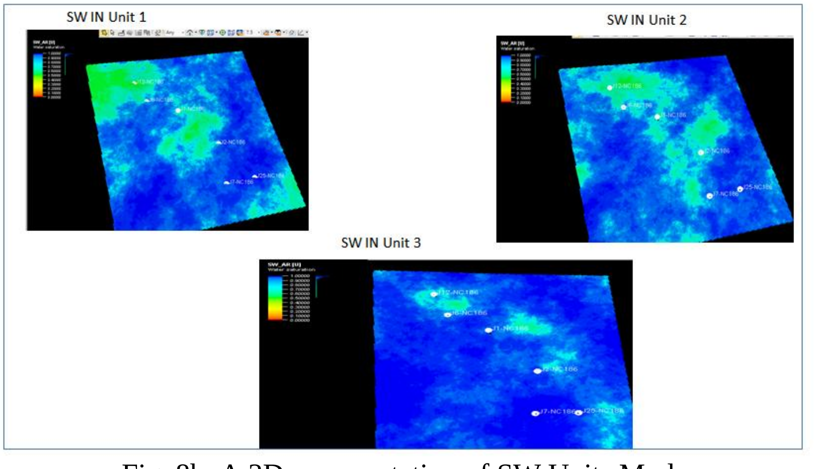

Fig. 8b. A 3D representation of SW Units Mode

6.6.3 Volume of Shale Model: After upscaling well logs for shale volume, a model has been constructed for the Hawaz reservoir units in the J Oil field. The geostatistical method utilized is the same as that used in the porosity model (SGS) and in the V.SH model. To ensure the accuracy of the shale volume model, the petrophysical properties of the original log data and the upscaled log data are compared. Figure (9) illustrates a 3D representation of the shale volume model for the J Oil field concerning the porosity model.

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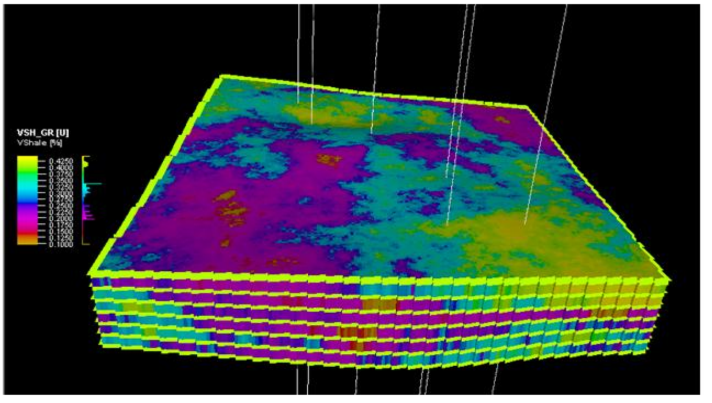

Fig. 9. A 3D Representation Volume of the Shale Model

6.6.4 Net pay Model: The net pay model has been constructed for the Hawaz reservoir units in the J Oil field using a geostatistical method similar to the one used in the net pay model (SGS) and the net pay thickness model. The petrophysical properties of the original log data were compared with the upscaled log data to confirm the accuracy of the net pay model. Figure 10 displays a 3D representation of the shale volume model for the J Oil field related to the SW model.

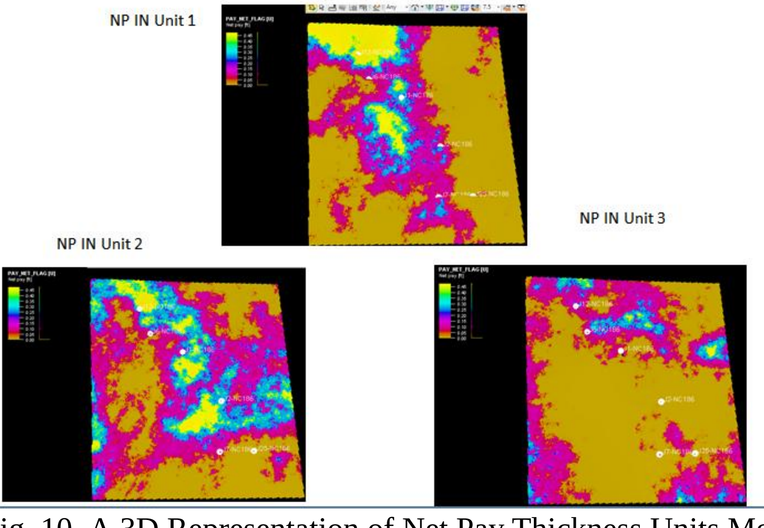

Fig. 10. A 3D Representation of Net Pay Thickness Units Model

7. Results and Discussions

The Hawaz reservoir can be categorized into six units based on different characteristics, such as porosity, water saturation, volume of shale, and net pay thickness. The H1 unit at the top of the

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reservoir in the J Oil Field has varying porosity levels from low in the south to high in the north. It also has high water saturation in most areas except the north and central areas, with low net pay thickness except in the north. The H2 unit is the second unit and has good porosity, hydrocarbon amount, and net pay thickness in most areas. The H3 unit is an active unit with fair porosity and decreasing water saturation towards the crest. The H4 unit is porous with water saturation estimated to be between 30-50%. The H5 unit has the worst properties and is considered a water zone with high water saturation. Lastly, the H6 unit at the lower part of the reservoir also has poor properties and is classified as a water zone with high water saturation.

8. Recommendations

The comprehensive study of the Hawaz reservoir in the J-Field of Concession NC186 provides valuable insights into its petrophysical characteristics and reservoir quality. Based on the integrated analysis of well-logging data (gamma-ray, neutron, density, resistivity, and sonic logs), core studies, and 3D geological modeling using Schlumberger Petrel and Techlog software, the following recommendations based on studies conducted by [1, 8, 9]are made for future exploration and development:

1) **Focus on High-Potential Zones (H2, H3, and H4)** The 3D property model highlights that Units H2, H3, and H4 exhibit favorable petrophysical properties, with an average porosity of 11%, low shale volume (10.3%), and significant hydrocarbon saturation. These units should be prioritized for further development due to their high reservoir quality and economic potential. Similar findings in the Murzuq Basin have been reported by [1], emphasizing the importance of targeting zones with optimal porosity and hydrocarbon saturation.

2) **Avoid Low-Potential Zones (H1, H5, and H6):** Units H1, H5, and H6 show high water saturation (up to 39.6%) and low net pay thickness, making them less attractive for hydrocarbon extraction. These zones should be deprioritized unless additional studies (such as enhanced oil recovery techniques) suggest improved viability.

3) **Spatial Variation in Water Saturation:** The study reveals a trend of increasing water saturation towards the

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southeast (near well J25-NC186) and decreasing values towards the northwest (near well J12-NC186). This spatial distribution should guide well placement, with a preference for drilling in the northwestern sector where hydrocarbon saturation is higher. Similar trends have been observed in other North African reservoirs, where structural and stratigraphic controls influence fluid distribution.

4) **Further Core and Seismic Integration:** While the petrophysical model provides a robust assessment, integrating core analysis with seismic data could enhance the understanding of lateral reservoir heterogeneity. Studies have demonstrated the benefits of combining seismic attributes with petrophysical models for improved reservoir characterization.

5) **Production Testing and Enhanced Recovery Methods:** Before full-field development, production testing in wells J12-NC186 and J6-NC186 (showing lower water saturation) is recommended to validate flow rates and connectivity. Additionally, water management strategies may be required in the southeastern part of the field due to higher water saturation.

Conclusions

- The Hawaz Reservoir in the study area varies in thickness, ranging from 327 feet in the northwest (well J12) to 540 feet in the southeast part (well J7i-NC186).
- This reservoir is the primary target and exhibits excellent characteristics, with an average porosity between 9.2% and 13%.
- The net-pay thickness within the reservoir ranges from 0.5 feet to 32.5 feet.
- Water saturation levels indicate good hydrocarbon saturation, with values ranging from 20.4% to 67.6%, making the J Oil Field reservoir favorable.
- A 3D geology model constructed with Petrel software for the Hawaz Reservoir in the J Oil Field reveals a symmetrical small anticline fold with four fault trap structures.
- The reservoir consists of six layers (Units H1 to H6), with Units H2 and H5 identified as active zones possessing the best petrophysical properties and substantial hydrocarbon quantities.

Reference

http://www.doi.org/10.62341/memr1607

[1] M. Muhend, T. Mohamed, A. Issa, A. Augustine, and O. Najib Meftah Almukhtar, "Uncertainty Analysis of Hydrocarbon Estimation Using 3D Geological Model: A Case Study of the F3 Sandstone Reservoir, Ghadames Basin, Libya," *Petroleum Science and Engineering*, vol. 9, no. 1, pp. 1-12, 2025, doi: 10.11648/j.pse.20250901.11.

[2] R. O. Muhend Milad, Najib Meftah Almukhtar Omar, "Predicting Waterflooding Performance IN A-NC186 Oil FIELD," *African Journal of Advanced Pure and Applied Sciences (AJAPAS)*, vol. 3, no. 3, pp. 251-258, 2024.

[3] A. K. Mohamed, "Reservoir quality of Hawaz formation, J oil field, concession NC186, NW Murzuq basin, SW Libya," *Arabian Journal of Geosciences*, vol. 9, pp. 1-17, 2016.

[4] R. M. M. Saheed, T. Š. Knudsen, M. A. M. Faraj, H. P. Nytoft, and B. Jovančićević, "Geochemical Characteristics Of Crude Oils From The Sharara-C Oil Field, Murzuq Basin, Southwestern Libya," *Journal of Petroleum Geology*, vol. 46, no. 1, pp. 103-123, 2023.

[5] A. F. Y. Ahmed, "Classification of hydrocarbons trapping systems of the Ghadames and Murzuq Basins in relation to Gargaf high, West Libya," 2019.

[6] M. Gil-Ortiz, "Sedimentology and sedimentary architecture of the Middle Ordovician Hawaz Formation in the subsurface of the Murzuq Basin (Libya)," 2022.

[7] E. Hallet, "Early years practice: For educators and teachers," 2016.

[8] M. A. Albaghday, M. Targhi, and M. Milad, "Reservoir Quality, Structural and Sedimentological Study of the Upper Cretaceous/Lower Paleocene Kalash Formation, Rachmat Oil Field, Concession 13, Eastern Sirte Basin, Libya."

[9] T. C. Segaran, A. Sidek, A. Rahim, and M. Milad, "Automated Pre-screening Method for Production Enhancement Using Electrical Submersible Pump in Malaysia's Offshore Brown Field," in *Proceedings of the 13th International Conference on Geotechnical Engineering in Tropical Regions (GEOTROPIKA 2024)*, Singapore, S. N. B. Jusoh, R. P. Jaya, S. Horpibulsuk, and B. A. B. Othman, Eds., 2025// 2025: Springer Nature Singapore, pp. 118-127.