

## **Sedimentology and Quantitative Well Logs Petrophysical Parameters, Lower Qishn Clastic Reservoir, Masila Oilfield, Yemen**

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Received: 7/1/2009

Accepted: 13/4/2009

*Abstract.* Oil in the Masila area was first discovered in late 1990 with commerciality being declared in late 1991. Oil production at Masila began in July 1993. About 90% of the oil reserves were found in the Lower Qishn Clastic reservoir of the Lower Cretaceous sequence.

The Lower Cretaceous Qishn Clastic Member in Masila Block 14, Republic of Yemen, a primary drilling objective, with estimated reserves of 1.1 billion barrels recoverable oil. Masila has produced approximately 656 million barrels of oil to date. Sedimentation took place in an elongate paleo-gulf of the Say'un-al Masila Basin, open to marine carbonates to the east. The Qishn Clastic Member unconformably overlies mixed carbonates and clastics of the Sa'af Member. Lower Qishn onlap resulted in deposition of brackish and tidal, estuarine to open bay or gulf deposits. The middle portion of the lower Qishn Clastic Member shows evidence of arid non-marine sedimentation, including debris flow deposits, red beds and shale-clastic conglomerates, in turn, overlain by interfingering coastal and non-marine deposits.

The porosities determinations of the investigated area from the studied wells indicate that the porosity of the Lower Qishn Clastics are relatively high-and the permeability of this reservoir range from 103 to 374 md. The water saturation shows low values. On the other hand, the hydrocarbon saturation is in a reverse relation i.e. the hydrocarbon decreases, where the water saturation increases.

Different Crossplots such as RHOB/NPHI, RHOB/NPHI Matrix, and GR-RHOB GR-NPHI cross plots were determined for

lithological identification of the Lower Qishn Clastic in the studied wells, which indicate that it is composed mainly of sandstone with shale and carbonates intercalations.

Such formation evaluation of the obtained petrophysical parameters have frequently proven that the formation has high hydrocarbon saturation in this area and containing many pay zones.

## 1. Introduction

The Masila area is located in the Hadhramaut region in east central Yemen (Fig.1). Masila area is considered one of the most important oil provinces in Yemen, which include a great number of oil fields and wells. Total known oil in place exceeds 1.6 billion STB, with proved ultimate recoverable reserves approaching 900 million STB. In addition, the reserve estimates (Proved, Probable, and Possible) are in excess of one billion barrels of recoverable oil (Canadian Oxy CO., 2004). About 90% of the reserves are found in the Lower Cretaceous Upper Qishn Clastics Member of the Qishn Formation. Oil is also found in at least seven other distinct reservoir units consisting of Lower Cretaceous and Middle to Upper Jurassic clastics and carbonates as well as fractured Cambrian granitic basement rocks (Canadian Oxy CO., 2004).

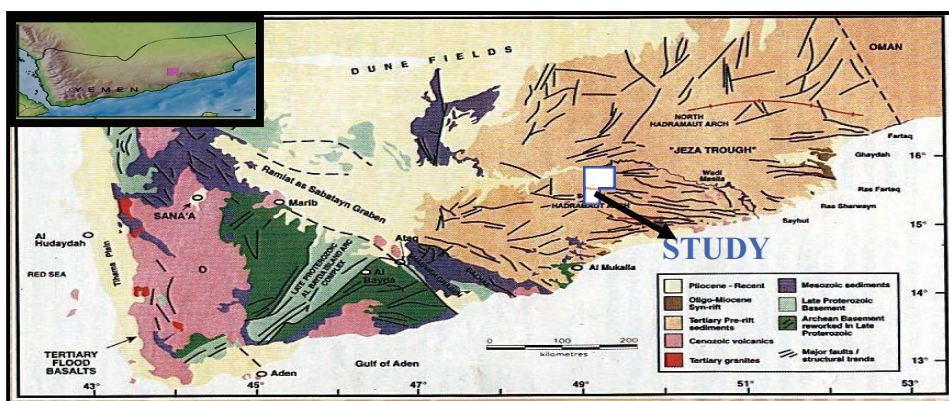


Fig. 1. A simplified geological map of Yemen, showing the location of Study area.

Well logging is the most tasks for any well after drilling to determine shale volume, porosity, permeability, and water saturation. This is done for 8 wells of the study area (Fig. 2). Shale volume was calculated using single and double curve indicator. Total porosity was determined primarily from the acoustic log which was calibrated to

depth-shifted. The neutron log was used when there were no acoustic data of poor quality. One of the features of modern log interpretation is the systematic usage of computer that allows a detailed level-by-level analysis of the formation to define the producing zones. Moreover, the presentations of the results through cross plots, and litho-saturation models help to give a quick conclusion about the petrophysical characteristics of the studied reservoir.

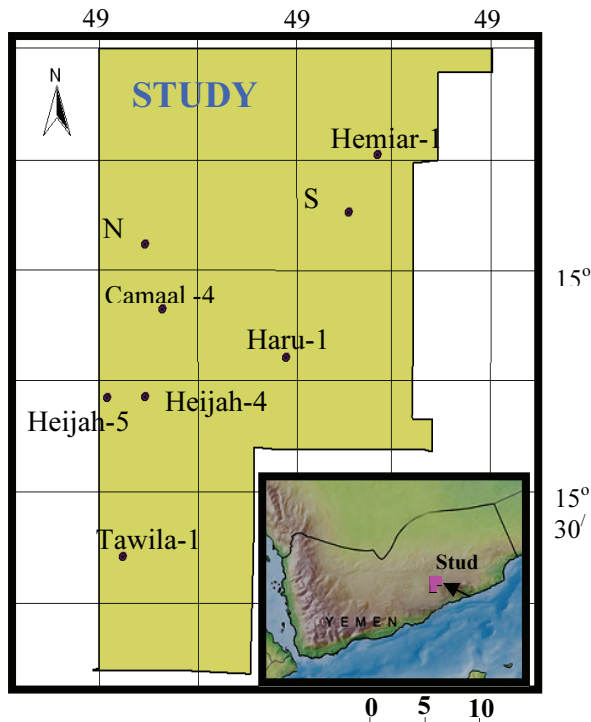


Fig. 2. Location map of the study area.

During a project to analyze the well log on 8 wells in the Lower Qishn Clastic Reservoirs offshore in Masila area, we used a new technique to determine accurate values of porosity, water saturation, and permeability from well logs. It was therefore necessary to obtain a quantitative reservoir description for all wells in the project area, even if the log suite did not lend itself to direct calculation with traditional log analysis methods. The basic logging data are in the form of spontaneous potential (SP), Caliper (CL), Deep (LLS, LLD), and Shallow (MSFL)

resistivity logs, porosity tools (Density, Neutron and sonic), litho-density (PEF) and Gamma-Ray (GR).

These highly detailed reservoir properties from log analysis were augmented by similarly detailed seismic and stratigraphic correlations, and integrated together in a reservoir simulator to provide an accurate historical and predictive model for production optimization. We would not have been able to do this to a useable level if only the wells with full porosity log suites were used.

The sequence outcrop of the Masila basin is dominantly Cenozoic rocks. The Jurassic limestone has been penetrated only in the offshore wells (Haitham and Nani, 1990). Less abundant Cretaceous sandstone, which is the oldest outcropping unit, is found in the area. The Oligocene-Miocene syn-rift rocks of the Shihir Group outcrop mostly in the costal area (Bosence *et al.*, 1996., Watchorn *et al.*, 1998). Quaternary volcanics occur in the eastern area of the basin. The general stratigraphy of the study area from oldest to youngest is illustrated in (Fig. 3). The following summary represents the stratigraphy and basin evolution of the Masila basin area based on published studies by Redfern and Jones (1995); Beydoun *et al.*, (1998); Redfern and Jones (1995); Cheng *et al.*, (1999); Canadian Oxy Co. (1999); and PEPA (2004).

## **2. General Geology**

### **2.1 Geologic Setting**

The Qishn Formation was deposited as predominantly was post-rift sediments in the east-west oriented Say'un-al Masila rift basin, that initiated during Late Jurassic to Early Cretaceous as part of the second Mesozoic rift phase. Deposition was related to a regional east to west transgression overlying a regional lower Cretaceous unconformity at the top of the Sa'af Member. Regionally, the Qishn Formation was deposited on an inner neritic to shallow-marine platform setting within the graben. During deposition of the Qishn Formation, the Say'un – al Masila Basin was open to fully-marine waters, based on the presence of correlative carbonate strata toward the southeast at Socotra Island in the Gulf of Aden. Carbonates intertongue with fluvial deltaic to littoral deposits, becoming fully siliciclastic westwards.



### 2.2.2 Kohlan Formation

During the Middle-Upper Jurassic time, sandstone was deposited widely across the Yemen, where thick sedimentation in pre-Jurassic topography lows took place. This thick sandstone deposit is known as the Kohlan Formation (Fig. 2). In general this formation is composed of siltstone and sandstone to conglomerate with some streaks of limestone and green clay.

### 2.2.3 Shuqra Formation

The Shuqra Formation of Upper Jurassic age (Oxfordian to Kimmeridgian), includes predominantly a platform carbonate with rectal build-ups. The Shuqra Formation is generally composed of limestones of different textures *e.g.* lime mudstone, wackestone and grainstone.

### 2.2.4 Madbi Formation

The Madbi Formation is generally, composed of porous lime grainstone to argillaceous lime mudstone. The lithofacies of this unit reflect open marine environments. This unit is classified into two members. The lower member is commonly argillaceous lime and basal sand, and forms a good reservoir in some oil fields of the Masila basin (Canadian Oxy CO, 2003). The upper member of the Madbi is composed of laminated organic rich shale, mudstone and calcareous sandstone. This member is a prolific source rocks in the Masila province.

### 2.2.5 Naifa Formation

In general, the Naifa Formation is made up of silty and dolomitic limestone and lime mudstone with wackestone. The upper part of the formation is composed of very porous clastic carbonate overlain by the Saar dolomite facies. Naifa Formation was deposited as chalk of shallow water to deep water marine conditions.

### 2.2.6 Saar Formation

This formation overlies conformably the Naifa Formation. In general, the Saar Formation is composed mainly of limestone, with some mudstone and sandstone. Oil companies classified the formation into lower Saar carbonate and upper Saar clastics.

### 2.2.7 Qishn Formation

#### 2.2.7.1 Nomenclature and Thickness

The term 'Clastic Member' is proposed for syn-rift, fluvial and shallow marine sandstones and mudstones and subordinate carbonates

(usually limestones) of Barremian age (Beydoun *et al.*, 1998). In east-central Yemen, the Qishn Formation is the lowermost clastic unit of the Tawila Group in the west and the lowermost carbonate unit of the Mahra Group in the east. The proposed type well is Sunah-I well from 1675m to 1935.5m below KB. The lithology of the unit consists of subequal amounts of sandstones and mudstones, the latter being more common in the lower part of the unit in thicker well sections (Holden, A. & Kerr, H. 1997).

#### 2.2.7.2 Unit Boundaries

The upper boundary of the Qishn Formation is marked by the lower mudstone bedding of the 'Shale Member'. The boundary is marked by a downhole decrease in gamma ray values and increase in sonic velocity. The lower boundary may be with sandstones and mudstones of the proposed 'Furt Formation', older carbonates or with basement. This boundary with the 'Furt Formation' is marked by an overall downhole decrease in sonic velocity. The sands of the 'Furt Formation' exhibit a higher gamma ray value. The boundary is also marked by a downhole change from carbonate stringers, which are predominantly limestone in the Qishn Formation 'Clastic Member', to dolomite in the 'Furt Formation' (Holden, A. & Kerr, H. 1997).

#### 2.2.7.3 Subdivision, Distribution and Depositional Environments

The Qishn Formation, in general is divided into two members, Lower Qishn Clastic and Upper Qishn Carbonate. In Masila Block 14, the ~198 m (650 ft) thick Qishn Clastics Member is further subdivided. A 128 m (419 ft) thick form the lower Qishn Clastics, and a 70 m (231 ft) thick, form the upper Qishn Clastics (Fig. 3).

The lower Qishn Clastics Member was deposited during the Middle to Late Barremian (G. Norris, 2001, personal communication) over a duration of 7 to 10 My. The lower two thirds of the upper Qishn Clastics Member were deposited in the Late Barremian to Early Aptian. The upper third was deposited during the Early to Middle Aptian. This could be interpreted as follows:

After the marine transgression resulted in the deposition of the Saar Formation, the sea level falls resulted in erosion of the Valanginian deposits. In the Hauterivian to Barremian time (Late early Cretaceous), the braided plain to shallow marine sediments deposited in the Say'un-Al Masila basin (mainly Lower Qishn Clastic Member). This basal unit is

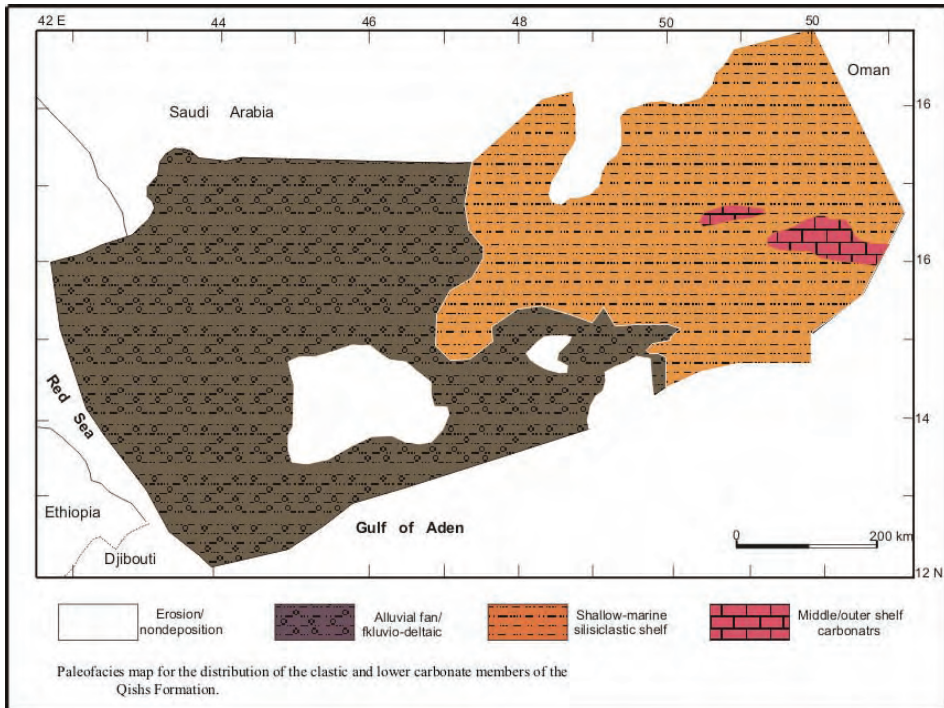
followed by the deposition of shallow marine shale and carbonate sediments during the Barremian–Aptian time (upper shale and carbonate members of Qishn Formation).

The distribution and thickness variation of the 'Clastic Member' has been recognized in 12 of the study wells. The thickness varies from 761 m in the A1 Furt-I well to 20m in the Hami-IX well. The 'Clastic Member' can be distinguished east of the Kharwah-I well and west of approximately 50°E. To the west of the Kharwah-1 well, the section cannot be differentiated due to the well's proximal location, and the subsequent dominance of clastic material throughout the Qishn Formation (Holden, A. & Kerr, H. 1997).

The Regional correlation of the 'Clastic Member' is a lateral equivalent of the 'Lower Carbonate Member', the latter being deposited in deeper marine conditions away from areas of sediment source (Fig. 4). The Environment of deposition of this unit is an alluvial fan/braid-plain to meander plain fluvio-deltaic sandstones, common shallow marine sandstones and mudstones. These pass laterally into the shallow to locally deeper marine lime mudstones and carbonates of the 'Lower Carbonate Member' of the Qishn Formation. (Holden, A. & Kerr, H. 1997).

Fully marine and brackish strata throughout the lower Qishn Clastics Member bear indicators of tides. Double mud and carbonaceous drapes, tidal bundles, evidence of salinity variations, mud flats and tidal inlets indicate significant prevailing macro-tides. Evidence of storms is extremely rare in fully marine strata. Marine conditions, dominated by carbonates prevailed to the east and non-marine clastics to the west. The Say'un–al Masila Basin had a funnel shape, tapering westwards from several hundred kilometers to approximately 60 km wide. To the east, it was connected to the open Tethys Ocean (paleo-Indian ocean) on the early-rifted Gondwanaland continent. The tapering and constricting configuration of the Say'un–al Masila rift basin facing the paleo-Indian ocean would have been the ideal setting for the development and amplification of tides (Beydoun *et al.*, 1998).





**Fig. 4. Facies map for the distribution of the Clastic and Lower carbonate members of the Qishn Formation.**

#### 2.2.7.4 Oil Potentialities

The Lower Qishn Clastic Member is representing the main reservoir rocks in the Masila area. From this point of view oil companies classified the Qishn formation into the Lower Qishn Clastic Member, and the Upper Qishn Carbonate Member. The Upper Qishn Carbonate Member consists of laminated to burrowed lime mudstone and wackestone interbedded with terrigenous mudstone and black fissile shale. These sediments were deposited in deep water under alternating open and closed marine conditions (Beydoun *et al.*, 1998). The basal red shale beds within the carbonate member are considered to be the main seismic marker in the Masila area.

#### 2.2.8 Lower Cretaceous – Tertiary Formations

The Late Lower Cretaceous–Tertiary Formations consist of clastic (Harshiyat Formation) and carbonate (Fartaq Formation) interbedded each other suggesting lacustrine to marginal marine depositional settings. A similar pattern of sedimentation occurred during the Late Cretaceous

time (Coniacian through Campanian), when fluvial systems domain (Mukalla Formation). These fluvial deposits prograded southeast in the Al- Masila basin. Transgression culminated in the Latest Cretaceous (Mastrichtian), when carbonate deposits were developed (Sharwan Formation). In the Late Paleocene, transgressive shale deposits of the Shammer Member were deposited at the base of the carbonates of the Umm Er- Radhuma Formation. The carbonate deposits continued to accumulate during the Early Eocene, followed by anhydrites of the Rus Formation during the Middle Miocene. A rise in the sea level during the Middle to Late Eocene resulted in widespread carbonate deposition of the Ghaydah Formation, which graded into shallow marine fine- grained Clastics of the Habashiya Formation.

### **2.3 Sequence Boundaries**

Two major sequence boundaries are present within the Qishn Clastics Member. The lowermost sequence boundary is present at the base of the lower Qishn Clastics Member, truncating the Sa'af Member. Evidence for this sequence boundary includes indications of lithification of sandstone clasts of the underlying truncated Sa'af Member incorporated into the base of the lower Qishn Clastics.

The second major sequence boundary occurs at the base of the base of the upper third of the Upper Qishn clastics. Strata of the lower Qishn Clastics, below the unconformity, consist of finely interdigitating (on a decimeter to meter scale) tidal flat, marginal marine, non-marine and paleosol sediments. The sediments of the upper third were deposited in a braided river system close to the shoreline. The facies relationships on either side of the unconformity represent an abrupt basin-ward shift in facies; one of the criteria to define a sequence boundary.

## **3. Available Data**

Eight wells, that cover the whole study area, were selected based on the different log types (Fig. 2 and 5). The available well logs are listed in Table 1. The logs include: Gamma ray (GR), Caliper (CL), Spontaneous Potential (SP), Apparent formation resistivity ( $R_{wa}$ ), shallow (MSFL), deep (LLS and LLD) resistivities, Formation Density compensated (FDC, Formation Density compensated log), Borehole Compensated Sonic (BHC, Borehole compensated), Compensated Neutron porosity (CNL, Compensated Neutron log) and Litho-Density

(LDT, lithology Density Tool). These logs are checked and matched for depth before processing and interpretation.

**Table 1. The available open hole well logs in the study area.**

No.	Well Name	Available Data
1	Camaal-4	GR, SP, LLS, LLD, MSFL, DTLN, RWA, CAL, PEF, RHOB, DRHO, NPHI, DPHI, SGR
2	Haru-1	GR, LLS, LLD, MSFL, RWA, CAL, SP, PEF, RHOB, DRHO, NPHI, DPHI, SGR
3	Heijah-3	GR, LLS, LLD, MSFL, DTLN, RWA, SP, CAL, PEF, DRHO, RHOB, NPHI, DPHI, SGR
4	Heijah-5	RWA, CAL, GR, SP, LLS, LLD, MSFL, SGR, PEF, DRHO, RHOB, NHPI, DPHI
5	Hemiar-1	CAL,GR, SP, LLS, LLD, MSFL, RWA, SGR, PEF, DRHO, PEF, RHOB, NPHI, DPHI
6	South Hemiar-1	RWA,GR, SP, LLS, LLD, MSFL, CAL, DTLN, SGR, PEF, DRHO, NPHI, DPHI, RHOB
7	North Camaal-1	GR, RWA, SP, LLD, LLS, MSFL, DTLN, CAL, SGR, PEF, RHOB, DRHO, NPHI, DPHI
8	Tawila-1	GR, SP, RWA, LLS, LLD, MSFL, CAL, DTLN, SGR, DRHO, PEF, RHOB, NPHI

### 3.1 Log Analysis Methodology

Our objective was to define a method that would utilize all available log data while providing the most consistent results between old and new well log suites. A detailed foot-by-foot analysis was required to allow summations of reservoir properties over each of many stratigraphic horizons. The well log evaluation has been achieved by using Interactive Petrophysics<sup>TM</sup> Program (IP). Interactive Petrophysics is a PC-based software application for reservoir property analysis and summation.

Shale volume ( $V_{sh}$ ) was calculated from single curve indicator such as the gamma ray (GR), spontaneous potential (SP), and deep resistivity (RESD) responses and Double curve indicator. The minimum of these values at each level was selected as the final value for shale volume.

A unique clean sand and pure shale value for GR, SP, and RESD were chosen for each zone in each well. A linear relationship was applied to the  $V_{sh}$  from GR. The resistivity equation for  $V_{sh}$  is similar to the GR equation, but using the logarithm of resistivity in each variable.

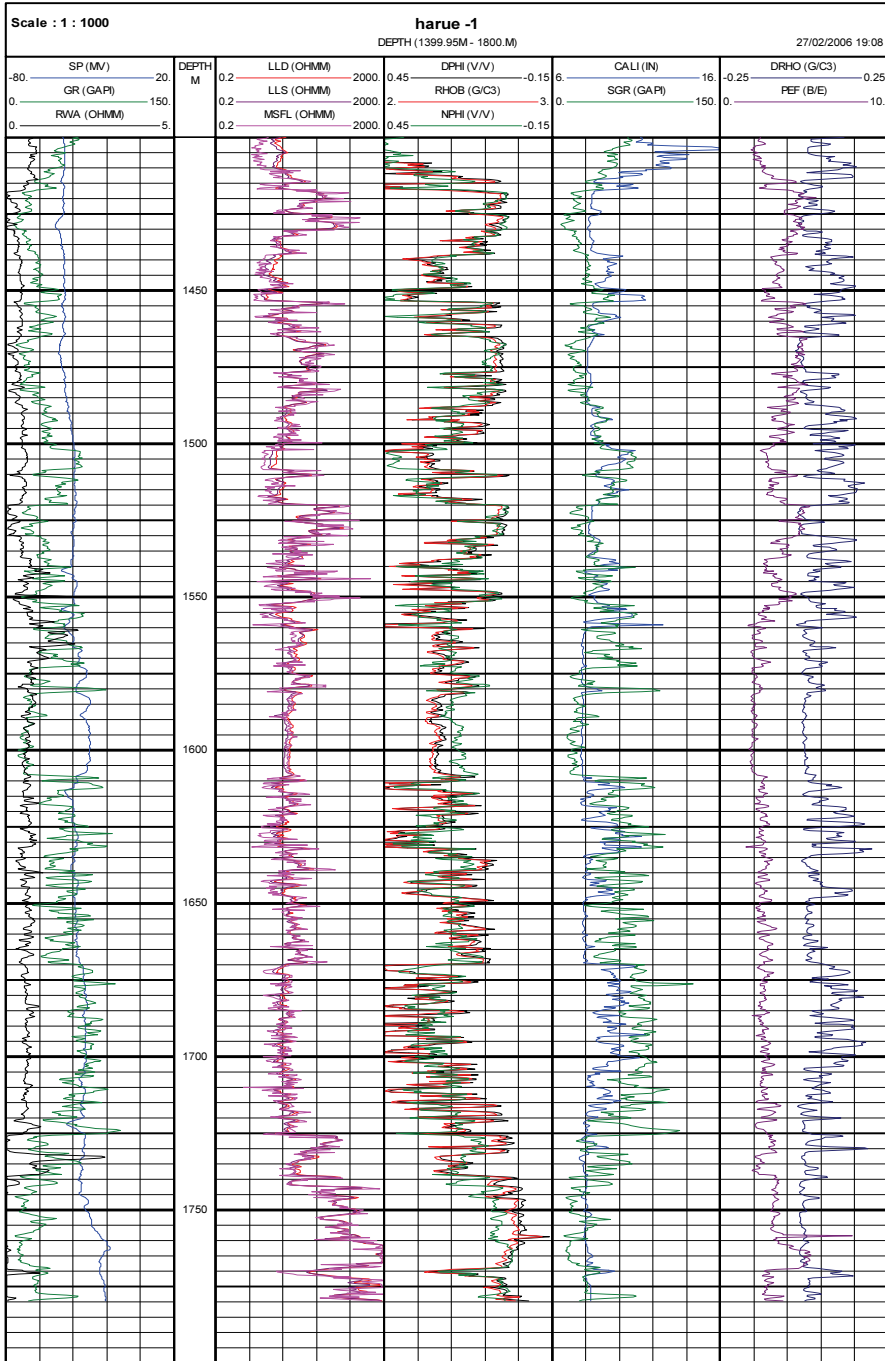


Fig. 5. Showing available well log data plot output from Interactive Petrophysics software.

Where a full suite of porosity logs was available, effective porosity (PHI<sub>e</sub>) was based on a shale corrected complex lithology model using PEF, density, and neutron data. The method is quite reliable in a wide variety of rock types. No matrix parameters are needed by this model unless light hydrocarbons are present. Shale corrected density and neutron data are used as input to the model.

Results were dependant on shale volume and the density, and neutron shale properties selected for the calculation. In wells with an incomplete suite of porosity logs, we used a model based on the shale corrected density log, shale corrected neutron log, or the shale corrected sonic log. Again, a comparison with core or nearby offset wells with a full log suite is necessary to confirm shale and matrix parameters.

The equation used was  $PHI_e = PHI_t * (1 - V_{sh})$ . This step was the most important contribution to the project as it integrates all available data in all wells in a consistent manner. The value for total porosity PHI<sub>t</sub> was derived from combining the readings of two porosity logs of the density and neutron logs. From this stage onward, both old and new wells were treated identically, with water saturation, permeability, and mappable reservoir properties being derived in a uniform and consistent manner.

Water saturation (Sw) was computed with a shale correction using the Simandoux equation and with the Waxman-Smits equation Rojstaczer, *et al.* (2008). Both equations reduce to the Archie equation when shale volume is zero. Simandoux and Waxman-Smits methods gave very similar results in this project area. The resistivity curves used were the long normal from ES logs, the deep induction, or the deep laterolog.

Absolute permeability at each well of the study area is estimated by using the following relation:

$$\log K = \frac{\ln(\phi_e(1 - S_{w_i}))}{0.59} + 5.0 \quad \text{Rojstaczer, et al. (2008)}$$

Where:

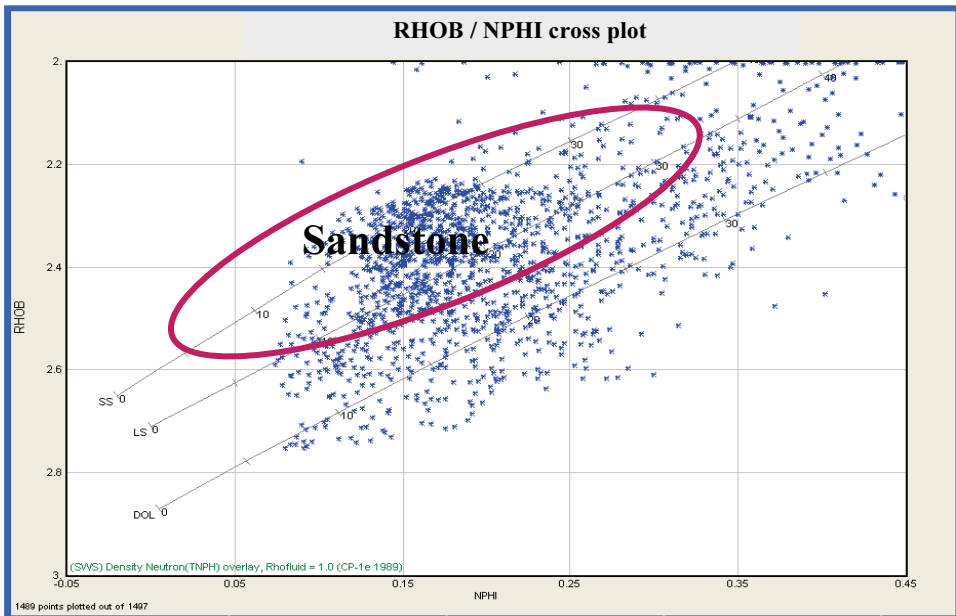
$K$  : is the absolute permeability in millidarcies.

$\phi_e$  : is the effective porosity, and

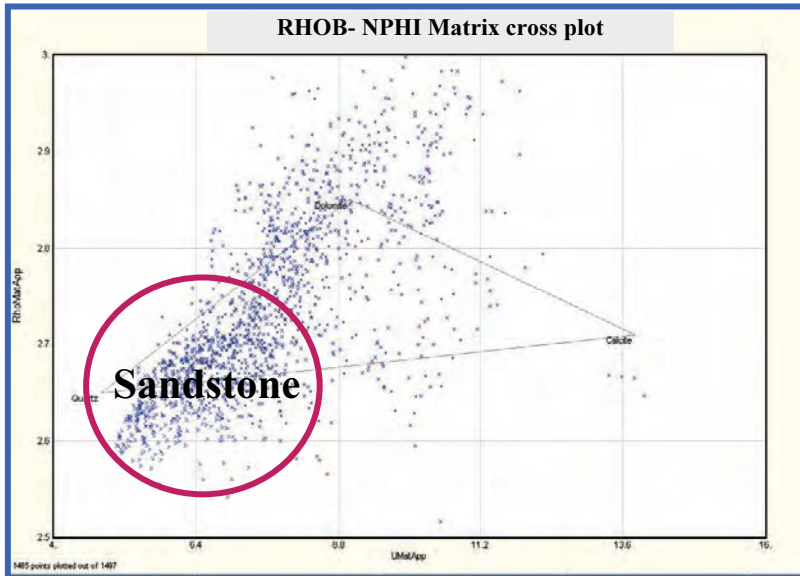
$S_{wi}$  : is the irreducible water saturation.

### *Cross-Plots Lithological Identification*

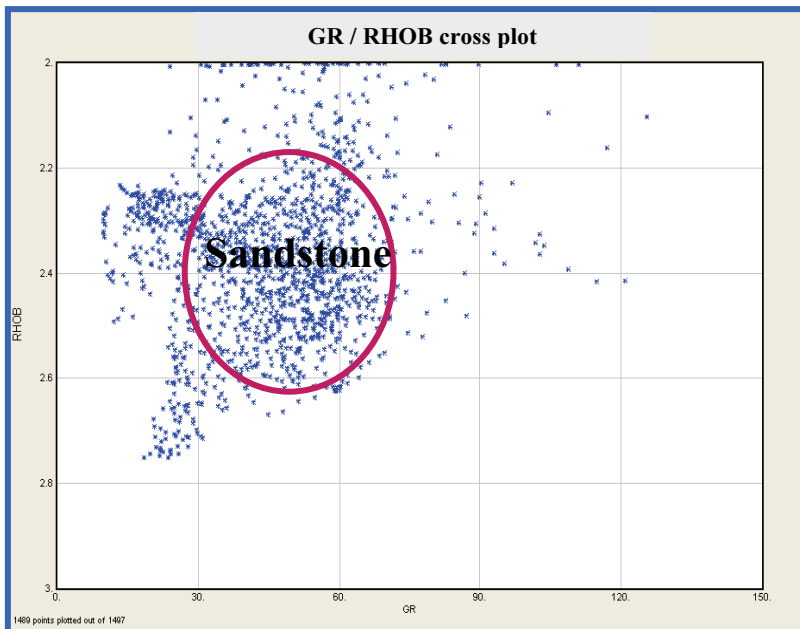
The type and amount of each lithologic component for Lower Qishn Clastic was determined through different cross plots. These cross plots give a quick view about the rock and mineral contents in a qualitative way. Some of these cross plots give the amount of lithologic contents in a quantitative way. Such cross plots are NPHI-RHOB cross-plot, NPHI-RHOB Matrix cross plots and GR-RHOB GR- NPHI cross plots. The lithology for all wells is almost the same. The following lithological identification of North Camaal-1 well is an example of such Cross-plots (Fig. 6 A-D).



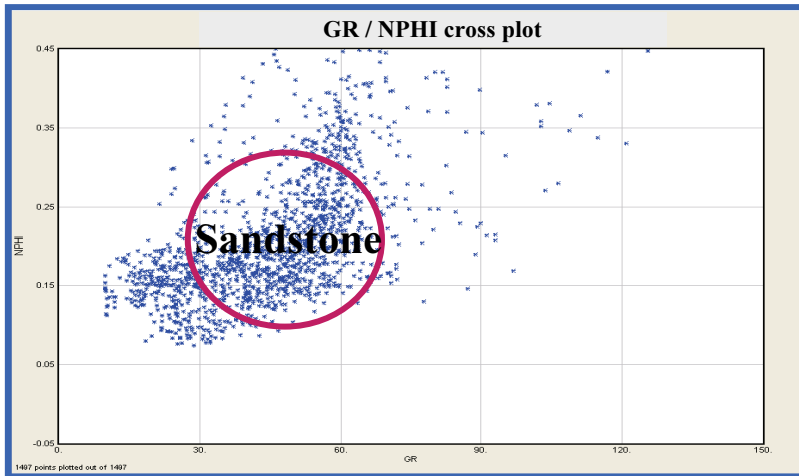
**Fig. 6.A. Lithological identification Crossplots of Lower Qishn Clastic - North Camaal-1 well.**



**Fig. 6.B. Lithological identification Crossplots of Lower Qishn Clastic - North Camaal-1 well.**



**Fig. 6.C. Lithological identification Crossplots of Lower Qishn Clastic -North Camaal-1 well.**



**Fig. 6.D. Lithological identification Crossplots of Lower Qishn Clastic -North Camaal-1 well.**

### *3.1.1 RHOB/NPHI Cross Plot Identification*

The cross plot of RHOB/NPHI (Fig. 6A) shows that the main lithology is carbonates (Limestone and dolomite) with shale. The sandstone content is generally low as shown from the lesser plotted points along the sandstone line in this cross plot.

### *3.1.2 RHOB / NPHI Matrix Cross Plot Identification*

The cross plot of RHOB / NPHI Matrix (Fig. 6B) reflects the same picture of the above plot. The scattered plotted points show that the main lithology is carbonates (Limestone and dolomite) with shale. The sandstone content is low as shown from the lesser-plotted points in the Quartz matrix zone in this cross plot.

### *3.1.3 GR/NPHI Cross Plot Identification*

This plot (Fig. 6C) reflects the scattering of plotted points that means the variation of lithology of this rock unit. It shows the points have a low GR and low NPHI indicating presence of limestone and dolomite, points have a medium GR and medium NPHI indicate sandstone and points have a high GR and high NPHI reflect the



abundance of shale. By comparing, it is clear that the main lithology is limestone and dolomite with shale and a few amount of sandstone.

#### *3.1.4 GR/RHOB Cross Plot Identification*

This plot (Fig. 6D) illustrates the same as in the above plot except that the density of limestone and dolomite are larger than sandstone. Thus the points of limestone and dolomite are plotted in the left direction of cross plot.

Finally we can conclude that the lithology of this reservoir from those Cross-plots show that the main lithology is sandstone with shale and carbonate. The sandstone content is generally high as shown from the highest -plotted points along the sandstone line in those cross plots (Fig. 6A-D).

### **3.2 Hydrocarbon Potential**

Evaluation of the oil potential of the reservoir rocks in the study area is based on the results of well logging analysis carried out for the wells in the study area. The analysis includes vertical petrophysical distribution cross plots of the analyzed data in each well and the horizontal Iso-parametric configuration maps. The vertical distribution in a form of litho-saturation cross plots (volumetric analysis) shows irregular changes in lithology and water and hydrocarbon contents (Fig. 7). The lateral Iso-parametric maps show the petrophysical parameter configuration in the form of water and hydrocarbon saturations, total porosity and effective porosity distribution (Fig. 8-10).

The total porosity distribution map of the Lower Qishn Clastic (Fig. 8) shows decreasing from central-western part toward northwestern, southwestern, and east parts of the study area, while the effective porosity distribution map (Fig. 9) shows the decreasing from central-southern part toward east and northwest, and increasing at northeastern part of the study area. Meanwhile the water saturation map of the Lower Qishn Clastic shows decreasing from central-western toward east, northeastern and southwestern parts of the study area (Fig. 10).

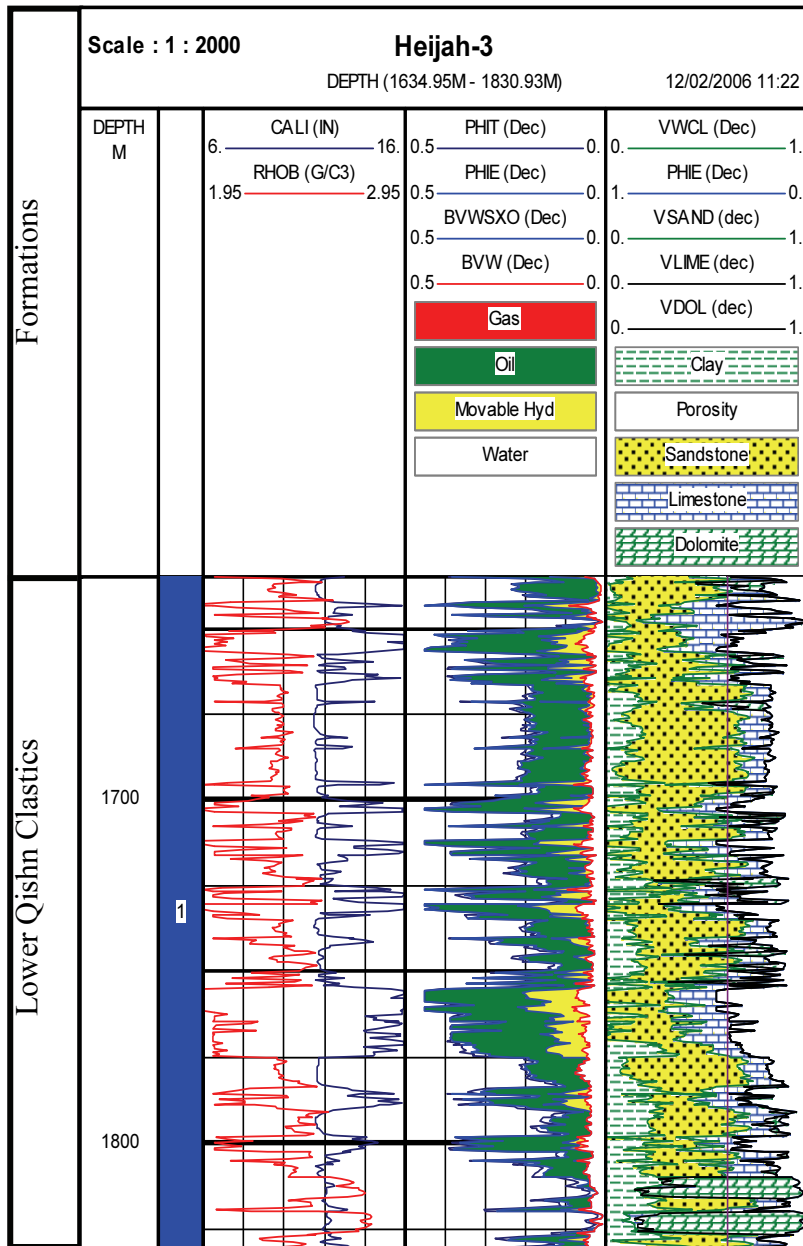


Fig. 7. Litho- saturation plotout put from Interactive Petrophysics software, showing log porosity derived from Vsh and Sw log of the Lower Qishn reservoir -Heijah-3 well.

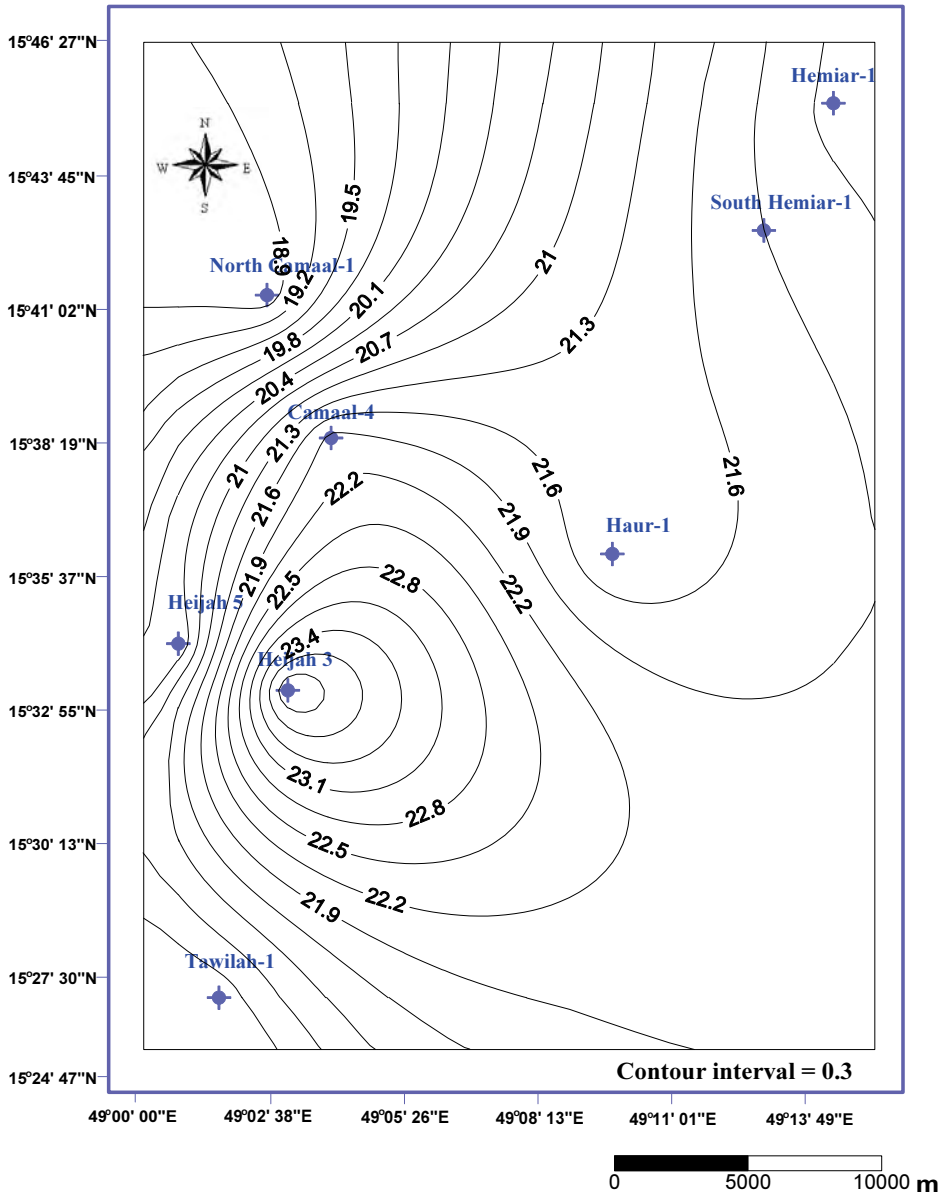


Fig. 8. Total porosity distribution map of the Lower. Qishn Clastic in study area.

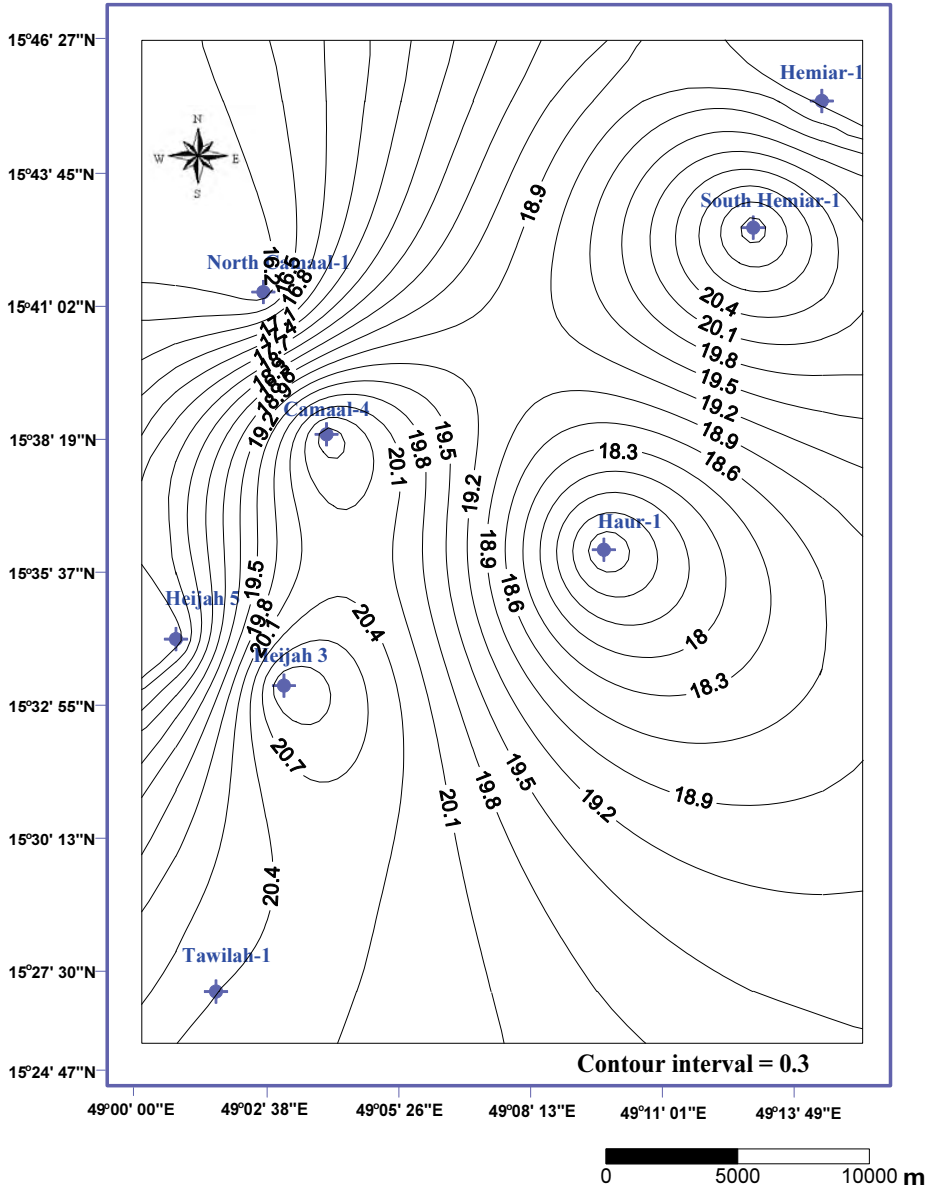


Fig. 9. Effective porosity distribution map of the Lower Qishn Clastic in study area.

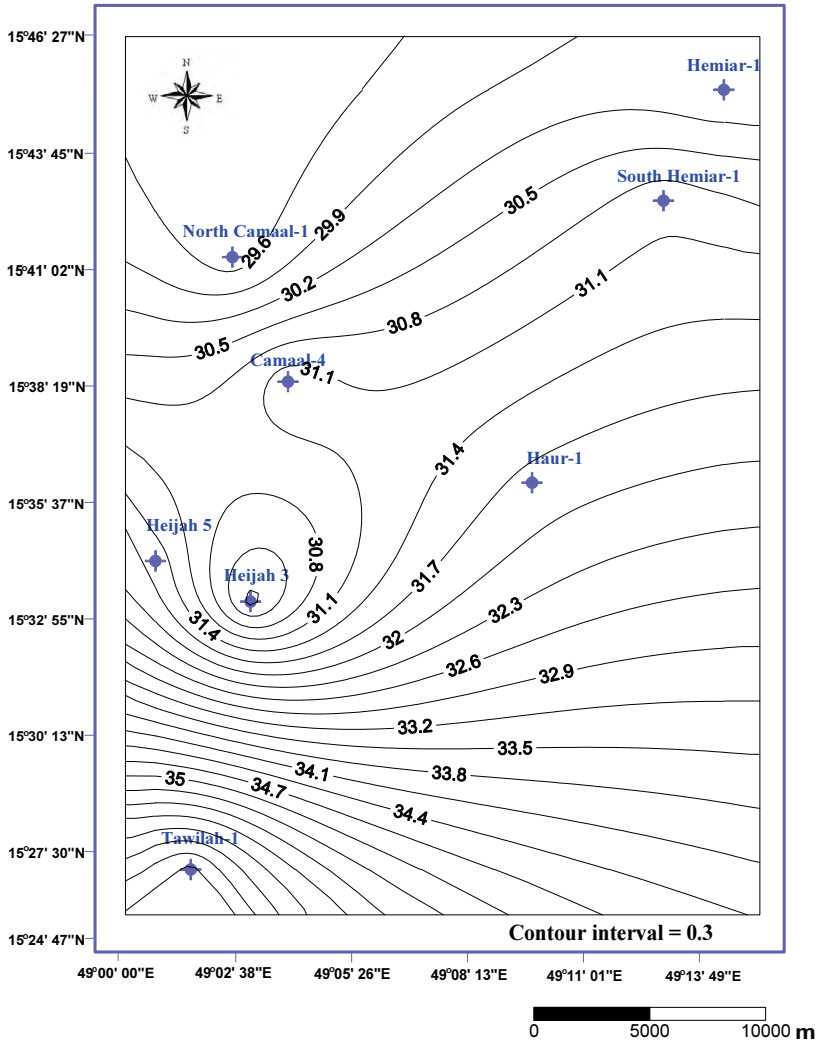


Fig. 10. Water saturation distribution map of the Lower Clastic Member in study area.

#### 4. Conclusions and Recommendations

Quantities analysis of well logs were carried out for the Lower Qishn Clastic reservoir encountered in the selected eight wells in the area under study. The reservoir evaluation that represents the main task in the present work is conducted to evaluate the petrophysical parameters needed for formation evaluation. It includes determination the volume of shale, porosities (total, and effective), lithological identification (sand, and carbonates), and fluid saturation (water, and hydrocarbon) for the

studied formations using the Interactive Petrophysics software (IP) that has been constructed for such purpose. The results of well log analysis were used in the evaluation of the hydrocarbon potentialities of the area under study.

The porosities analyses of the investigated reservoir for the studied wells concluded that the total porosity ranges from 18 to 24.3% while the effective porosity ranges from 25 to 18%. The permeability of this reservoir ranges from 375 to 103 md. Meanwhile the water saturation values ranges from 29 to 37%, whereas the hydrocarbon saturation has matching with the water saturation in a reverse relationship. The hydrocarbon occurrence decreases, where the water saturation increases.

Wireline logs are the only source for more information about the transected lithology. Using the parameters density, porosity, natural gamma ray, photoelectric factor and sigma various components of the sediment such as limestone, dolomite, sandstone, and clay can be distinguished and continuous lithology profiles for each hole established. This information is used to examine the depositional environment and its development in time. The lithological studies of the investigated reservoir indicate that the main lithology is composed mainly of sandstone with shale and carbonates.

From petrophysical parameters we can conclude that the reservoir has high hydrocarbon saturation in this area and contain many pay zones.

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## دراسات رسوبية وبتروفيزيائية لسجلات الآبار للجزء السفلي من مكنم مكون الكشن الفتاتي للنفط من حقل المسيله باليمن

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المستخلص. اكتشف النفط لأول مرة بمنطقة المسيلة سنة ١٩٩٠م وتم تقييمه ليصبح اقتصاديا سنة ١٩٩١م، كما بدأ الإنتاج الفعلي سنة ١٩٩٣م. وقد وجد أن حوالي ٩٠٪ من الزيت الخام موجود في صخور مكنم مكون الكشن السفلي الفتاتي، التابع لعصر الكريتايوي المبكر.

وقد قدرت احتياطيات هذا المكنم بحوالي ١,١ بليون برميل. وهذا الجزء الفتاتي من مكنم الكشن يعلو (بعدم تطابق) تتابعات كربوناتيية - فتاتيية مختلطة. وتشير الدراسات السابقة إلى أن صخور هذا المكنم ترسبت من مياه خليطة (نهريية - بحريية) على مسطحات المد والجزر التي تنتشر فوقها البحيرات والخلجان. والجزء الأوسط من صخور هذا المكنم تعكس ظروف ترسيب غير بحريية جافة، حيث تتخللها بعض الطبقات الحمراء وطبقات الكنجلوميرات الغنية بكسرات الطفلة، يعلوها تتابعات متداخلة بحريية شاطئيية وغير بحريية.

وخلال هذه الدراسات البتروفيزيائيية تم تحليل سجلات الآبار لثمانية آبار تخترق صخور هذا المكنم. وقد تم استخدام طريقة جديدة لتعيين المسامية والنفاذية ... إلخ لصخور



الممكن باستخدام سجلات الآبار. حيث استخدمت كل من spontaneous potential (SP), Caliper (CL), Deep (LLS, LLD), and Shallow (MSFL) resistivity logs, porosity tools (Density, Neutron and .sonic), litho-density (PEF) and Gamma-Ray (GR)

وقد تم مضاهاة خصائص المكنم الناتجة وربطها مع المعلومات السيزمية والطباقية لتعطي صورة واضحة لنمذجة الإنتاج النفطي للحقل. حيث تشير الدراسات الخاصة بالمسامية إلى وجود مسامية مرتفعة لصخور هذا المكنم. كما نجد أن النفاذية تتراوح من ٣٧٤ إلى ١٠٣. كما وجد أن معدلات التشبع بالمياه لصخور هذا المكنم ذات قيم منخفضة. كما وجد أنه توجد علاقة عكسية بين التشبع بالهيدروكربونات والتشبع بالمياه. وقد وجد أن معدل التشبع بالهيدروكربونات معدلاً عالياً، كما توجد عدة نطق منتجة.