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EMIRATES INTERNATIONAL UNIVERSITY
FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY
OIL AND GAS ENGINEERING DEPARTMENT

RESERVOIR CHARACTERIZATION OF UPPER QISHN CLASTIC FORMATION MEMBER OF TASOUR FIELD – BLOCK 32

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE
OF BACHELOR OF SCIENCE
IN OIL AND GAS ENGINEERING

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DECLARATION

We hereby declare that this Bachelor's Project is the result of our own work, except for quotations and summaries which have been duly acknowledged.

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APPROVAL

This is to certify that the project titled **Reservoir Characterization of Upper Qishn Clastic Formation Member of Tasour Field – Block 32** has been read and approved for meeting part of the requirements and regulations governing the award of the Bachelor of Engineering (Oil and Gas) degree of Emirates International University, Sana'a, Yemen.

Project Supervisor**: Assoc. Prof. Adel M. Al-Matary**

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ABSTRACT

Reservoir characterization required to describe a reservoir of its ability to store and produce hydrocarbons, reservoir characterization integrates the technical disciplines of geology, geophysics, reservoir engineering, petrophysics, economics and data management, Reservoir characterization is the process of integrating various qualities and quantities of data in a consistent manner to describe reservoir properties of interest at inter well locations such as (matrix lithology, Shale volume, Porosity, Permeability, Reservoir thickness and Saturation).

This study had done using **Interactive Petrophysics IP™** Software based on interpretations of twelve well logs at Tasour Field – Block – 32 – Yemen. Upper Qishn clastic formation member is the main reservoir. The reservoir had subdivided into three zones (Q1, Q2, Q3) based on the reading of Gamma Ray "GR". The Q1 is mainly composed of sandstone with shale. The average values for the sandstone, effective porosity, water saturation, hydrocarbon saturation, clay volume and thickness are about 76.33 %, 16.32 %, 31.23 %, 68.76 %, 23.67 % and 12.92 m respectively.

The Q2 is mainly composed of shaly sand. The average values for the sandstone, effective porosity, water saturation, hydrocarbon saturation, clay volume and thickness are about 59.9 %, 11.68 %, 60.45 %, 33.55 %, 40.1 % and 39.24 m respectively. The Q3 is mainly composed of sandstone with interbedded shale. The average values for the sandstone, effective porosity, water saturation, hydrocarbon saturation, clay volume and thickness are about 70.3 %, 16.54 %, 60.2 %, 39.82 %, 29.7 % and 34.12 m respectively.

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First of all, we owe our most sincere gratitude to Allah the almighty and the most powerful for offering us such a strength, endurance, willingness, and capability to accomplish this project.

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API	American Petroleum Institute
BHA	Bottom Hole Assembly
CALI	Caliper
CCL	Casing Collar Locater
CEC	Cation Exchange Capacity
CMR	Combinable Magnetic Resonance
DST	Drill Stem Test
E&P	Exploration and Production
EOPP	Early Oil Production Phase
FOL	First Oil Level
FWLS	Free Water Levels
FWS	Full Waveform Sonic
GOC	Gas Oil Contact
GR	Gamma Ray
GR_{clean} or GR_{min}	Gamma Ray Reading in Clean Sand
GR_{SH} or GR_{max}	Gamma Ray Reading in Shale Formation
GST	Gamma Ray Spectroscopy Tool
GWC	Gas Water Contact
HI	Hydrogen Index
ID	Inner Diameter
IPL	Integrated Porosity Lithology
JHOC	Jannah Hunt Oil Company
K	Formation Permeability
LLD	Laterolog Deep
LLS	Laterolog Shallow
LTPP	Long-Term Production Phase
LWD	Logging While Drilling
M	Cementation Factor
M	Mobility
MD	Measured Depth
MSFL	Micro Spherical Focused Log
MWD	Measurement While Drilling
N	Saturation Exponent
N/G	Net to Gross Ratio
NMR	Nuclear Magnetic Resonance
NPHI	Compensated Neutron Porosity
NW-SE	North West-South East
OBM	Oil Based Mud
$Ø_{eff}$	Effective Porosity
$Ø_{total}$	Total Porosity

OWC	Oil Water Contact
PC	Capillary Pressure
PEF	Photoelectric Effect
PPM	Part Per Million
PVT	Pressure/Volume/Temperature
RHOB	Bulk Density
RMF*	Resistivity of Mud Filtrate
ROP	Rate of Penetration
R_T*	Resistivity of True Zone
R_W*	Formation Water Resistivity
SCAL	Special Core Analysis
SP	Spontaneous Potential
S_W*	Water Saturation
SWCS*	Sidewall Cores
TD	Total Depth
TDT	Thermal Decay Tool
TVD	True Vertical Depth
V_{sh}*	Volume Of Shale
PB	Bulk Density
PF	Fluid Density
PG	Gas Density
PM	Matrix Density
ΔT	Interval Travel Time

CHAPTER ONE

1. INTRODUCTION

1.1. Introduction

The term “reservoir” essentially refers to all the pertinent information that is required to describe characterization a reservoir in terms of its ability to store and produce hydrocarbons. This entails knowing the complete reservoir architecture including the internal and external geometry, its model with distribution of reservoir properties (static such as porosity, permeability, heterogeneity, net pay thickness, etc.), and understanding the fluid flow within the reservoir (dynamic). Such information helps improve production rates, rejuvenate oil fields, predict future reservoir performance, minimizes costly expenditure, and helps managements of oil companies to draw up accurate financial models. Regarded as an important phase between the discovery of an oil or gas field and the reservoir management phase, to collate all the information mentioned above, reservoir characterization integrates the technical disciplines of geology, geophysics, reservoir engineering, petrophysics, economics and data management. Understanding of characterization of any reservoir formation has an impact on the successful management and exploitation of that reservoir, as it can affect the drilling practices, evaluation programs, and completion method. The characterization of a reservoir aims to the best detailed geological knowledge of depositional reconstruction “both of its geometry and of its internal structure”.

Therefore, this study will focus on determination of reservoir characterization of upper Qishn clastic Member formation in Tasour field, Block 32, Masilah basin. Evaluation of upper Qishn clastic Member formation from lithology, fluids properties and reservoir performance are a part of this graduation project. Performing the petrophysical properties from log data (matrix Lithology, Shale volume, Porosity and Saturation) will also be done using related software.

Using well logs, and geological data will be the mean used data to determine the reservoir characterization using related software **IP Interactive petrophysics V3.5**.

1.2. Study Area

Yemen is geographically located at the southwestern part of the Arabian Peninsula, situated between latitudes (12 40" – 18 50" N) and longitudes (42 50" - 53 00"E). It encompasses an area approximately of 536, 870 square Km as shown in **Fig. 1-1**.

Yemen is bounded on the west by the Red Sea a north south by the Gulf of Aden, which opens to the east into the Arabian Sea. East of Yemen lies Oman and north of Yemen lies Saudi Arabia.

The study area is located in the Masila basin which are located at Hadramawt region south-central Yemen, adjacent to the prolific Nexen/Occidental Masila fields. The study area includes Tasour field in Block 32 is shown at (**Fig. 1-1**).

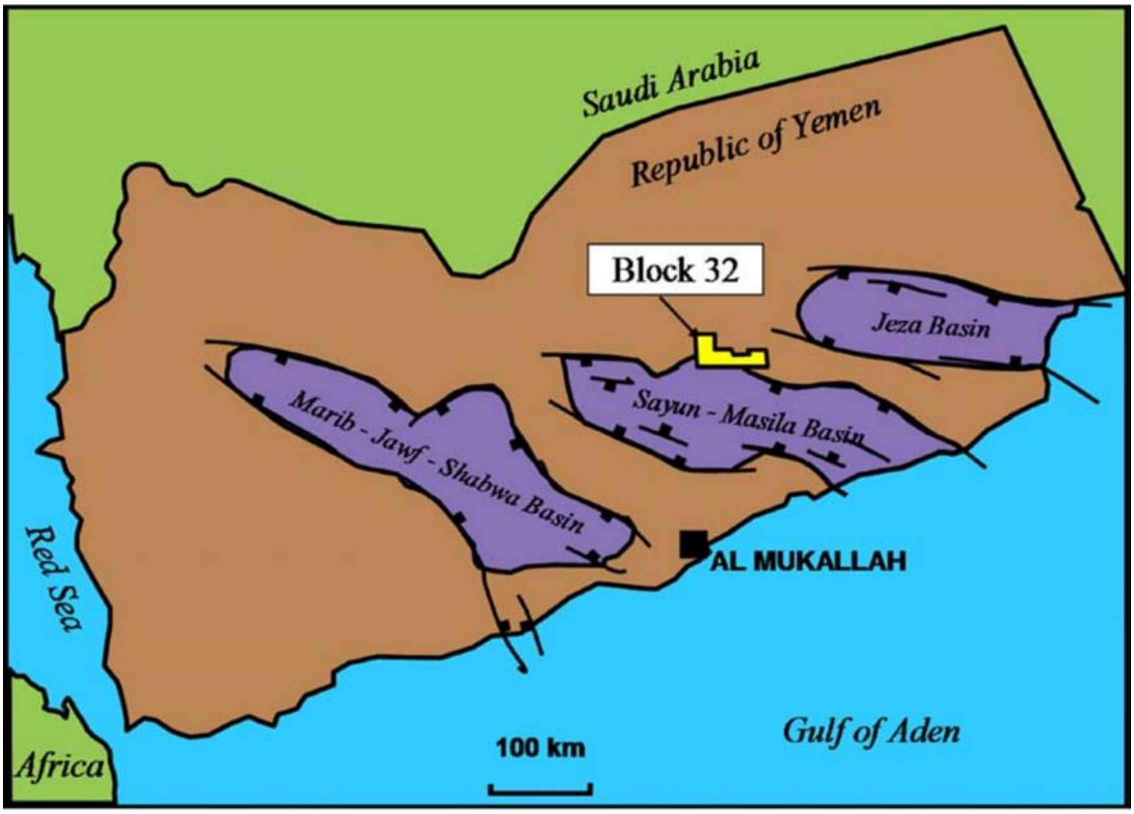

Figure 1-1 Location map of Block 32 on the north side of the Sayun-Masila basin, Hadhramaut region.

1.3. Previous studies

Geological and stratigraphic studies of Yemen including the Masila basin have been carried out by the Canadian Oxy Company (1992), Redfern and Jones (1995), Mohammed Hail Hakimi Basem A. Al Qadasi, Yousif Al Sharrabi, Omar T. Al Sorore, Nazeeha G. Al Samet. Alan Holden and Helen M. Kerr (1997), Hassan S. Naji & Mohammad H. Hakimi (2009), Hassan S. Naji, M. H. Hakimi and M. Khalil (2010), Nabil Mohammed Ahmed Alareeq (2008), Beydoun et. al., (1998).

Canadian Oxy Company (1992) studied the Qishn Formation east of the type section at Wadi Al-Masila and subdivided it into seven lithologic units.**(Ahlbrandt 2002)**

Mohammed Hail Hakimi Basem A. Al Qadasi, Yousif Al Sharrabi, Omar T. Al Sorore, Nazeeha G. Al Samet. Alan Holden and Helen M. Kerr (1997) Petrophysical properties of Cretaceous clastic rocks (Qishn Formation) in the Sharyoof oilfield, onshore Masila Basin, Yemen.**(Hakimi*, et al. 2016)**

Hassan S. Naji & Mohammad H. Hakimi (2009) Stratigraphy, deposition, and structural framework of the cretaceous (review) and 3D geological model of the lower cretaceous reservoirs, Masila oil field, Yemen.**(Hakimi& and Sharief 2010)**

Hassan S. Naji, M. H. Hakimi and M. Khalil (2010) Hydrocarbon Potentialities and Reservoir Characterization of Lower Cretaceous Successions of Masila Oil Field, Yemen.**(Hassan S. Naji)**

Nabil Mohammed Ahmed Alareeq (2008) Sedimentological Evolution and Petroleum System in The Central Part of Sayun-Masila Basin Republic of Yemen.**(Ahmed 2008)**

Beydoun et. al., (1998) subdivided the Mesozoic stratigraphic section in Yemen into many rock units.**(Beydoun 1998)**

1.4. Geological and Stratigraphical Setting of Masila basin

The Masilah basin, based on data from Geophysical and Geological carried out by Oil Companies, and Exploration wells drilled in the basin, the basin filled with carbonate and terrigenous sediments the filling of the basin includes Paleozoic, Mesozoic and Cenozoic sediments **Fig. 1-2**.**(Redfern 1995)**

The most current detailed stratigraphic and basin nomenclature of Yemen is provided by **(Beydoun 1998).** Recent active oil exploration works in Sayun-Masila basin revealed the presence of a subsurface Jurassic to Recent stratigraphic column. It consists of alternating depositional cycles of clastic and non-clastic (carbonate) rocks (**Fig. 1-2**). The Jurassic and Lower Cretaceous strata in Yemen, as a regionally and locally at Sayun-Masila basin, reflect post Pangia breakup and basin creation formed by rifting. The Sayun-Masila basin is characterized by numerous unconformities surfaces due to volcanic activation and deposition of the Jurassic sediments directly on the basement. At Masila block, the sedimentary basin fill ranges in thickness from 4000 m in the depocenters to 1800m on the structural highs.

1.5. Stratigraphical Units for Masila basin

1.5.1. Basement Complex Rocks:

The basement complex rocks in the studied area were described solely from deep drilled holes. They consist of granites intruded by basic dykes and metamorphic rocks (amphibolites, gneiss, schists and blue-green phyllitic to green schist facies and metasediments).

1.5.2. Jurassic – Amran Group

1.5.2.1. Kuhlan 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 Kuhlan Formation. In general, this formation is composed of siltstone and sandstone to conglomerate with some streaks of limestone and green clay.

1.5.2.2. 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.

1.5.2.3. 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. The upper member of the Madbi is composed of laminated organic rich shale, mudstone and calcareous sandstone. This member is a prolific source rock in the Masila province.

1.5.2.4. 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.

1.5.2.5. 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.

1.5.3. Cretaceous – Tawilah Group

1.5.3.1. Qishn Carbonate Formation:

Qishn Carbonate Formation: 1578 m to 1715.5 m (thickness: 137.5 m) The Qishn Carbonate formation is made up of mainly Limestone, also it comprises the Red Shale Bed which act as a regional marker. The top of this formation is transition of Clay to Limestone. The Limestone is argillaceous in nature.

1.5.3.2. Qishn Clastics Formation:

Qishn Clastics Formation: 1715.5 m to 1968 m (thickness: 252.5 m). The Qishn Clastics formation divided in two parts:

Upper Qishn Clastics:

From 1715.5 m to 1812 m (thickness: 96.5 m). This formation is the main objective of this study; it is composed of mainly Sandstone with Claystone interbeds, some Limestone were also observed at the top.

Lower Qishn Clastics:

From 1812 m to 1968 m (thickness :156 m). This is dominated by Claystone/Shale with Sand, Sandstone and Limestone interbedding towards bottom. Also includes traces of Siltstone and Dolomite.

1.5.3.3. SAAR Carbonate Formation:

SAAR Carbonate Formation: 1968 m to 1992 m (TD)The SAAR carbonate formation comprehends Limestone and Dolomite.

1.5.3.4. Harshiyat Formation:

Harshiyat Formation: 797.5 m to 1578 m (thickness: 780.5 m). This formation consists of predominantly Sand with intercalations of Claystone/Shale and Sandstone. Towards the base of this formation traces of Dolomite were described. The base of this formation includes of Claystone which grades into Argillaceous Limestone.

1.5.3.5. Fartaq Formation:

Fartaq Formation: 750 m to 797.5 m (thickness: 47.5 m). The Fartaq formation consists of an upper section of mainly Dolomite and a lower section of Limestone with minor Shale and Dolomite horizons.

1.5.3.6. Mukalla Formation:

Mukalla Formation: 316 m to 750 m (thickness: 434 m). Mukalla formation consists of interbedded unconsolidated Sand and very soft, plastic Clay.

1.5.3.7. Sharwayn Formation:

Sharwayn Formation: 289 m to 316 m (thickness: 27 m) This thin formation is represented by pyrite rich Shale, greyish, sub-blocky to sub-fissile and Siltstone, dark grey to blackish, sub-blocky, lignitic and pyritic.

1.5.4. Paleocene - Hadhramaut Group

1.5.4.1. Umm Er Radhuma Formation:

Umm Er Radhuma Formation: 47 m to 289 m (thickness: 242 m). The Umm Er Radhuma Formation comprises a carbonate sequence consisting of Limestone, mudstone to wackestone, hard, fine crystalline and dolomitic Limestone stringers becoming argillaceous towards the base of the formation.

1.5.4.2. Lower Jeza Formation:

Lower Jeza Formation: surface to 47 m. This formation consists of Limestone, cream, tan, hard, chalky to crystalline, cherty, locally gypsiferous and interbedded Shale, yellow to pink.

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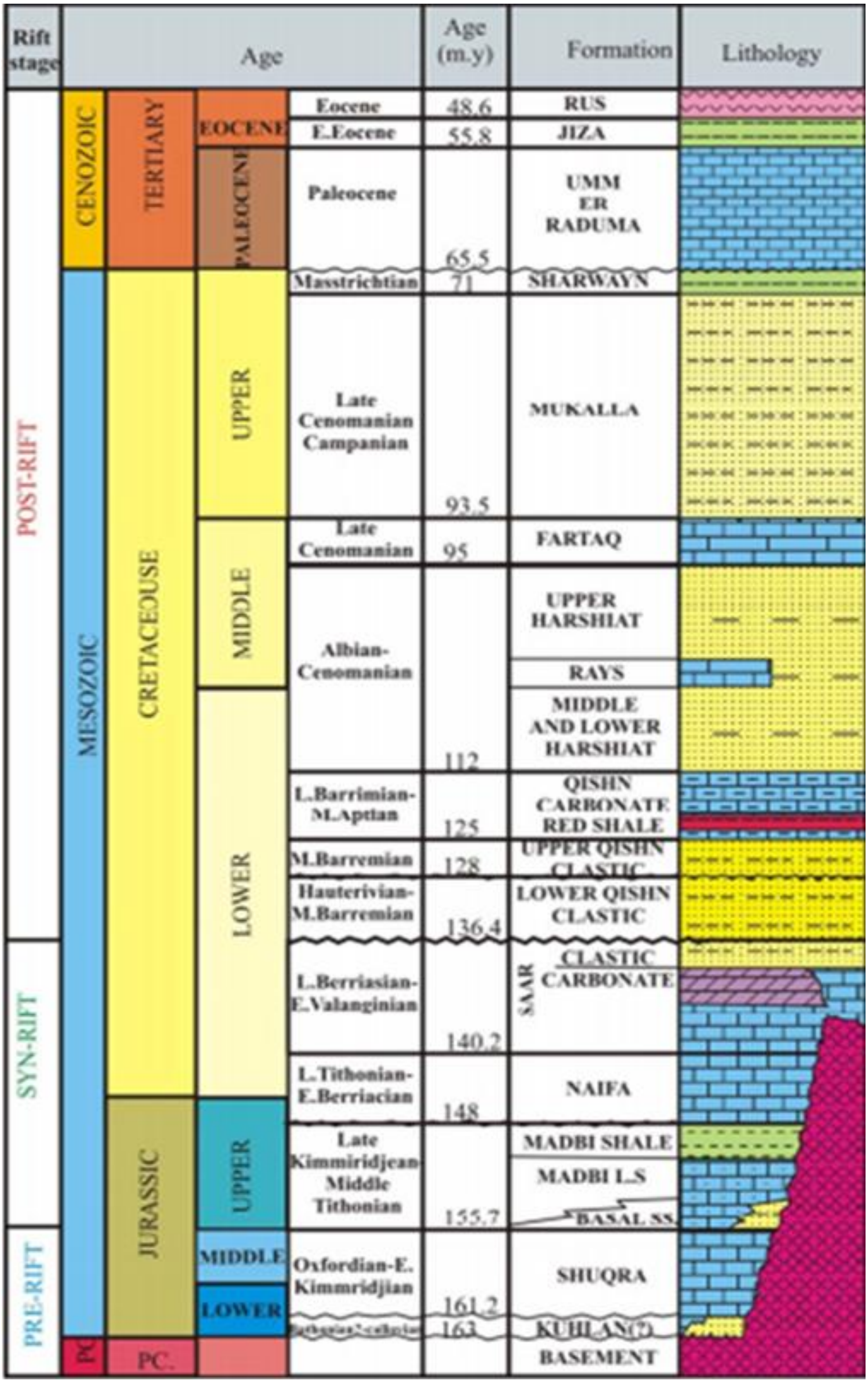

Figure 1-2 Lithostratigraphy Of the Sayun-Masila Basin.

1.6. Aim and Plane:

1.6.1. Aims:

The aim of this study is to integrate petrophysical log data to qualify and quantify reservoir characterization of upper Qishn clastic Member formation in Tasour field, block 32, Masilah basin.

1.6.2. Plane

To achieve the previous Aim, the following plane had achieved:

1. Determination of reservoir depth and thicknesses in the wells.
2. Determine the lithology through the identification of sand units from chosen top sand to the last hydrocarbon bearing sand, using Gamma Ray Log.
3. Estimating the Shale volume and fluids saturations.
4. Interpretation of porosity logs to determine the other types of porosities.
5. Integration of all the available data to evaluate the production potential of the well.

CHAPTER TWO

2. DATABASE AND METHODOLOGY

2.1. Introduction.

Reservoir Characterization studies was carried out on upper Qishn clastic Member formation in Tasour field, block 32, Masilah basin at the **Fig. 2-1** Base map. For this study data collection 19 Wells logs were tabulated and prepared in LAS formats **Table. 2-1**.

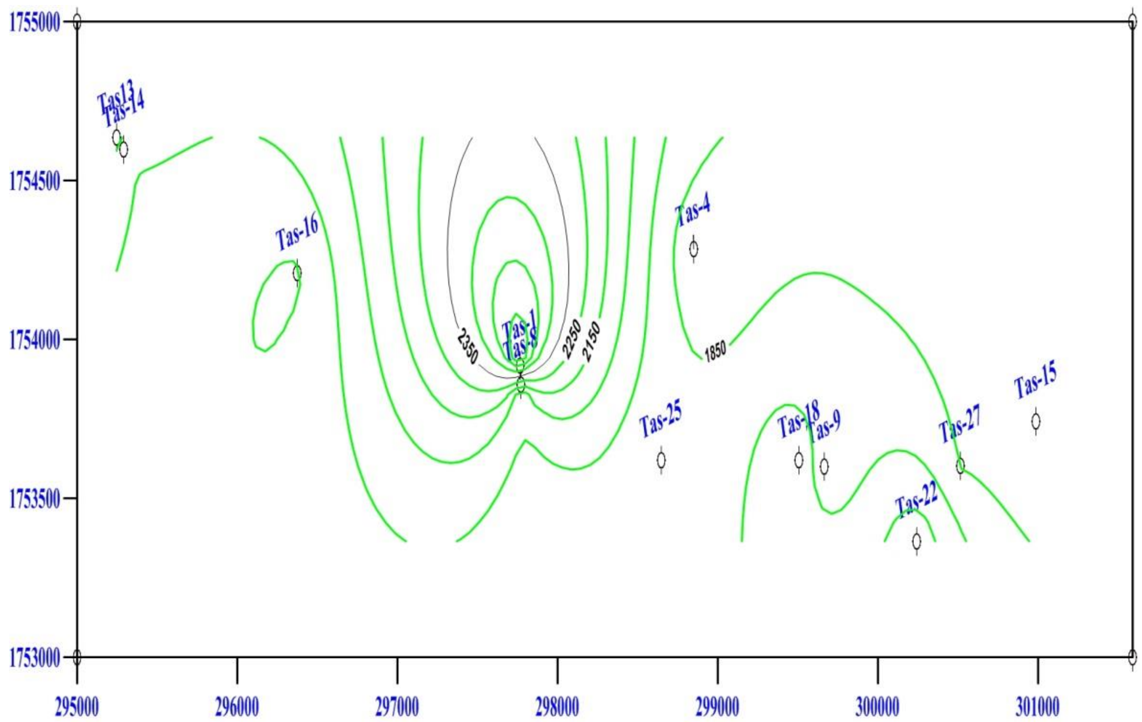

Figure 2-1 Base map for Tasour field, block 32, Masilah basin

Table 2-1 The Data Used in The Study

Well Name	Top Depth	Bottom Depth	X	Y	TD
Tasour-1	1648.7	1755.3	297765	1753,917	2763.0
Tasour-4	1706.51	1742.69	298849	1754283.5	1770
Tasour-8	1829.2	1925.81	289663.8	1753600.1	1998
Tasour-9	1707.96	1817.5	299663.83	1753600.09	1875
Tasour-13	1936.01	2024.84	295245.5	1754634.8	2104
Tasour-14	1798.86	1884.41	295291.6	1754596.6	1966
Tasour-15	1624	1738.5	300987	1753741.6	1760.5
Tasour-16	1729	1837.8	2963750.3	1754208.4	1837.81
Tasour-18	1752	1842.09	99508.3	1753619.3	2040.63
Tasour-22	1715.7	1816.3	300244	1753364.8	2123
Tasour-25	1705	1816.8	298646	1753620	1860.1
Tasour-26	1672.6	1750.5	300516	1753603	1845

2.2. Methodology of study

2.2.1. Reservoir Characterization

The following standard module are available under the Characterization menu : caly volume ,porosity & water saturation.

2.2.1.1. Clay volume

Clay volume is calculated from multiple clay indicators : it is either from single curve.e.e (gammaray (GR) spountanous potential (SP)),alternatively two curve.e.g (neutron/density , and sonic/density)curve . the minimum of these values at each level was selected as the final value of the shale volume.

Shale volume from GR

Gamma-ray is one of the best tools used for identifying and determining the shale volume (**Schlumberger, 1972**). This is principally due to its sensitive response for the radioactive materials normally concentrated in the shaly rocks. The following equation is used to determine Gamma-ray index (**Schlumberger, 1974**)

$$I_{sh} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}} \quad \% \qquad 2\text{-}1$$

The shale volume index $\mathbf{I_{sh}}$, determine an average $\mathbf{GR_{log}}$ reading in clean sands ($\mathbf{GR_{clean}}$ sand or $\mathbf{GR_{min}}$) which is the minimum value and a value for shales ($\mathbf{GR_{sh}}$) which is the maximum value.

Shale volume from SP

SP log can be used to calculated the volume of shale through this formula (Schlumerger,1972 b, andc):

$$V_{sh} = 1 - \frac{psp}{ssp} \quad \% \qquad 2\text{-}2$$

Pseudo – spontaneous potential of shaly bed **PSP**, static spontaneous potential of thick clean bed **SSP**

Shale volume from crossplot

In this work , shale volume calculated from the neutron-density log was determined via the interactive petrophysics program using the following equation (Schlumberger ,2008)

$$V_{sh} = \left(\frac{Pb_{log}(\emptyset\, N_{ma} - 1) - \emptyset\, N_{log}(P_{ma} - P_f) - P_f \emptyset N_{ma} + P_{ma}}{(P_{sh} - P_f)(\emptyset N_{ma} - 1) - (\emptyset N_{sh} - 1)(P_{ma} - P_f)}\right) \qquad 2\text{-}3$$

Shale volume from neutron-density combination $\mathbf{V_{sh}}$, density log reading of the analyzed zone $\mathbf{Pb_{log}}$, gm/cc, density log reading against thick shale bed $\mathbf{P_{sh}}$, gm/cc, density of fluid $\mathbf{P_f}$, gm/cc, density of matrix $\mathbf{P_{ma}}$,gm/cc, neutron log reading of the analyzed zone $\mathbf{NØ_{log}}$, neutron reading of matrix $\mathbf{NØ_{ma}}$**,** neutron log reading against thick shale zone $\mathbf{NØ_{sh}}$

2.2.1.2. Estmution of porosity

porosity is very important parameter for formation evaluation and calculating fluid saturation. porosity is the percentage of voide to the total volume of rock. it is measured as a percent and has the symbol(Ø). The four types of porosity log (total, primary, secondary and effective porosities) can be calculated by using (sonic, density and neutron logs).

Porosity from Density (ØD)

Prosity from density is selected a good tool for porosity determination because thr effect of the fluid content on it is negligible. however, it is effected by the following factors:

A) Gas satiration, which reduces density readings**.**
B) High shale percentages, which greatly effects porosity estimation.

Porosity From The Density.

$$\emptyset_D = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} \qquad 2\text{-}4$$

porosity from the density $\mathbf{Ø_D}$, density of fluid **Pf**, gm/cc, the matrix density $\mathbf{P_{ma}}$, as calculated from Pd-Rt cross plots, bulk density log $\mathbf{P_b}$, gm/cc

Porosity from Sonic (Øs)

sonic porosity (**Ø**s)is determined from the sonic log, depending on the shale content, matrix type, and fluid saturation. The following equation was used for the porosity evaluation for consolidated rocks(**Wyllie,1958**):

$$\emptyset_S = \frac{\Delta t_{log} - \Delta t_{mat}}{\Delta t_f - \Delta t_{mat}} \qquad 2\text{-}5$$

sonic log $\mathbf{\Delta t_{log}}$, sonic matrix value $\mathbf{\Delta t_{ma}}$, sonic transit time of the fluid $\mathbf{\Delta t_f}$

Porosity from Neutron (ØN)

The neutron in the form of compensated neutron porosity log (CNL) measures the hydrocarbon index of the formation and records the neutron porosity in API units. it is desinged to determine formation porosity direction. it is greatly effected by gas saturation.

In this work, neutron porosity was determined via the interactive petrophysics™ porogram using the density – neutron porositymodel as follows (**Schlumberger ,2008**)

$$\emptyset N = \frac{(\emptyset_{neu} - V_{sh} * Neu_{sh} + Neu_{ma} + Exfact + Neu_{sal}}{(Sxo + (1 - Sxo) * Neu_{HYHI})} \qquad 2\text{-}6$$

$$Exfact = \left(\frac{P_{ma}}{2.65}\right)^2 *(2 *Sxo *Ø^2_x +0.045 *Ø_x)* (1-Swx) \quad 2\text{-}7$$

$$Ø_x = Ø + V_{sh} * Neu_{sh}$$

$$S_{wx} = \frac{Ø * (Sxo + (1 - Sxo) * Neu_{HYHI}) + V_{sh} * Neu_{sh}}{Ø_X} \quad 2\text{-}8$$

Total porosity From Combination of Neutron and Density (ØT).

Formation porosity can be determined from the density-neutron combination through the following equation (Schlumberger ,1972) .

$$Ø_t = \sqrt{\frac{Ø^2_{NC} - Ø^2_{DC}}{2}} \qquad 2\text{-}9$$

Effective porosity ($Ø_E$)

There are two ways to calculate the effective porosities ($Ø_e$) (Schlumberger ,1972): the first is the use of the general equation :

$$Ø_E\ 1 = Ø_T (1-V_{sh}) \quad 2\text{-}10$$

2.2.1.3. Determination of the resistivities.

Resisitivity is rock property on which the entire science of logging first developed . resistance is the inherent property of all materials , regardless of their shape and size , to resist the flow of an electric current .

Determination of formation water resistivity (RW) From SP

The water resistivity (**R_W**) which is determined from the SP log module is used to create a continuous **R_W** curve . this is useful for estimating values overs with depth,and account for the temperature gradient over the computed interval.

The formation water resistivity (**R_w**) is caculated by ratio method

$$R_w = \left(\frac{Rt * Rmt}{Rxo}\right) \qquad 2\text{-}11$$

Correction of mud cake and mud filtrate resistivities (Rmc & Rmf)

The resistivities of the different fluids (Rmc & Rmf) can be corrected to formation tempreture using Arp, formula (1953).

$$\boldsymbol{R_2 = R_1 * \frac{(T_1 + 6.77)}{(T_2 + 6.77)}} \qquad 2\text{-}12$$

Determination of rock resistivities (R_{xo} and R_t)

According to the diameter of invasion , the rock resistivities are divided into flushed zone resistivity (**R_{xo}**) and uninvaded zone resistivity (**R_t**) .

A. The Flushed Zone Resistivites (R_{xo}):

The flushed zone resisitivites (**R_{xo}**) were measured by the Micro Latero Logs (MLL)

Micro latero log(MLL): the value of Rxo of an invaded zone were corrected depends on the thickness of mud cake (**H_{mc}**) using the following mathematical equation (Dresser Atlas ,1983):

$$\boldsymbol{H_{mc} = \frac{(Bit\ Size - Caliper)}{2}} \qquad 2\text{-}13$$

B. Uninvaded zone resistivity (Rt):

The uninvaded zone resistivity (**R_t**) were measured through Dual Laterolog (LLD and LLS).

Dual Laterolog (LLD and LLS) ,the resistivity vaule are corrected for the borehole effect by using the mathematical equations (Bateman and Konen ,1978).

RLLD(Corr)=C*RLLD

RLLS(Corr)=C*RLLS

Where **C** is the correction factor which depends upon the hole diameter.

Determination of formation resistivity factor (F)

The formation resistivity factor (F) provides a useful and convenient way to clarify the nature of the pore structure of reservoir , it is calculated using Archie formula as :

$$F = \frac{R_0}{R_w} \qquad 2\text{-}14$$

This formula can be used in three ways :

1- To determine R_o when **F** and R_w are known , then be compared with true resistivity of the formation (R_t) to detect the presence of hydrocarbons .
2- To determine **F** when R_o and R_w are known , then used to estimate the porosity of the formation.
3- To determine R_w when R_o and **F** are known , then be used to determine salinity of formation water.

2.2.1.4. Determination of Fluid Saturation.

This part exploits the formerly deduced petrophysical parameters to calculate the fluid saturations and to acquire the information needed about the reservoir characteristics. The determination of the fluid saturations involves principally the discrimination between the various fluid components (water and hydrocarbons) filling up the pores of the flushed and uninvaded zones. The process of determining fluid saturation requires the availability of corrected values of fluid resistivities (R_w & R_{mf}), and rock resistivities (R_{xo} & R_t).

Water Saturation.

Water saturation is the percentage of pore volume in rock, which is occupied by formation water. It represents an important log interpretation concept, because it helps the determination of the hydrocarbon saturation of a reservoir. The water saturation is estimated in both the uninvaded-zone (S_w) and flushed zone (S_{xo}). Water saturations in clean and shaly zones are studied by many workers as ***Archie*** (1942); Modified ***Simandoux*** and others.

A. Uninvaded – Zone water saturation (Sw)

Clean zone :

The water saturation determination from resistivity logs in the non-shaly (clean) formations with homogeneous inter-granular porosity is based on Archie,s formula (1942), as follow :

$$S_w = \left(F \frac{R_w}{R_t} \right)^{1/n} \qquad 2\text{-}15$$

$$F = \left(\frac{a}{\emptyset^m} \right) \qquad 2\text{-}16$$

F formation factor **a** is the tortuosity factor, equal to **1 in carbonates**, **0.62 in nonconsolidated sands** and **0.81 in consolidated sands**, according to Humble's work (**Schlumberger, 1987**), **m** is the cementation factor, equal to **2 in carbonates and in consolidated sands** and **2.15 in unconsolidated sands**, according to Humble's work (**Schlumberger,1997**) and **n** is the saturation exponent which varies from 1**.8 to 2.5** but is normally equal to 2.

Shaly zone:

The water saturation (S_w) was determined using the so-called modified simandoux equation this model uses the following equations (**PGL , 2008**)

$$\frac{1}{R_t} = \frac{\emptyset^2 {S_W}^2}{a\, R_W\, (V_{sh})} + \frac{V_{sh} * S_w}{R_{sh}} \qquad 2\text{-}17$$

Ø porosity, $\mathbf{R_t}$ uninvaded zone resistivity, $\mathbf{R_w}$ formation water resistivity, $\mathbf{R_{sh}}$ resistivity log reading against shaly zone ohm.m, $\mathbf{S_w}$ water saturation .

B. Flushed – zone saturation (S_{xo})

Clean zones

Water saturation in the flushed zone (S_{xo}) is calculated by using Archie,s equation (1942).

$$S_w = \left(F \frac{R_{mf}}{R_{xo}} \right)^{1/n} \qquad 2\text{-}18$$

$\mathbf{R_{xo}}$ flushed zone resistivity, $\mathbf{R_{mf}}$ mud filtrate resistivity, **F** formation factor, **a** is the tortuosity factor, equal to 1 in carbonates, 0.62 in non-consolidated sands and 0.81 in consolidated sands.

Shaly zones

In the shaly zone , the water saturation ($\mathbf{S_w}$) was computed using the dual water model. this model uses the following equations (**Schlumberger ,2004**) for the flushed zone ($\mathbf{S_{xo}}$).

$$\frac{1}{\sqrt{Rxo}} = \left(\sqrt{\frac{\emptyset^m}{aR_{mf}}} + \frac{V_{cl}^{\left(1-\frac{V_{cl}}{2}\right)}}{\sqrt{R_{cl}}}\right) * S_{xo}^{n/2} \qquad 2\text{-}19$$

Hydrocarbon saturation (S_h)

The hydrocarbon total saturation is calculated through the formula :

$$S_h = 1 - S_w \qquad 2\text{-}20$$

The hydrocarbon saturation is usually differentiated into its residual (S_{hr}) and movable (S_{hm}) fractions , which can be calculated from water saturations in the uninvaded and flushed zones (S_w and S_{xo}) ,as following:

$$S_{hr} = 1 - S_{xo} \qquad 2\text{-}21$$

$$S_{hm} = S_h - S_{hr} = S_{xo} - S_w \qquad 2\text{-}22$$

CHAPTER THREE

3. Zonation for Upper Qishn Formation Reservoir

3.1. Introduction:

According to GR log, Upper Qishn Formation has various responds.

3.2. Zonation for Upper Qishn Formation Reservoir

Upper Qishn clastic formation had subdivided into three formations (**Q1, Q2, Q3**) for example in tasour-1 well the reservoir divided into three zones which are Q1, Q2, and Q3 based on the reading of GR logs "Total gamma-ray log" as shown in the **Fig. 3-1**.

- In the Q1 formation, GR curve shows that the value of GR log low which indicate to sandy formation.
- In Q2 formation, it has been noticed that the GR reading is high which indicates to shaly formation.
- In Q3 Formation, the upper section shows low GR reading which indicates to sandy formation. But the lower section shows high GR reading which indicates to shaly formation. As a result, Q3 formation considered as a Shaly sand formation.

Fig. 3-2 shows the zonation process for some wells of interest.

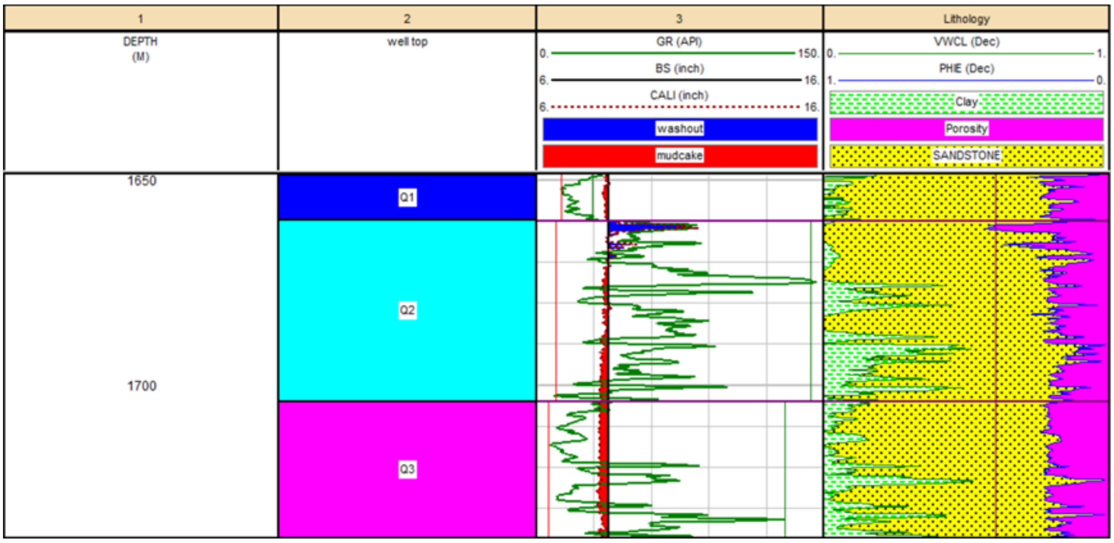

Figure 3-1 Zoning of Upper Qishn Formation Member in Tasour Field Block 32 Masilah Basin

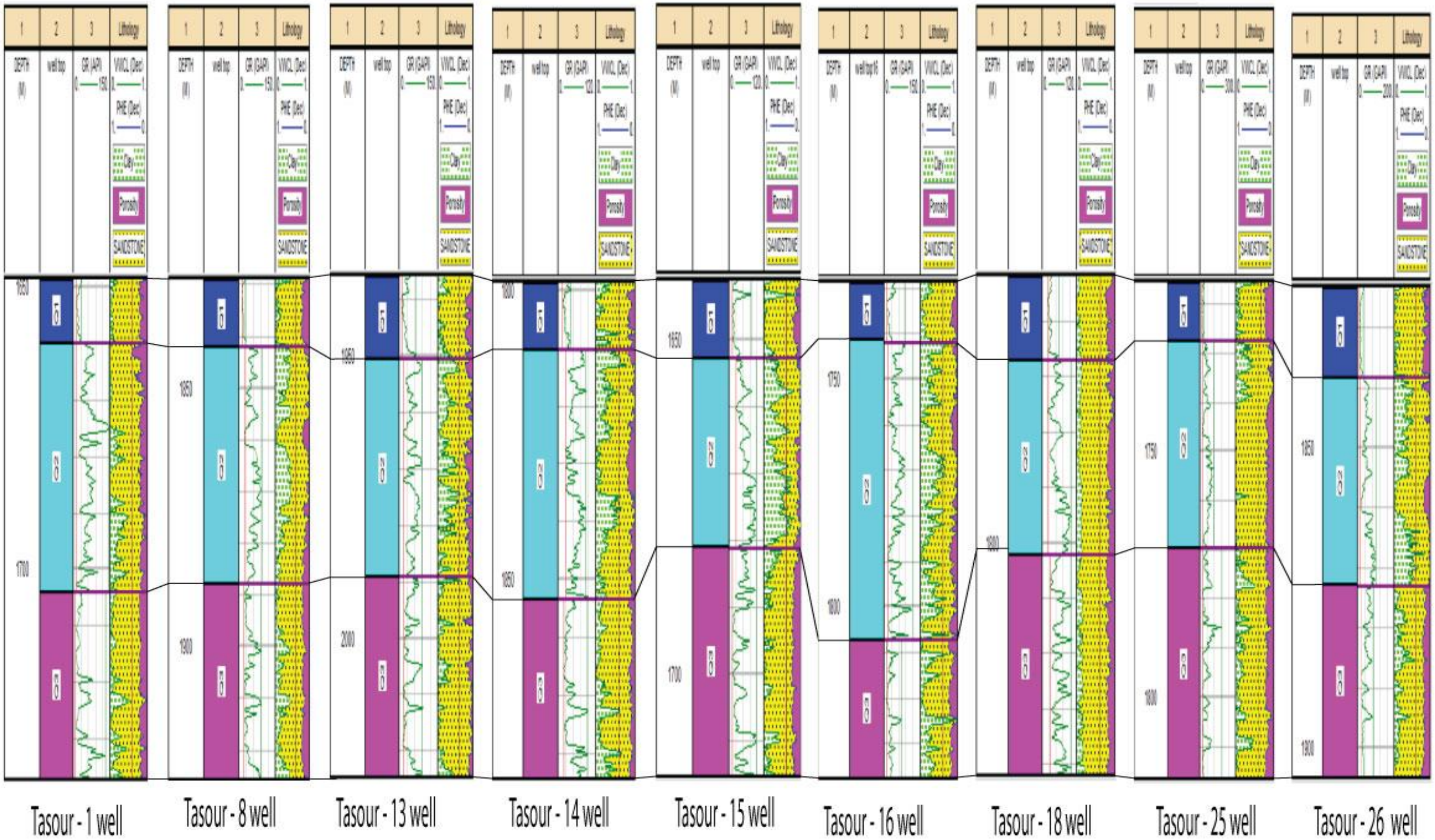

Figure 3-2 Tasour Well after zonation Process

Table 3-1 Summary for the Zonation Process

No.	Well	Q1		Q2		Q3	
		Top	Bottom	Top	Bottom	Top	Bottom
1	Tasour 1	1648.7	1659.8	1659.8	1691.2	1691.2	1737.4
2	Tasour 4	1706.5	1719.83	1719.83	1732.03	1732.03	1742.69
3	Tasour 8	1829.2	1841.98	1841.98	1888	1888	1925.8
4	Tasour 9	1708	1720.44	1720.44	1787.5	1787.5	1817.5
5	Tasour 13	1936	1950.42	1950.42	1989.3	1989.3	2024.8
6	Tasour 14	1798.9	1810.36	1810.36	1853.5	1853.5	1884.4
7	Tasour 15	1641.3	1652.9	1652.9	1681.1	1681.1	1715.2
8	Tasour 16	1729	1741.4	1741.4	1807.5	1807.46	1837.8
9	Tasour 18	1752	1767.1	1767.1	1802.3	1802.3	1842.1
10	Tasour 22	1738	1750.8	1750.8	1781.3	1781.3	1816.3
11	Tasour 25	1715.7	1727.45	1727.45	1769.82	1769.82	1816.8
12	Tasour 26	1823.5	1838.5	1838.5	1872.9	1872.9	1905

3.3. Reservoir Characterization for Tasour Field – Block -32

The objective of this work is to study the reservoir characterization of Upper Qishn formation member in Tasour field block 32 Masilah basin and to evaluate the hydrocarbon potentialities by integrating a variety of the state-of-the-art computer packages Interactive Petrophysics IP Software, which is used for well logs. The packages include:

1. Reservoir characterization and evaluation, which are based on well log geophysical analysis of the reservoirs and hydrocarbon potentialities.
2. Interpretation to calculate measurable quantities such as shale volumes, porosity, and fluid saturations.

This work is based on the study of well logs for twelve wells, which cover the study area. This data is obtained from the Production and Exploration Authority (PEPA) of Yemen. The logs in the studied wells include: GR: Total gamma-ray log - SP: Self potential log – CAL: Caliper log - LLS: Shallow laterolog - LLD: Deep laterolog - MSFL: Micro spherical focused log – ΔT: Sonic log – RHOB: Bulk density log – NPHI: Neutron porosity log.

3.3.1. Tasour-1 well log Interpretation:

Tasour-1 well was the first well to be drilled on Block 32 by DNO as operator was intended as an exploration well. The well was vertically drilled at top depth 1648.7 m and bottom depth 1737.4 m in the upper Qishn Classics formation.

3.3.1.1. Q1 Formation- (1648.7 m - 1659.8 m)

This formation has considered as a **shaly sand** formation. The value of sand/sandstone is **93.9 %**, clay volume of **6.1 %**, effective porosity of **20.3 %**, water saturation of **13.5 %**, hydrocarbon saturation of **86.5 %**, and thickness of **11.1 m** (**Fig. 3-3**).

3.3.1.2. Q2 formation- (1659.8 m - 1691.2 m)

The Q2 mainly composed of sandstone and shale (**shaly sand**), the value of sand/sandstone is **68 %,** clay volume of **32 %,** effective porosity of **20.5 %**, water saturation of **80 %**, hydrocarbon saturation of **20 %**, and thickness of **31.4 m** (**Fig. 3-3**).

3.3.1.3. Q3 formation- (1691.2 m - 1737.4 m)

Most of this zone considered as a sandstone, and the rest as a shale (**Shaly sand**). sand/sandstone is about **85.3 %** and the clay volume **14.7 %**. Effective porosity is about **20.3 %**, water saturation is about 73.3 %, hydrocarbon saturation is about **26.7 %,** and thickness is about **46.2 m** (**Fig 3-3**).

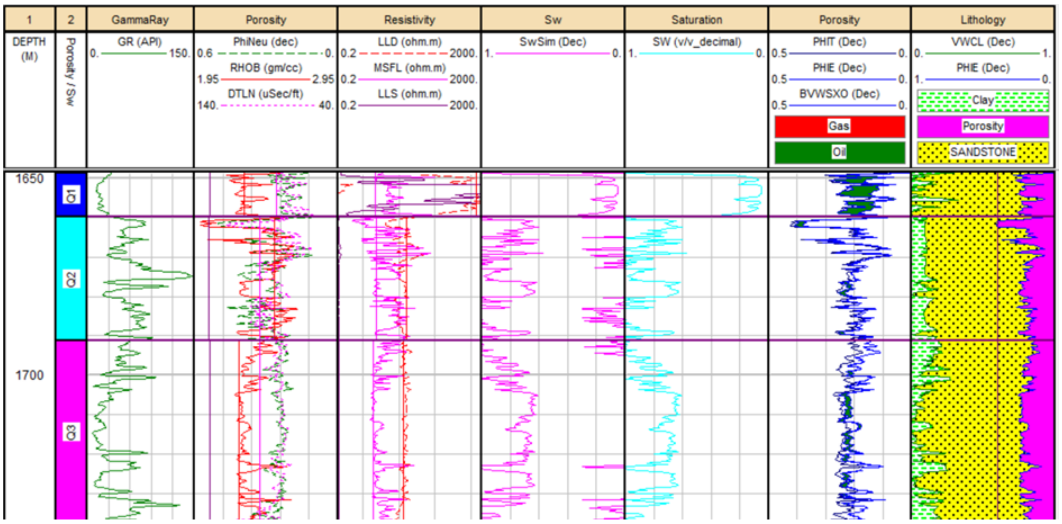

Figure 3-3 Litho-saturation of Qishn formation member in Tasour 1

3.3.2. Tasour-4 well log Interpretation:

Tasour - 4 well was the fourth well to be drilled on Block 32 by DNO as operator. This well was intended as a producing oil well. The well was vertically drilled at top depth 1706.5 m and bottom depth 1742.69 in the upper Qishn Clastics formation.

3.3.2.1. Q1 formation - (1706 m - 1719.83 m)

The Q1 mainly composed of shaly sand , the value of sand/sandstone is 88%, the value of clay volume is 22% ,the value of effective porosity is 18.7% ,the value of water saturation is 40% ,the value of hydrocarbon saturation is 60% ,the value of thickness is 13.33 m. for more details are shown in **Fig 3-4**.

3.3.2.2. Q2 formation- (1719 m - 1732.03 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 65 %, the value of clay volume is 45 %, the value of effective porosity is 8.7 %, the value of water saturation is 84 %, the value of hydrocarbon saturation is 16 %, the value of thickness is 12.2 m (**Fig. 3-4**).

3.3.2.3. Q3 formation- (1732.03 m - 1742.69 m)

The sandstone has the most area of this zone and little of shale (shaly sand) , the value of sand/sandstone is 70% ,the value of clay volume is 29% ,the value of effective porosity is 14.7% ,the value of water saturation is 56.5% ,the value of hydrocarbon saturation is 43.5%, the value of thickness is 10.7 m. For more details are shown in **Fig 3-4**.

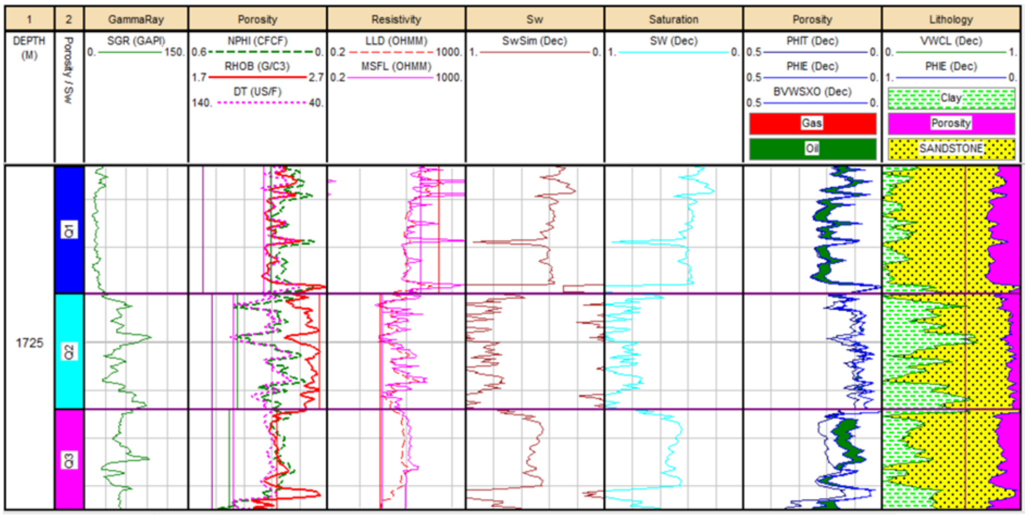

Figure 3-4 Litho-saturation of Qishn formation member in Tasour 4.

3.3.3. Tasour-8 well log Interpretation:

The Tasour - 8 well was the eighth well to be drilled on Block - 32 by DNO as operator. This well was intended as an appraisal well. The well was directionally drilled at top depth **1829.2 m** and bottom depth **1925.8 m** in the upper Qishn Clastics formation.

3.3.3.1. Q1 formation- (1829.2 - 1841.98 m)

The Q1 mainly composed of **shaly sand** , the value of sand/sandstone is **70.5 %**, the value of clay volume is **29.5 %**, the value of effective porosity is **20 %**, the value of water saturation is **9.1 %**, the value of hydrocarbon saturation is **90.9 %**, the value of thickness is **12.78 m**. for more details are shown in **Fig 3-5**.

3.3.3.2. Q2 formation- (1841.98 m - 1888 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 58 %, the value of clay volume is 42 %, the value of effective porosity is 8.7%, the value of water saturation is 68.7 %, the value of hydrocarbon saturation is 31.3%, the value of thickness is 46.1 m. For more details are shown in **Fig 3-5**.

3.3.3.3. Q3 formation- (1888 m - 1925.8 m)

Q3 is mostly sandstone with a little of shale (**shaly sand**), the value of sand/sandstone is **68.6 %**, the value of clay volume is **31.4 %**, the value of effective porosity is **18.9 %**, the value of water saturation is **79.3 %**, the value of hydrocarbon saturation is **20.7 %**, the value of thickness is **37.8 m**. For more details are shown in **Fig 3-5**.

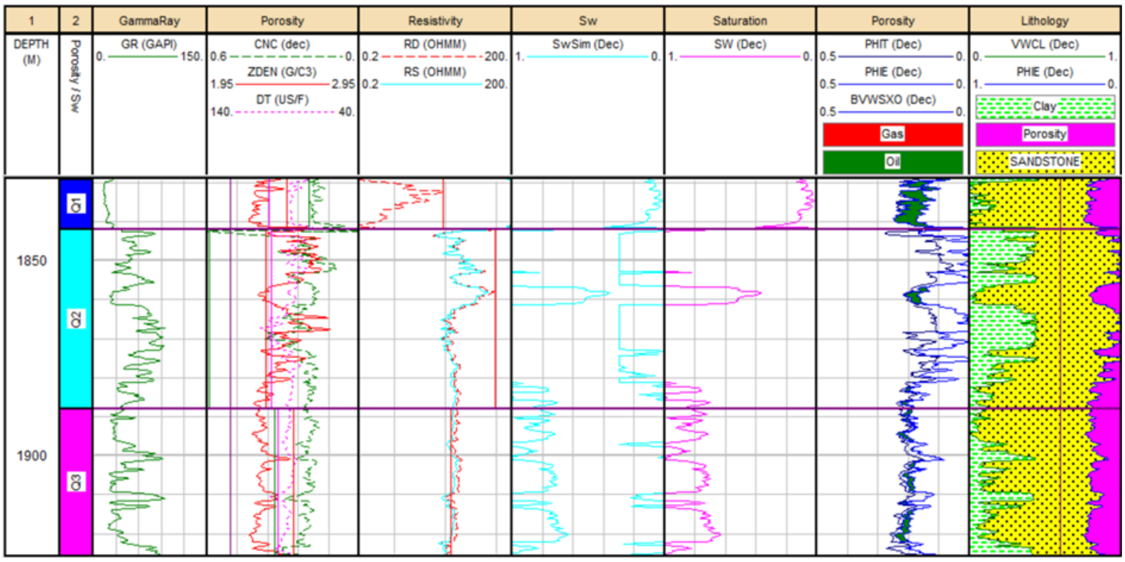

Figure 3-5 Litho-saturation of Qishn formation member in Tasour 8.

3.3.4. Tasour-9 well log Interpretation:

The Tasour-9 well was the ninth well to be drilled on Block 32 by DNO as operator was intended as an appraisal well. The well was vertically drilled at top depth 1708 m and bottom depth 1817.5 m in the upper Qishn Clastics formation.

3.3.4.1. Q1 formation- (1708 m - 1841.98 m)

The most area of this zone is shaly sand , the value of sand/sandstone is 69.8%, the value of clay volume is 30.2% ,the value of effective porosity is 15.3% ,the value of water saturation is 29.1% ,the value of hydrocarbon saturation is 70.9 % ,the value of thickness is 12.44 m. for more details are shown in **Fig 3-6**.

3.3.4.2. Q2 formation- (1720.44 m - 1787.5 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 58.6%, the value of clay volume is 41.4 %, the value of effective porosity is 14.1%, the value of water saturation is 71.6%, the value of hydrocarbon saturation is 28.4%, the value of thickness is 67.06 m, **Fig 3-6**.

3.3.4.3. Q3 formation- (1787.5 m - 1817.5 m)

The sandstone has the most area of this zone and little of shale (shaly sand) ,the value of sand/sandstone is 82% ,the value of clay volume is 18% ,the value of effective porosity is 18.3% ,the value of water saturation is 63.5% ,the value of hydrocarbon saturation is 36.5% ,the value of thickness is 30 m**, Fig 3-6**

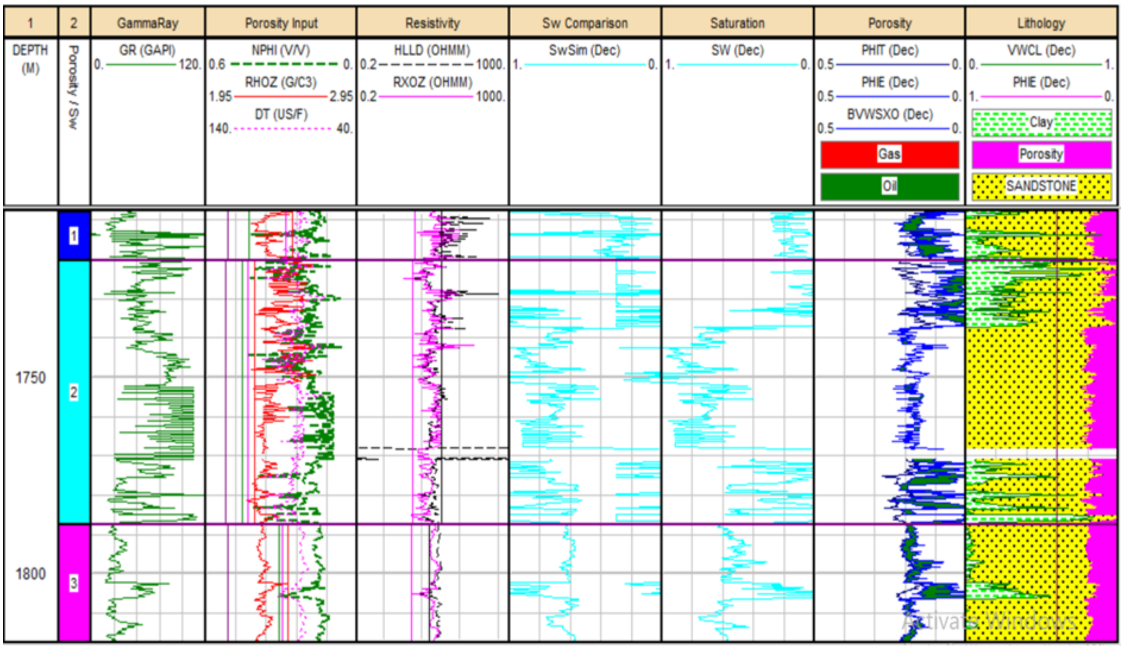

Figure 3-6 Litho-saturation of Qishn formation member in Tasour 9

3.3.5. Tasour-13 well log Interpretation:

The Tasour-13 well was the thirteenth well to be drilled on Block 32 by DNO as operator was intended as an appraisal well. The well was directionally drilled at top depth 1936 m and bottom depth 2024.8 in the upper Qishn Clastics formation.

3.3.5.1. Q1 formation- (1963 m - 1950.42 m)

The most area of this zone is shaly sand, the value of sand/sandstone is 80 %, the value of clay volume is 20 %, the value of effective porosity is 13.5 %, the value of water saturation is 49.3 %, the value of hydrocarbon saturation is 50.7%, the value of thickness is 14.4 m, **Fig 3-7**.

3.3.5.2. Q2 formation- (1950.42 m - 1989.3 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 62.4 %, the value of clay volume is 37.6 %, the value of effective porosity is 12.1 % ,the value of water saturation is 74.3 % ,the value of hydrocarbon saturation is 25.7 % ,the value of thickness is 38.9 m, **Fig 3-7.**

3.3.5.3. Q3 formation- (1989.3 m - 2024.8 m)

The sandstone has the most area of this zone and little of shale (shaly sand) , the value of sand/sandstone is 88 % ,the value of clay volume is 22 % ,the value of effective porosity is 7.1 % ,the value of water saturation is 71.6 % ,the value of hydrocarbon saturation is 28.4 % ,the value of thickness is 35.5 m, **Fig 3-7**.

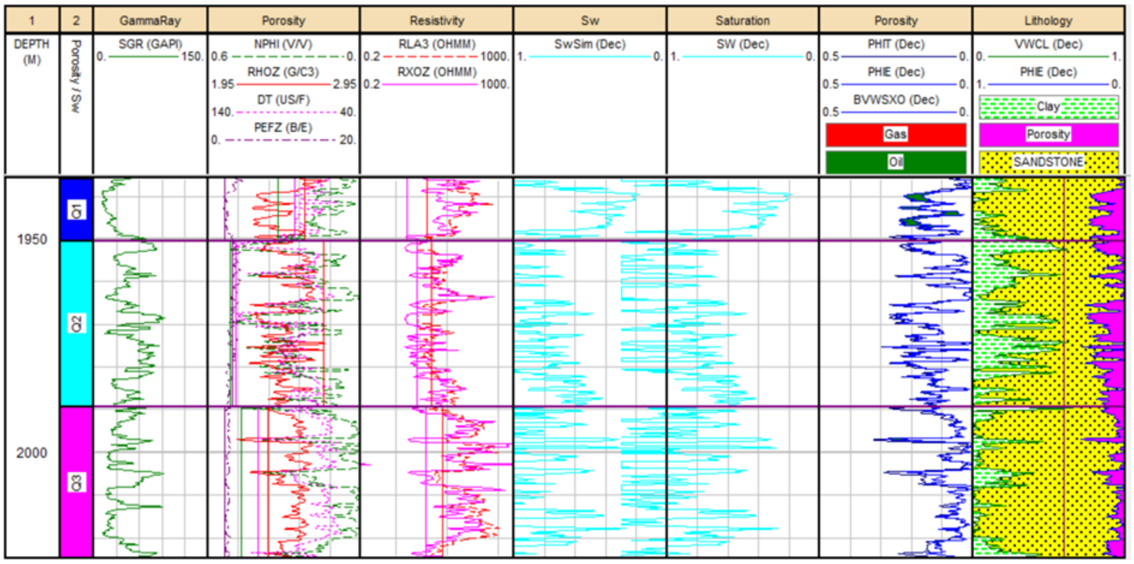

Figure 3-7 Litho-saturation of Qishn formation member in Tasour 13.

3.3.6. Tasour-14 well log Interpretation:

The Tasour-14 well was the fourteenth well to be drilled on Block 32 by DNO as operator was intended as appraisal well. The well was directionally drilled at top depth 1798.9m and bottom depth 1884.4 m in the upper Qishn Clastics formation.

3.3.6.1. Q1 formation- (1798.9 m - 1810.36 m)

The most area of this zone is shaly sand, the value of sand/sandstone is 71%, the value of clay volume is 29%, the value of effective porosity is 12.3%, the value of water saturation is 43%, the value of hydrocarbon saturation is 57%, the value of thickness is 11.5 m. as shown in **Fig 3-8**.

3.3.6.2. Q2 formation- (1810.36 m - 1853.5 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 65.7 %, the value of clay volume is 34.3 %, the value of effective porosity is 9.8 %, the value of water saturation is 68.3 %, the value of hydrocarbon saturation is 31.7 %, the value of thickness is 43.1 m, **Fig 3-8**.

3.3.6.3. Q3 formation- (1853.5 m - 1884.4 m)

The sandstone has the most area of this zone and little of shale (shaly sand) ,the value of sand/sandstone is 74.7 % ,the value of clay volume is 25.3 % ,the value of effective porosity is 10.4 % ,the value of water saturation is 75 % ,the value of hydrocarbon saturation is 25 %, the value of thickness is 30.9 m, **Fig 3-8**.

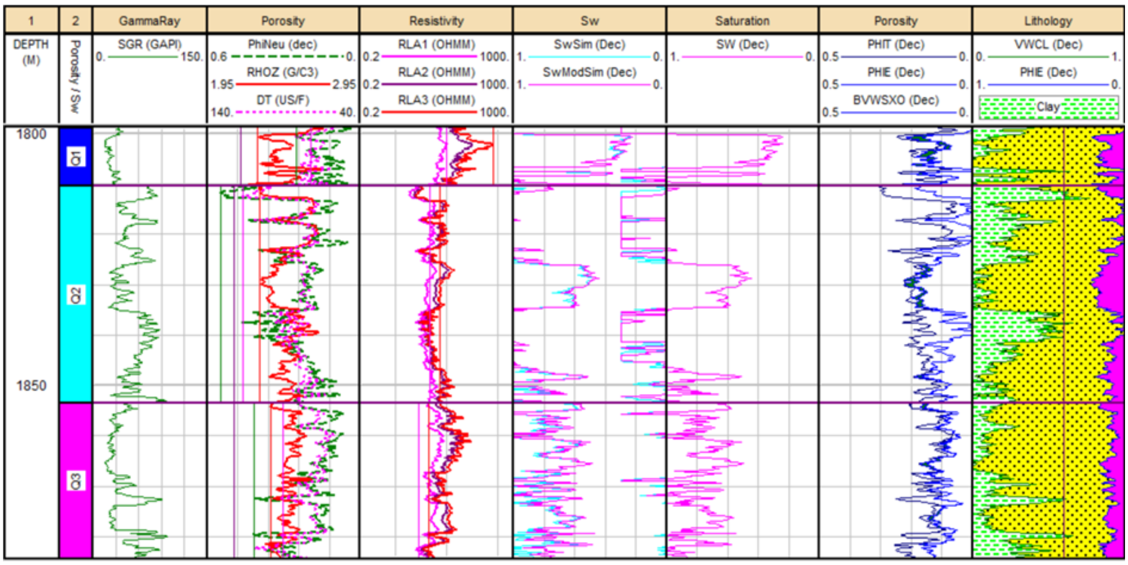

Figure 3-8 Litho-saturation of Qishn formation member in Tasour 14.

3.3.7. Tasour-15 well log Interpretation:

The Tasour-15 well was the fifteenth well to be drilled on Block 32 by DNO as operator was intended as an appraisal well. The well was vertically drilled at top depth 1641.3 m and bottom depth 1715.2 in the upper Qishn Clastics formation.

3.3.7.1. Q1 formation- (1641.3 m - 1652.9 m)

The most area of this zone is shaly sand, the value of sand/sandstone is 81.8 %, the value of clay volume is 18.2 %, the value of effective porosity is 13.3 %, the value of water saturation is 60 %, the value of hydrocarbon saturation is 40 %, the value of thickness is 11.6 m, **Fig 3-9**.

3.3.7.2. Q2 formation- (1652.9 m - 1681.1 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 45.4 %, the value of clay volume is 54.6 %, the value of effective porosity is 6.1 %, the value of water saturation is 87 %, the value of hydrocarbon saturation is 13 %, the value of thickness is 24.2 m, **Fig 3-9.**

3.3.7.3. Q3 formation- (1681.1 m - 1715.2 m)

The sandstone has the most area of this zone and little of shale (shaly sand), the value of sand/sandstone is 61.2%, the value of clay volume is 38.8 %, the value of effective porosity is 20 %, the value of water saturation is 88.9 %, the value of hydrocarbon saturation is 11.1 %, the value of thickness is 34 m, **Fig 3-9.**

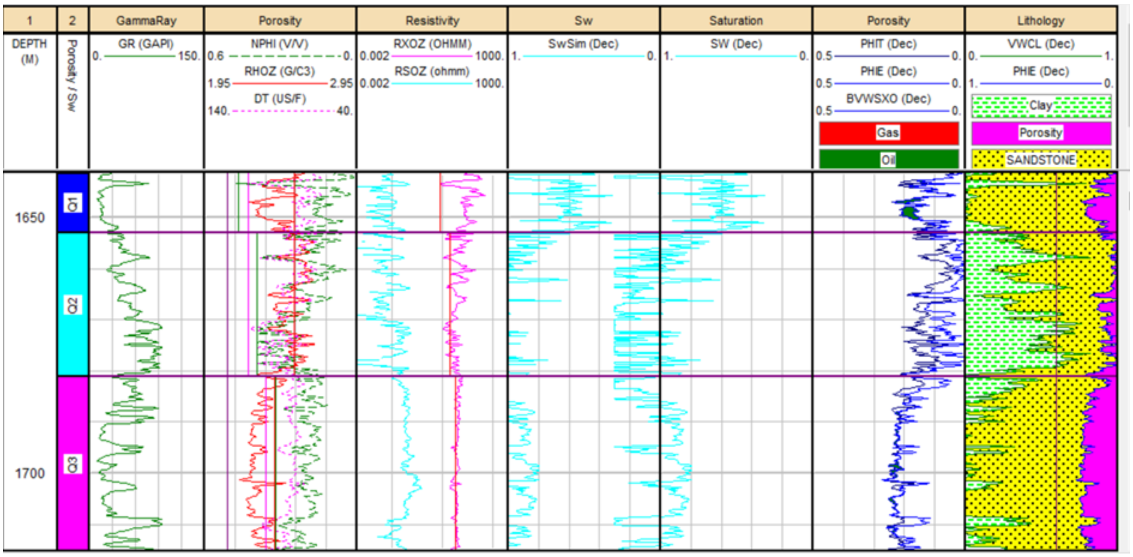

Figure 3-9 Litho-saturation of Qishn formation member in Tasour 15.

3.3.8. Tasour-16 well log Interpretation:

The Tasour-16 well was the sixteenth well to be drilled on Block 32 by DNO as operator was intended as a development well. The well was directionally drilled at top depth 1729 m and bottom depth 1837.8 m in the upper Qishn Clastics formation.

3.3.8.1. Q1 formation- (1729 m - 1742.24 m)

The most area of this zone is shaly sand, the value of sand/sandstone is 78%, the value of clay volume is 22%, the value of effective porosity is 10.5% ,the value of water saturation is 52.6% ,the value of hydrocarbon saturation is 47.4% ,the value of thickness is 13.2 m, **Fig 3-10.**

3.3.8.2. Q2 formation- (1742.24 m - 1807.5 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 40.2%, the value of clay volume is 39.8%, the value of effective porosity is 9.2%, the value of water saturation is 68.5%, the value of hydrocarbon saturation is 31.5%, the value of thickness is 65.3 m, **Fig 3-10.**

3.3.8.3. Q3 formation- (1807.46 m - 1837.8 m)

The sandstone has the most area of this zone and little of shale (shaly sand) , the value of sand/sandstone is 52.6% ,the value of clay volume is 47.4% ,the value of effective porosity is 17% ,the value of water saturation is 54.2% ,the value of hydrocarbon saturation is 45.8% ,the value of thickness is 30.3 m, **Fig 3-10.**

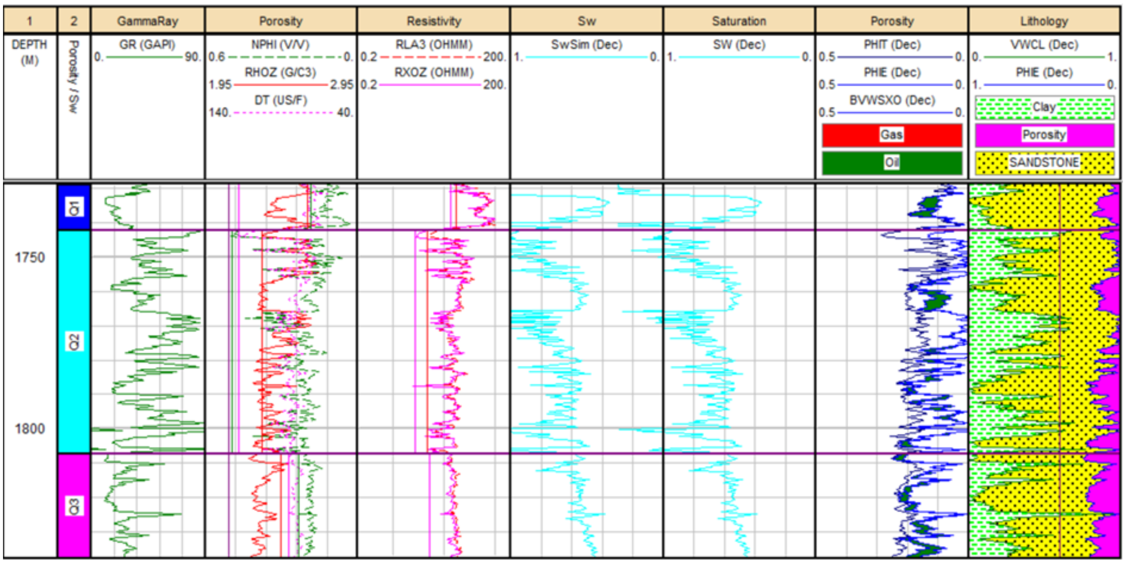

Figure 3-10 Litho-saturation of Qishn formation member in Tasour 16.

3.3.9. Tasour-18 well log Interpretation:

The Tasour-18 well was the eighteenth well to be drilled on Block 32 by DNO as operator was intended as a development well. The well was directionally drilled at top depth 1752 m and bottom depth 1842.1 in the upper Qishn Clastics formation.

3.3.9.1. Q1 formation- (1752 m - 1767.1 m)

The most area of this zone is shaly sand, the value of sand/sandstone is 83.8 %, the value of clay volume is 16.2 %, the value of effective porosity is 18.3 %, the value of water saturation is 35.3 %, the value of hydrocarbon saturation is 64.7 %, the value of thickness is 15.1 m**, Fig. 3-11.**

3.3.9.2. Q2 formation- (1767.1 m - 1802.3 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 64.7 %, the value of clay volume is 35.3 %, the value of effective porosity is 14.5 %, the value of water saturation is 65.2 %, the value of hydrocarbon saturation is 34.8 %, the value of thickness is 35.3 m**, Fig. 3-11.**

3.3.9.3. Q3 formation- (1802.3 m - 1842.1 m)

The sandstone has the most area of this zone and little of shale (shaly sand) , the value of sand/sandstone is 73.3 %, the value of clay volume is 26.7 %, the value of effective porosity is 17.6% ,the value of water saturation is 70.4 %, the value of hydrocarbon saturation is 29.6 %, the value of thickness is 39.8 m**, Fig. 3-11.**

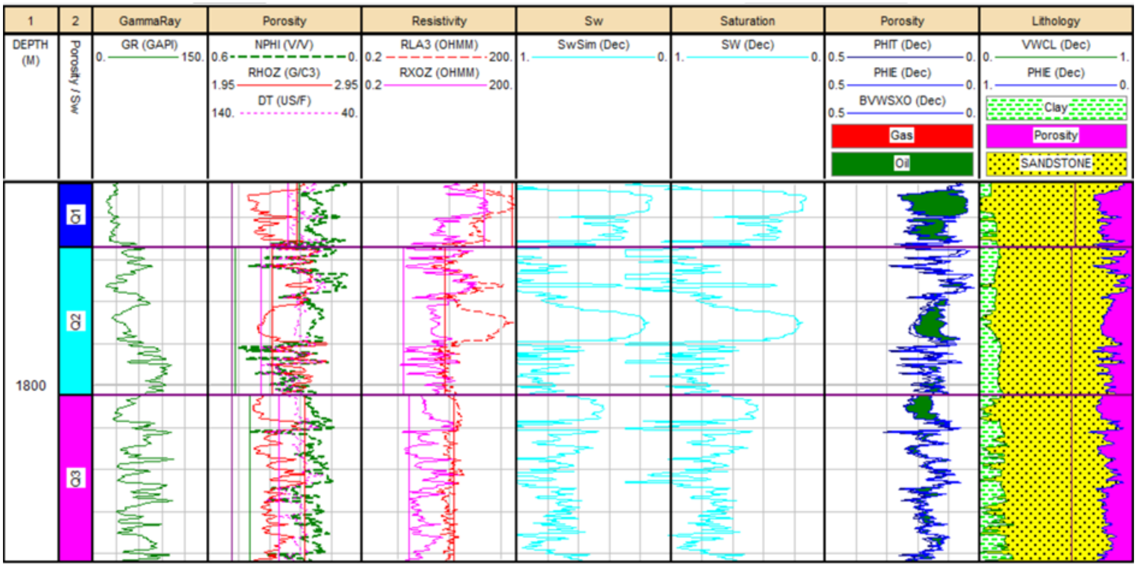

Figure 3-11 Litho-saturation of Qishn formation member in Tasour 18.

3.3.10. Tasour-22 well log Interpretation:

The Tasour-22 well was the twenty second well to be drilled on Block 32 by DNO as operator was intended as a appraisal well. The well was directionally drilled at top depth 1738 m and bottom depth 1816.3 in the upper Qishn Clastics formation.

3.3.10.1. Q1 formation- (1738 m - 1750.8 m)

The most area of this zone is shaly sand, the value of sand/sandstone is 84.6 %, the value of clay volume is 15.4 %, the value of effective porosity is 17.4 %, the value of water saturation is 20.9 %, the value of hydrocarbon saturation is 79.1 %, the value of thickness is 12.8 m. for more details are shown in Fig 4-10.

3.3.10.2. Q2 formation- (1750.8 m - 1781.3 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 69.8 %, the value of clay volume is 30.2 %, the value of effective porosity is 16.8 %, the value of water saturation is 49.4 %, the value of hydrocarbon saturation is 50.6 %, the value of thickness is 30.5 m**, Fig. 3-12.**

3.3.10.3. Q3 formation- (1781.5 m - 1816.3 m)

The sandstone has the most area of this zone and little of shale (shaly sand), the value of sand/sandstone is 79.9%, the value of clay volume is 20.1% ,the value of effective porosity is 18.4% ,the value of water saturation is 42.6% ,the value of hydrocarbon saturation is 57.4% ,the value of thickness is 35 m**, Fig. 3-12.**

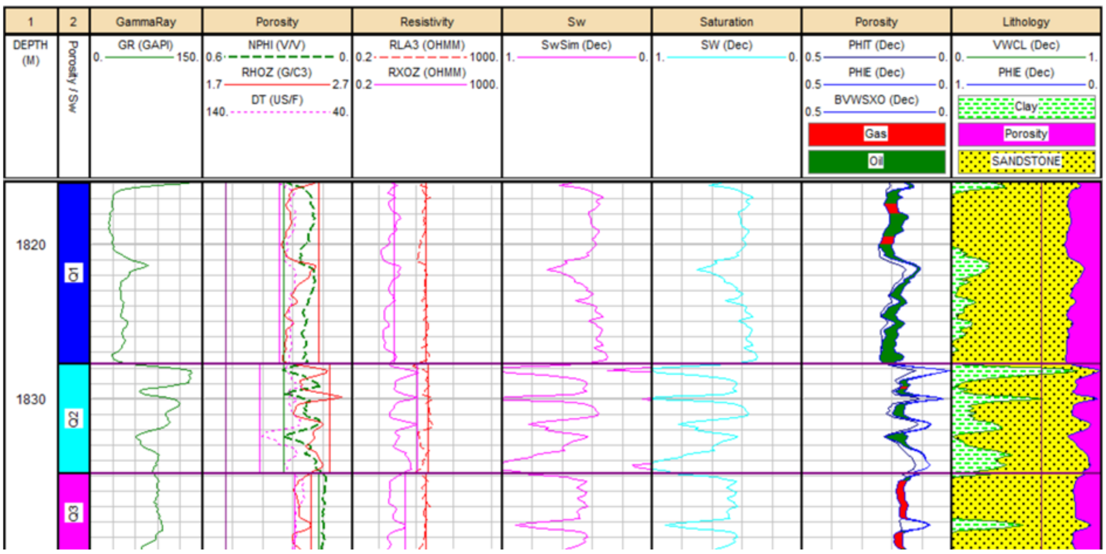

Figure 3-12 Litho-saturation of Qishn formation member in Tasour 22.

3.3.11. Tasour-25 well log Interpretation:

The Tasour-25 well was the fifteenth well to be drilled on Block 32 by DNO as operator was intended as an Infill/Development well. The well was directionally drilled at top depth 1715.7 m and bottom depth 1861.8 m in the upper Qishn Clastics formation.

3.3.11.1. Q1 formation- (1715.7 m - 1727.45 m)

The most area of this zone is shaly sand, the value of sand/sandstone is 59%, the value of clay volume is 41%, the value of effective porosity is 20.7%, the value of water saturation is 9%, the value of hydrocarbon saturation is 91%, the value of thickness is 11.7 m**, Fig. 3-13.**

3.3.11.2. Q2 formation- (1727.45 m - 1769.82 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 71.2 %, the value of clay volume is 28.8 %, the value of effective porosity is 14.5 %, the value of water saturation is 27.2 %, the value of hydrocarbon saturation is 72.8 %, the value of thickness is 42.4 m**, Fig. 3-13**

3.3.11.3. Q3 formation- (1769.82 m - 1816.8 m)

The sandstone has the most area of this zone and little of shale (shaly sand) ,the value of sand/sandstone is 58 %, the value of clay volume is 4 %, the value of effective porosity is 18.3 %, the value of water saturation is 21.5 %, the value of hydrocarbon saturation is 78.5 %, the value of thickness is 47 m**, Fig. 3-13.**

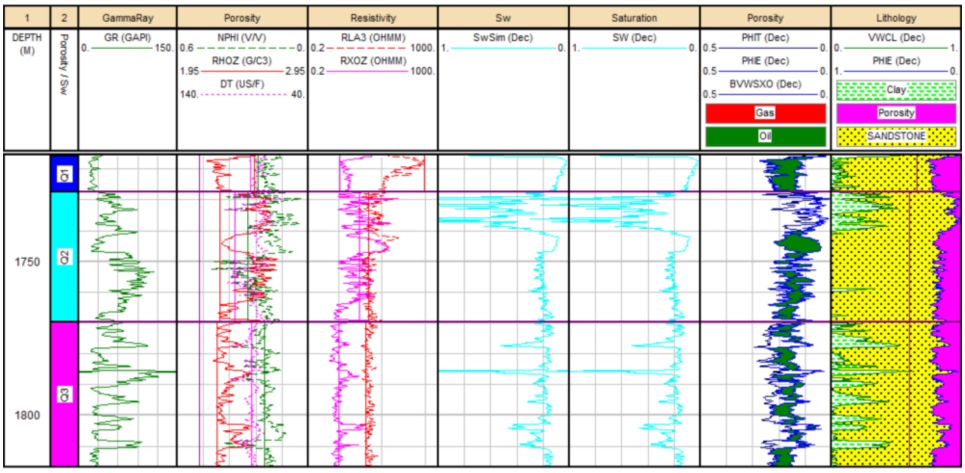

Figure 3-13 Litho-saturation of Qishn formation member in Tasour 25.

3.3.12. Tasour-26 well log Interpretation:

The Tasour-26 well was the fifteenth well to be drilled on Block 32 by DNO as operator was intended as an Infill/Development well. The well was directionally drilled at top depth 1823.5 m and bottom depth 1905 m in the upper Qishn Clastics formation.

3.3.12.1. Q1 formation- (1823.5 m - 1838.5 m)

The most area of this zone is shaly sand, the value of sand/sandstone is 65.6 %, the value of clay volume is 34.4 %, the value of effective porosity is 15.5 %, the value of water saturation is 13 %, the value of hydrocarbon saturation is 87 %, the value of thickness is 15 m**, Fig. 3-14.**

3.3.12.2. Q2 formation- (1838.5 m - 1872.9 m)

The Q2 mainly composed of sandstone and shale (shaly sand), the value of sand/sandstone is 40.1%, the value of clay volume is 59.9 %, the value of effective porosity is 5.1 %, the value of water saturation is 53.2 %, the value of hydrocarbon saturation is 46.8 %, the value of thickness is 34.4 m**, Fig. 3-14.**

3.3.12.3. Q3 formation- (1872.9 m - 1905 m)

The sandstone has the most area of this zone and little of shale (shaly sand) ,the value of sand/sandstone is 59.2% ,the value of clay volume is 40.2% ,the value of effective porosity is 17.5% ,the value of water saturation is 25.4% ,the value of hydrocarbon saturation is 74.6% ,the value of thickness is 32.1 m**, Fig. 3-14.**

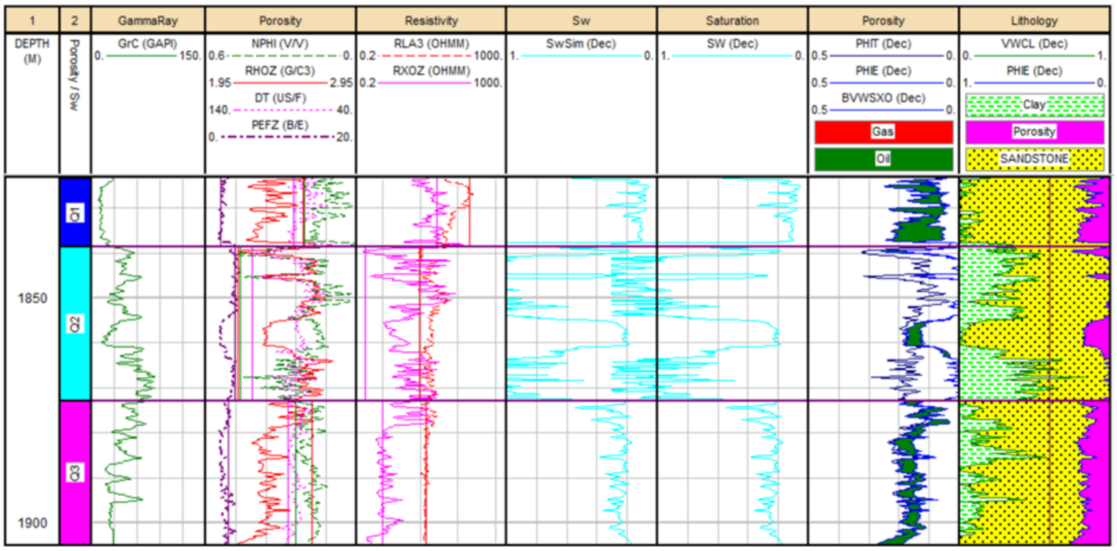

Figure 3-14 Litho-saturation of Qishn formation member in Tasour 26.

CHAPTER FOUR

4. SUMMARY AND CONCLUSION

4.1. INTRODUCTION

In This study the reservoir characterization of Upper Qishn formation member in Tasour field block 32 Masilah basin which are based on well log geophysical analysis of the reservoirs and hydrocarbon potentialities by applying the analysis for twelve wells (Tasour 1, Tasour-4, Tasour-8, Tasour-9, Tasour-13, Tasour-14, Tasour-15, Tasour-16, Tasour-18 Tasour-22, Tasour-25, Tasour-26).

4.2. Summary

Characterization of upper Qishn reservoir clastic member in Tasour field block 32 Masilah basin.

This study we subdivided the upper Qishn clastic into three formations (Q1, Q2, Q3). The zonation process had done based on the reading of Gamma Ray (GR) log.

4.2.1. Characterization of Upper Qishn reservoir clastic member:

4.2.1.1. The Upper Qishn Reservoir Clastic Q1:

The Q1 is mainly composed of sandstone with a little amount of interbedded shale. The percent of sand/sandstone ranges from 59 – 94 % and the average of sandstone is about 76.33 %, the value of the effective porosity ranges from 10 - 20 % and the average effective porosity is about 16.32 % , the value of saturation water ranges from 9 – 60 % and the average saturation is about 31.23 %, the values of hydrocarbon saturation ranges from 40 – 91 % and the average value is about 68.76 %, the value of clay volume ranges from 6 – 41 % and the average is about 23.67 %, the value of thickness ranges from 11 - 15 m, and the average is about 12.92 m. This is represented by well logs collected from Tasour-1, Tasour-4, Tasour-8, Tasour-9, Tasour-13, Tasour-14, Tasour-15, Tasour-16, Tasour-18 Tasour-22, Tasour-25, Tasour-26.

4.2.1.2. The Upper Qishn Reservoir Clastic Q2:

The Q2 is mainly composed of sandstone with interbedded shale. The percent of sand/sandstone ranges from 40.1 - 71.2 %, and the average of sandstone is about 59.9

%, the value of the effective porosity ranges from 5.1 - 20.5 % and the average effective porosity is about 11.68 %, the value of saturation water ranges from 27.2 - 84 % and the average saturation is about 66.45 %, the value of hydrocarbon saturation ranges from 13 - 72.8 % and the average value is about 33.55 %, the value of clay volume ranges from 28.8 - 59.9 % and the average is about 40.1 %, the value of thickness ranges from 12.2 - 67.06 m, and the average is about 39.24 m. This is represented by well logs collected from Tasour-1, Tasour-4, Tasour-8, Tasour-9, Tasour-13, Tasour-14, Tasour-15, Tasour-16, Tasour-18 Tasour-22, Tasour-25, Tasour-26.

4.2.1.3. The Upper Qishn Reservoir Clastic Q3:

The Q3 is mainly composed of sandstone with a little amount of interbedded shale. The percent of sand/sandstone ranges from 52.3 - 85.3 %, and the average of sandstone is about 70.3 %, the value of the effective porosity ranges from 14.7 - 20.3 % and the average effective porosity is about 16.54 % ,the value of saturation water ranges from 21.5 - 88.9 % and the average saturation is about 60.2 %,the value of hydrocarbon saturation ranges from 11.1 - 78.5 % and the average value is about 39.82 %,the value of clay volume ranges from 14.7 - 47.4 % and the average is about 29.7 %, the value of thickness ranges from 10.7 - 47 m, and the average is about 34.12 m. This is represented by well logs collected fromTasour-1, Tasour-4, Tasour-8, Tasour-9, Tasour-13, Tasour-14, Tasour-15, Tasour-16, Tasour-18 Tasour-22, Tasour-25, Tasour-26.

4.3. Conclusion

The general matrix of the Upper Qishn Clastic unit consists of sandstones interbedded with minor mud stone, siltstone and limestone intercalations. This unit is considered the major reservoir of Masilah basin hydrocarbon-bearing. From this study we subdivided the upper Qishn clastic into three zones (Q1, Q2, Q3).

Table. 4-1, **Table. 4-2**, and **Table. 4-3** show the conclusion of the characterization for the Q1, Q2, and Q3 respectively for each well.

Table 4-1 Characterization of Upper Qishn Clastic - Zone Q1

No.	Well	Top m	Bottom m	Thickness m	Sh %	Sw %	Porosity E %	Vsh %
1	**Tasour 1**	1648.7	1659.8	11.1	86.5	13.5	20.3	6.1
2	**Tasour 4**	1706.5	1719.83	13.33	60	40	18.7	22
3	**Tasour 8**	1829.2	1841.98	12.78	90.9	9.1	20	29.5
4	**Tasour 9**	1708	1720.44	12.44	70.9	29.1	15.3	30.2
5	**Tasour 13**	1936	1950.42	14.4	50.7	49.3	13.5	20
6	**Tasour 14**	1798.9	1810.36	11.5	57	43	12.3	29
7	**Tasour 15**	1641.3	1652.9	11.6	40	60	13.3	18.2
8	**Tasour 16**	1729	1741.4	13.24	47.4	52.6	10.5	22
9	**Tasour 18**	1752	1767.1	15.1	64.7	35.3	18.3	16.2
10	**Tasour 22**	1738	1750.8	12.8	79.1	20.9	17.4	15.4
11	**Tasour 25**	1715.7	1727.45	11.7	91	9	20.7	41
12	**Tasour 26**	1823.5	1838.5	15	87	13	15.5	34.4
Mean		--------	----------	**12.92**	**68.76**	**31.23**	**16.32**	**23.67**

Table 4-2 Characterization of Upper Qishn Clastic - Zone Q2

No.	Well	Top m	Bottom m	Thickness m	Sh %	Sw %	Porosity E %	Vsh %
1	**Tasour 1**	1659.8	1691.2	31.4	20	80	20.5	32
2	**Tasour 4**	1719.83	1732.03	12.2	16	84	8.7	45
3	**Tasour 8**	1841.98	1888	46.1	31.3	68.7	8.7	42
4	**Tasour 9**	1720.44	1787.5	67.06	28.4	71.6	14.1	41.4
5	**Tasour 13**	1950.42	1989.3	38.9	25.7	74.3	12.1	37.6
6	**Tasour 14**	1810.36	1853.5	43.1	31.7	68.3	9.8	34.3
7	**Tasour 15**	1652.9	1681.1	24.2	13	87	6.1	54.6
8	**Tasour 16**	1742.24	1807.5	65.3	31.5	68.5	9.2	39.8
9	**Tasour 18**	1767.1	1802.3	35.3	34.8	65.2	14.5	35.3
10	**Tasour 22**	1750.8	1781.3	30.5	50.6	49.4	16.8	30.2
11	**Tasour 25**	1727.45	1769.82	42.4	72.8	27.2	14.5	28.8
12	**Tasour 26**	1838.5	1872.9	34.4	46.8	53.2	5.1	59.9
Mean		----------	----------	**39.24**	**33.55**	**66.45**	**11.68**	**40.1**

Table 4-3 Characterization of Upper Qishn Clastic - Zone Q3

No.	Well	Top m	Bottom m	Thickness m	Sh %	Sw %	Porosity E %	Vsh %
1	**Tasour 1**	1691.2	1737.4	46.2	26.7	73.3	20.3	14.7
2	**Tasour 4**	1732.03	1742.69	10.7	43.5	56.5	14.7	29.8
3	**Tasour 8**	1888	1925.8	37.8	20.7	79.3	18.9	31.4
4	**Tasour 9**	1787.5	1817.5	30	36.5	63.5	18.3	18
5	**Tasour 13**	1989.3	2024.8	35.5	28.4	71.6	7.1	22
6	**Tasour 14**	1853.5	1884.4	30.9	25	75	10.4	25.3
7	**Tasour 15**	1681.1	1715.2	34	11.1	88.9	20	38.8
8	**Tasour 16**	1807.46	1837.8	30.3	45.8	54.2	17	47.4
9	**Tasour 18**	1802.3	1842.1	39.8	29.6	70.4	17.6	26.7
10	**Tasour 22**	1781.5	1816.3	35	57.4	42.6	18.4	20.1
11	**Tasour 25**	1769.82	1816.8	47	78.5	21.5	18.3	42
12	**Tasour 26**	1872.9	1905	32.1	74.6	25.4	17.5	40.2
Mean		----------	----------	34.12	39.82	60.2	16.54	29.7

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