Implementing of well log data to Identify Lithology of Lidam formation in Gialo oil field *(Sirte basin, NE Libya)*

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ABSTRACT

This paper discuses identifying of lithology of The Lidam carbonate reservoir of Gialo oil Field in Sirte basin by means of well log data. The Lidam Formation is unconformably overlies the Nubian formation and underlies Lower Sirte shale representing an age Cenomanian time (U. Cretaceous).
In this study, well log data analysis has been performed. The analysis includes values of gamma ray, resistivity, neutron, density and sonic log data. This analysis is being obtained from different types of logging tools. These values of well log data are plotted on several diagrams of Schlumerger. This shows different location of sedimentary facies and mineral composition of the studied formation according to their content of elements which reflect particular rock type. Available well log data on Lidam reservoir rock suggest that the formation in this area is an average thickness about 90 feet included limestone, dolomite and anhydrite. The studied interval of Lidam reservoir is dominated by sediments interpreted as Lagoonal to tidal flat setting (supratidal, intertidal and subtidal environments).

Keywords: Well logs, lithology, Lidam Formation, Gialo, Sirte basin

INTRODUCTION

Well log data is an important tools in the direct measurement and evaluation of reservoir rock. In this study reservoir properties analysis is made. The study of the lithology of the Lidam Formation in Gialo Field of the eastern part of Sirte basin is the task of this study. This paper presents a major analytical data-base and observation of thin section acquired form core samples from the subsurface in the Lidam formation in the study area. Besides investigation of different logs response on the lithology. The Lidam is present also at eastern Sirte Basin in the Masrab area, at western Sirte Basin in Khalifa area and in the Bahi area of central Sirte Basin. The well log data is used for the evaluation of the Lidam formation in the study area (Figure 1).

Study area (The Gialo oil field)

The study area is located in the Gialo Field, concession NC 59E in the eastern Sirte basin, Libya (Figure 1) this study is based on the well 3V4-59E is the target. In general this area is a relatively flat, sandy plain with a low relief.

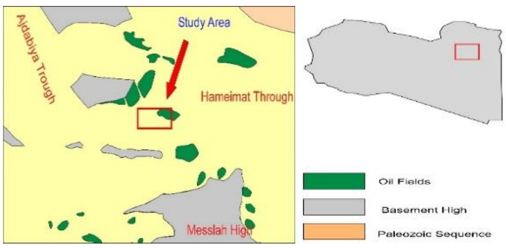


Figure 1: Show Location map of Study Area (modified after Wintreshall Oil Company 2002).

Geological setting

The study area has been affected by the tectonic and structural setting of the Sirte Basin and consequently the thickness of the sediments distribution controlled accordingly. The thick sediments deposited in low area (grabens) and thin sediments on high area (horsts). The deep reservoir of Lidam Formation has been affected and controlled by that tectonic and rifting of Sirte Basin. The Structure configuration of study area represents anticline structure, extending east-west direction and bounded by major normal faults.

Stratigraphic framework of the study Area:

The oldest sedimentary formation that has been penetrated in the area is the Cambro /Ordovician Gargaf Quartzite, while the youngest Oligocene sandstone of the Diba formation.

The Lidam formation is unconformable overlies the Nubian formation and underlies lower Sirte shale representing an age Cenomanian time (U. Cretaceous) (figure 2). A general stratigraphic column is illustrated in figure 2. It is composed of the following Stratigraphic units:

a) Nubian Formation (Sarir Sandstone equivalent):

Nubian Formation (Jurassic-Lower Cretaceous) consists of non-marine sandstones distributing in Sirt Basin, particularly in the southeastern. It is unconformable contact with underlying granitic basement volcanics or various Lower Paleozoic formations, and overlying various marine Upper Cretaceous formations (Barr and Weegar, 1972).

b) Lidam Formation:

This formation in general consists of dolomite, Limestone, anhydrite, and shale. The Lidam formation represents the earliest marine deposit in many part of Sirt Basin. The Lidam Formation is found mainly in the principal trough areas of the Sirt Basin where it attains a maximum thickness of about 600' (Barr and Weegar, 1972). However in this study is as thick as 80 feet (table 1). This formation will be more discussed later.

Table 1: The Formation Tops of the Lidam Formation in the study area, Sirt Basin.

Name of well		Well 3V4-59E
Top	(KB)ft	10134
Bottom	(KB)ft	10214
Thick (Ft)		80

c) Sirte shale:

The Sirte Shale (Campanian to Early Maastrichtian) consists of a shale sequence with thin limestone interbeds. In the eastern part of Sirte Basin; it consists of calcareous shales with dolomite and sandy interbeds. The shale contains zones with very high radioactive values, which coincide with the zones of maximum organic richness.

Previous studies

The subsurface geological history of the Sirte Basin was studied by many geologists of oil companies since late 1950's. All oil companies have been searching and exploration for hydrocarbons in their blocks and concessions; however, most if not all of their detailed reports are considered confidential and unpublished.

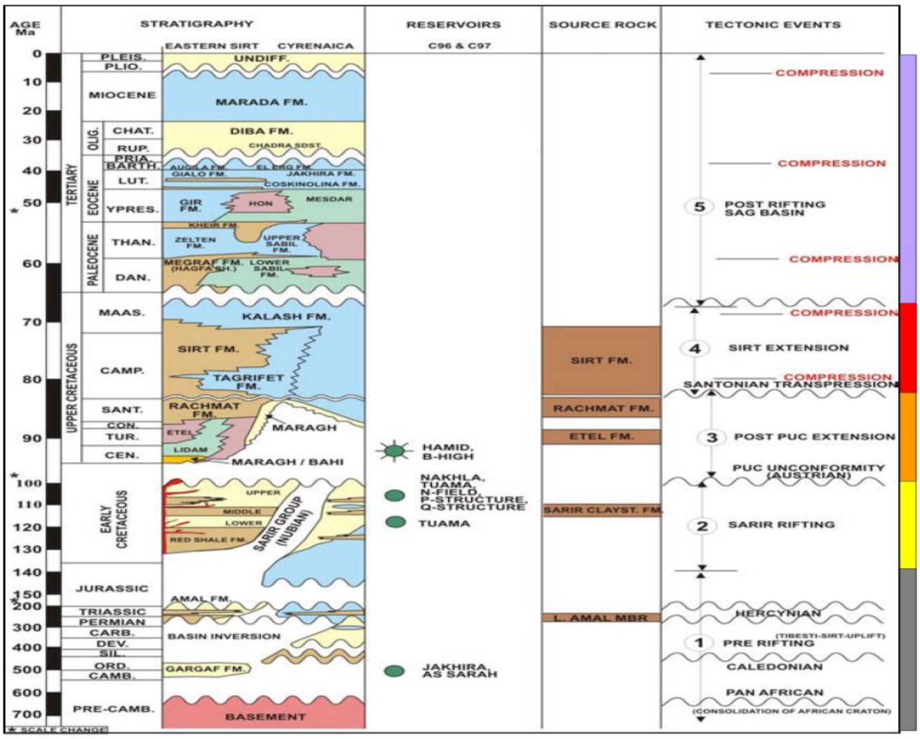


Figure 2: Geologic Column of the Study area, Sirt Basin (Barr and Weegar, 1972).

MATERIALS AND METHODS

The materials used in this paper are based on data compiled from the wireline log data and petrographical thin sections of the reservoir rocks in area.

In this study, the Geological, petrophysical properties and content of mineralogy of the Lidam formation in concessions 59E has been discussed.

.**Table (2)**; Equations and methods that used in the Petrophysical analysis on the units of Lidam Formation Gialo Field**.**

$I_{GR} = \frac{GR\max - GR\log}{GR\max - GR\min}$
$V_{sh} = 0.33\left(2^{\left(2*I_{GR}-1.0\right)}\right)$
$\rho maa = \frac{\rho b\log - \phi t * \rho f}{1-\phi t}$
$\Delta t_{maa} = \frac{\Delta t\log - \phi t * \Delta tf}{1-\phi t}$
$Umaa = \frac{Pe\rho e - \phi tUf}{1-\phi t}$
$\rho e = \frac{\rho b + 0.1883}{1.0704}$
$\phi_d = \frac{\rho b_{\log} - \rho b_{ma}}{\rho b_f - \rho b_{ma}}$
$\phi_S = \frac{\Delta t_{\log} - \Delta t_{ma}}{\Delta tfl - \Delta t_{ma}}$
Vsh = volume of shale, $\mathbf{I_{GR}}$ = gamma ray index, $\mathbf{GR_{log}}$ = gamma ray log API, $\mathbf{GR_{max}}$ = gamma ray in front of shale, $\mathbf{GR_{min}}$ = gamma ray in front of clean formation, **Δtlog** = sonic log reading from log, **Δtfl** = travel time in fluid = 189µsec/ft (salt mud), **ρblog** = Bulk density log reading from log, **ρbfl** = density value of fluid (1.1g /cc), **Φn** = neutron porosity of the formation from compensated neutron, **Φnf** = neutron porosity of fluid (use 1.0), $\mathbf{\rho_{maa}}$ = an apparent grain density, $\mathbf{\Delta t_{maa}}$ = an apparent matrix transit time, $\mathbf{\Phi_t}$ = apparent total porosity, **Pe** is photoelectric absorption cross section Index.

DISCUSSION

Interpretation the depositional environment of Lidam Formation by well log data:-

The relationships of resistivity log and log porosity (neutron, sonic and density logs) can be used as an indicator of the type of facies type as well as lithology which in turn reflect depositional environment.

Based on deep Resistivity verses Neutron porosity log of Asquith 1983 (figure 3).The lithofacies of the Lidam Formation are low to medium energy; intertidal and subtidal carbonate evaporates sediments. Additionally the types of carbonates are Oolitic wackestone and argillaceous bioclastic wackestone according to resistivity verses sonic porosity of Asquith 1983 (Figure 4).

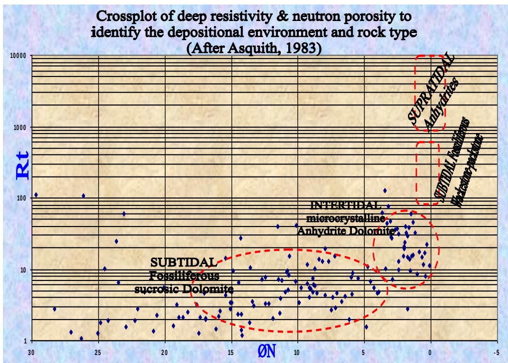


Figure 3. The Crossplot of deep resistivity vs. neutron porosity to identify the depositional environment and rock type, the well 3V4-59E in the study area

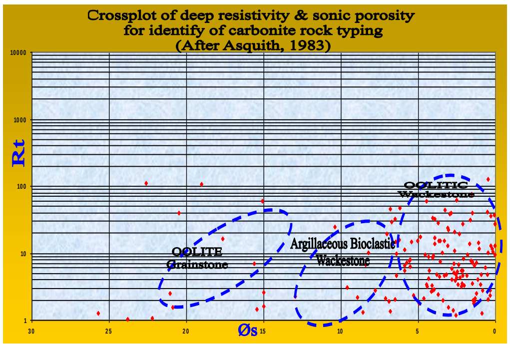


Figure 4. The crossplot of deep resistivity vs. sonic porosity to identify carbonate rock type, the well 3V4-59E in the study area.

Qualitative evaluation of lithology (Lithology identification from Crossplot):

Identifying of lithology present in the formation based on well log data is indirect method. The cross plot technique which based on log data is commonly used to identify the occurrence of mineralogy which in turn lithology information.

Calculation of volume of shale

The presence of shale in a reservoir can cause erroneous values for water saturation and porosity derived from logs. Therefore shale volume must calculated and excluded from the reservoir matrix which has the effective porosity. Also connate water in clay minerals maybe added erroneously to water saturation. The shale volume of Lidam formation in well 3V4-59E is determined from gamma ray log using formula of Schlumberger 1974. Mostly of the Lidam Formation is clean (6.3%). (Figure 7)

Table 3: Shows the Averages Shale Volume in well 3V4-59E in the study Area, Sirt basin.

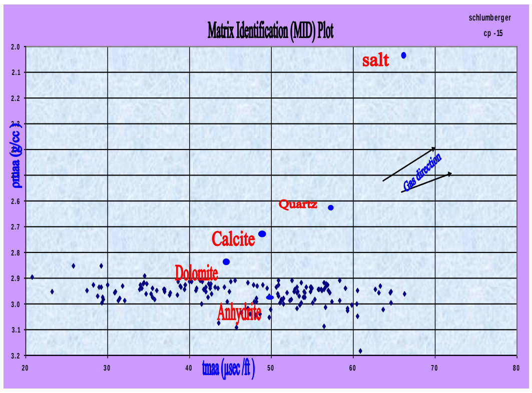
From logs	Well 3V4-59 E
Volume of shale %	6.3

The MID Crossplot:

The MID matrix identification crossplot requires data from neutron, density and sonic logs. Figure 5 shows the relationship between Δt_{maa} and ρ_{maa} of data from Lidam formation, cluster together in the end – members: anhydrite, dolomite, and limestone.

U_{maa} can be determined from the chart (CP-14). Figure 6 shows, the relationship between (U_{maa} and ρ_{maa}) of data from Lidam formation, cluster together in the end – members: anhydrite, dolomite. In this case, lithology is varies from dolomite to dolomitic Limestone. Notice that few of the data points are above the dolomite-limestone line, indicating secondary porosity from vugs and /or fractures.

Figure 5. The MID plot (ρmaa vs. tmaa) of data from Lidam Formation of the well 3V4-59E in



the Study Area

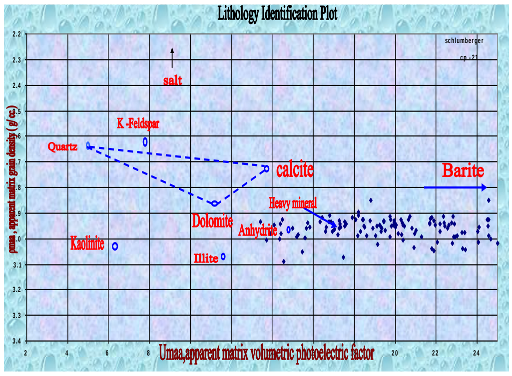


Figure 6. The MID plot (Umaa vs. tmaa) of data from Lidam Formation of the well 3V4-59E in the study Area

The Porosity Cross plot:-

1- The Density - Neutron Crossplot:

This type of crossplot is used for binary mixtures of sandstone and limestone, limestone and dolomite, dolomite and anhydrite, as well as sandstone and shale, in figure 7. In this case, lithology is varies from dolomite to dolomitic Limestone. Notice that most of the data points are under the dolomite- limestone line

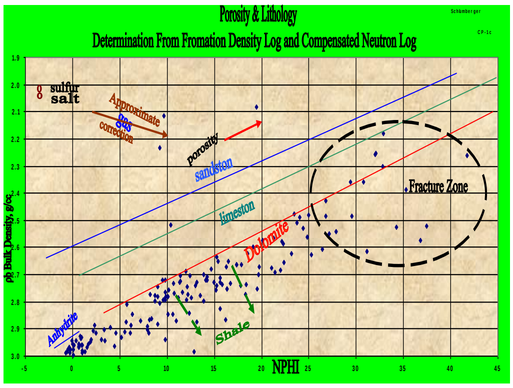


Figure 7. Illustrates the relationship between Formation density Log and neutron Log of data from Lidam Formation of the well 3V4-59E in the study area

2- Sonic - Neutron Crossplot:

The sonic – compensated neutron cross plot which uses the Wyllie time average equation used typically for binary mixtures of sandstone and limestone or limestone and dolomite (Figure 8). However, the sonic – compensated neutron cross plot is not particularly useful in fractured or vuggy formation.

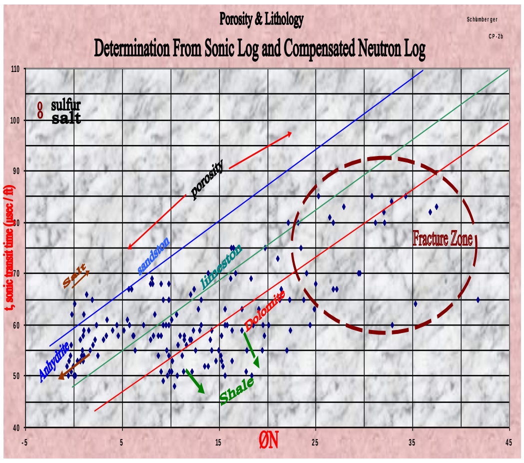


Figure 8. Illustrates the relationship between sonic log and neutron Log of data from Lidam Formation of the well 3V4-59E in the study area.

1- Density - Sonic Crossplot:

The density - sonic cross plot which uses the Raymer – Hunt – Gardner equation for the sonic density relationship. These are sued typically for binary mixtures of sandstone and limestone or limestone and dolomite with gypsum, trona, salt, or sylvite. The data from Lidam formation cluster in the region of dolomite, anhydrite, however some data points scattered around limestone and gypsum region.

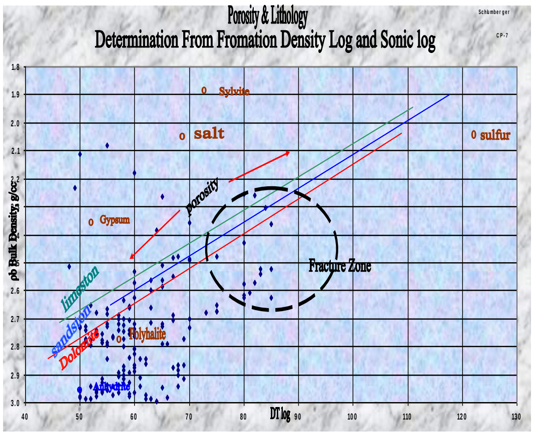


Figure 9. Illustrates the relationship between formation density log and sonic log of data from Lidam Formation of the well 3V4-59E in the study area.

Lithology identification from core analysis:

Core analysis can provide much information about lithology. In this paper the well log based interpretation is supported by thin section in well 3V4-59E.

Petrographical analysis:

The two thin sections based observation of studied Lidam Formation in the well 3V4-59E give information as following:

The thin section of the Lidam formation in well 3V4-59E at depth (10179 ft) as in thin section figure 10 shows the majority of minerals are calcite and dolomite with fractures filled with anhydrite. figure 11 is a thin section at depth (10141 ft) fractures filled with anhydrite in calcite and dolomite matrix.

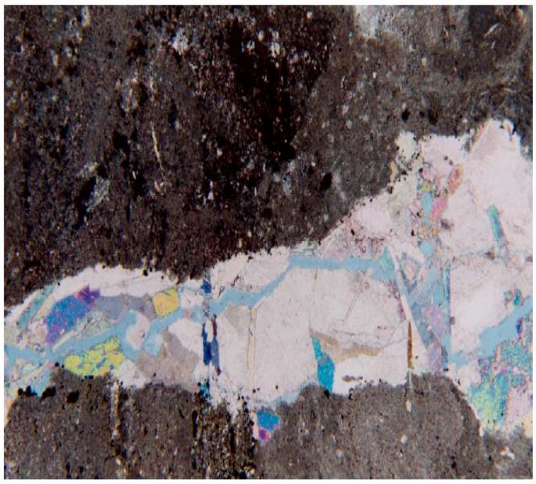


Figure 10. Shows large fracture is partially filled with blocky anhydrite dolomite limestone lithofacies, 12.5X, PPL, 3V4-59E (10479 ft) (After Waha Oil Company 2004).

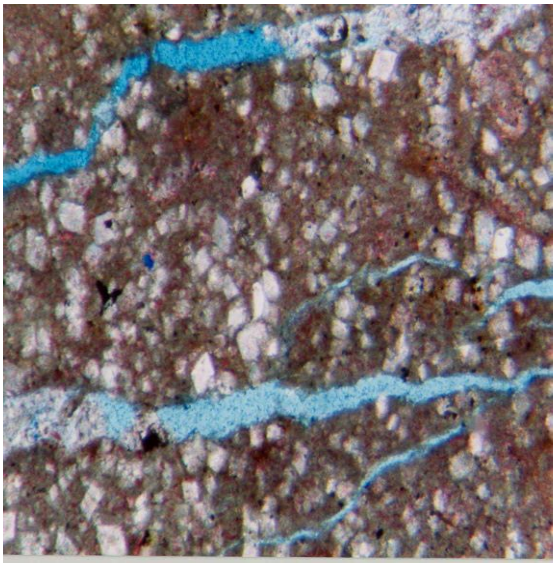


Figure 11. Shows fractures by thin section for Lidam Reservoir of the Well 3V4-59E (10141 ft) 10X, PPL, (After Waha Oil Company 2004)

Table 2: Shows the Zone Parameters of Well 3V4 59E in the Study Area, Sirt Basin.

Name	Δt (μs / ft)		GR (API)		NPHI		ρb(gm/cm³)	
Mineral or lithology type	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Total Porosity	**189**	185 230	**0.0714**	00 5.0	**0.973**	0.90 1.0	**1.0341**	0.90 1.2
Dolomite	**45**	42 50	**25**	11.5 45	**0.0056**	-0.02 0.025	**2.87**	2.87 2.90
Calcite	**49**	40 51	**20**	10 62	**-0.0112**	-0.05 0.02	**2.71**	2.68 2.78
Anhydrate	**54**	53 56.6	**00**	00	**-0.0063**	-0.007 -0.005	**3.04**	2.98 3.16
Shale	**73**	63 85	**85**	35 220	**0.259**	0.10 0.43	**2.52**	2.30 2.74
Value of Theoretical.	81.68		33.19		0.26		2.59	
Value from log.	80		35		0.22		2.58	

CONCLUSION

The Lidam reservoir mainly composed of limestone, dolomite, anhydrite and shale, both qualitative and quantitative well logs analysis will be widely elaborated along the study area.

Certainly, different rocks have different responses for different logs. The responses are a function of the characteristics of a different minerals present in the rock type and their relation volume in the studied zone on the one hand, and on the kind of fluids occupying the pore spaces or the others. These concepts are exploited to estimate the lithological model.

A given lithological model at a certain depth of reservoir rock is composed of the main mineral plus other mineral impurities in addition to pore volume filled by fluid or fluids.

Obviously, the Lidam Carbonate reservoir rock lithological model is characterized by calcite, as the main mineral, plus two or three other components, including porosity filled by fluid.

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