Palacký University Olomouc

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Application of Well Logging Data to Determine Petrophysical Properties of Shiranish Formation

Bachelor thesis

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Petroleum Engineering (B0724A330002)

Fulltime study

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Dedication

This research is dedicated to our dear parents, who have continuously provided their moral, spiritual, emotional, and financial support. They have served as our source of inspiration, guidance, and strength when we have felt like giving up.

To our friends who helped us overcome obstacles and acted as our supporters. They motivate us to complete this crucial study on schedule. They constantly send us messages of encouragement.

To our professors who had faith in our ability to complete our study on schedule, helped us improve our research, and motivated us with their own inspirational experiences as students.

Finally, we devoted this book to our mighty God, who provides strength, mental power, protection, and abilities. All of this, we offer to you

In Olomouc, June 28, 2023

…………………………………………

Chalang Nawzad Mohamed

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENT

First of all, I would like to thank my beloved family and parents for supporting me throughout my years of education and helping me surpass. Then I would like to thank the university of Palacky for giving me this opportunity to prove myself and take their knowledge back and hopefully spread it and put it to good use, I would also like to thank my supervisor Prof. Ondrej Babek for this opportunity to be my supervisor for my final project, thanks to Mr. Hussein Hussein for being a great advisor and putting a lot of time and effort into this final year with me. Also thank to Dr. Reber Mahmood for helping us out a lot this year at the university. And I would also like to thank all of my teachers throughout my four years of studying. Also a big thank you to all of my friends who showed support and last but not least I would like to thank God.

ABSTRAKTNÍ

Vlastnosti lze odhadnout pomocí protokolů studní, jako je odpor hornin, rychlost zvuku, hustota. Zaznamenaná data pak mohou být interpretována pro stanovení litologie a pórovitosti penetrovaného útvaru. Studniční kulatiny se také používají pro stanovení horního a spodního kontaktu formace. Hlavním cílem této studie je stanovení fyzikálních vlastností útvaru (nádrže), litologie, objemu břidlice a pórovitosti. Vzhledem k nedostatku moderního vybavení, jako je Borehole Televiewer a vzorky hornin, jsou konvenční metody těžby z vrtů zásadní pro identifikaci petrofyzických parametrů a v podstatě pomáhají při charakterizaci a vylepšení nádrže. V této studii byla pro své petrofyzické rysy použita formace Liassic Shiranish na ropném poli Tawke v severním Iráku. Neutron-Density Crossplot k nalezení litologie, gama záření k určení objemu břidlice, Sonic log a hustota log se používají k nalezení pórovitosti a lomové pórovitosti jsou jen některé z různých metod, které byly zkombinovány.

Formace Shiranish vytvořila dobrou pórovitost a lomovou pórovitost s pórovitostí 20 % - 25 % maximální hodnoty z logaritmu hustoty a sonického logaritmu.

Podle gama paprsku má útvar nízké gama záření, které je kolem 20 API a nízký objem břidlice v první zóně, ale pro druhou zónu se objem břidlice zvyšuje na 28% a možná není formace čistá a zahrnuje jíl minerály a také gama záření je kolem 50 API. Data ukazují dvě zóny, z nichž první má dosah mezi 2692 a 2625 metry a druhá začíná.

Po pečlivém zvážení a pochopení z dat těžby z vrtů jsme dospěli k závěru, že formace je formace s nízkým obsahem břidlic a má dobrou kvalitu. V první zóně dosahuje pórovitost 20 %, což je dobrá kvalita pro formování. Ve druhé zóně však podle záznamu posuvného měřítka, který ukazuje vymytí v okolí vrtu a rozsah pórovitosti je příliš velký, nemůžeme údajům v této oblasti věřit.

ABSTRACT

The petrophysicalproperties can be estimated using well logs such as rocks resistivity, sonic velocity, density. The recorded data can then be interpreted to determine the lithology and porosity of the penetrated formation. Well logs are also used for determining the upper and lower contact of formation. The main objective of this study is to determine the physical properties of the formation (reservoir), Lithology, shale volume, and porosity.

Due to the lack of modern equipment like the Borehole Televiewer and rock samples, conventional well logging methods are essential in the identification of petrophysical parameters and essentially help in reservoir characterization and enhancement. In this study, the Liassic Shiranish Formation in the Tawke oil field, northern Iraq, was used for its petrophysical features. The Neutron-Density Crossplot to find lithology, Gamma ray to determine shale volume, Sonic log, and density log are used to find porosity and fracture porosity are just a few of the diverse methodologies that have been combined.

The Shiranish Formation has established good porosity and fracture porosity with Porosity 20%- 25% of maximum value from density log and sonic log respectively.

According to the gamma ray, the formation has a low gamma ray which is around 20 API and low shale volume in the first zone, but for the second zone the volume of shale increases to 28% and possibly the formation is not pure and includes clay minerals, and also the gamma ray is around 50 API. The data shows two zones, the first of which has a range between 2692 and 2625 meters, and the second of which is starting.

After careful consideration and understanding from the well logging data, we concluded that the formation is a low shale formation and has a good quality. In the first zone, the porosity reaches 20%, which is a good quality for the formation. However, in the second zone, according to the caliper log, which shows wash out around the well and the range of porosity is too great, we cannot trust the data in this area.

Klíčová slova: Shiranish Formation, těžba vrtu, charakteristika nádrže, pórovitost

Keywords: Shiranish Formation, well logging, reservoir characteristics, porosity

Number of pages: 43

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CHAPTER ONE: INTRODUCTION

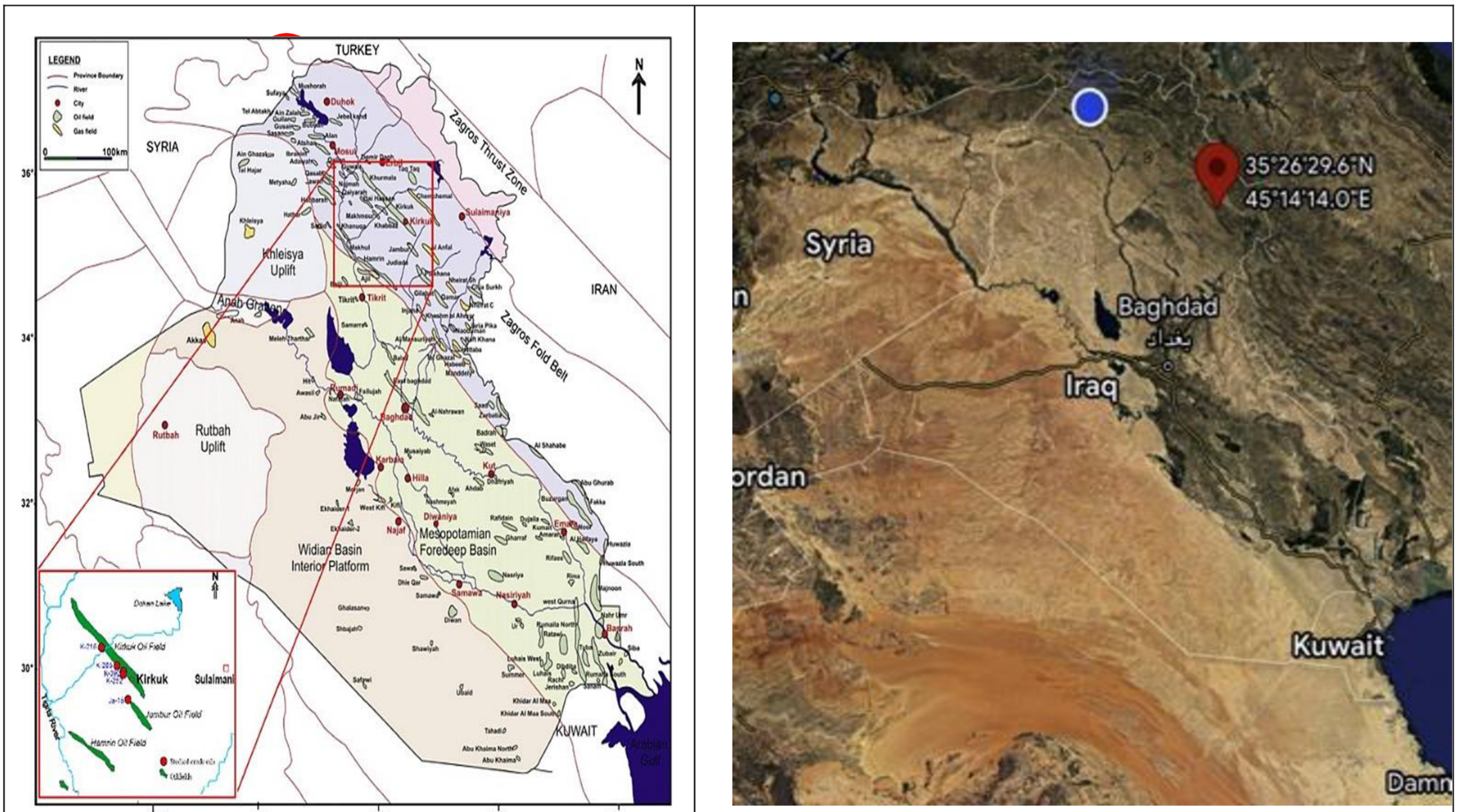
1.1 Preface

In the most reservoir characterization studies, log data are used as the main tool for evaluating the formations in the study. The advantage of this work, in addition to previous work done on the studied formations, is to receive as much as possible of other available data.

1.2 Study Field

In northern Iraq, the Upper Campanian - Maastrichtian Shiranish Formation is regarded as an essential fractured carbonate reservoir (Znad, Rabeea KH, Saddam Essa Mostafa, and Mahmood AH Al-Sumaidaie., 2020), however it is not productive when not fractured. One of the primary pay zones in the Tawke Field is created from fractured limestone of the Shiranish Formation (Garland, Abalioglu,, Akca, Cassidy, and Hiffoleau, , 2010). Oil has also been extracted from the fractured Shiranish Formation in the Ain Zalah and Butmah fields, as well as from the Kirkuk Field's Baba dome in northern Iraq.

Tawke Oilfield is located in Iraq's Low Folded Zone and structurally comprises of a longitudinal, asymmetrical anticline approximately 29 km long and 11 km broad (Baban, and Ranyayi, 2013). The anticline is readily apparent on the surface, as Miocene sandstones crop out, forming ridges roughly 13 km long and 7 km wide. The Formation is deposited under the sabkha environment..



Khabaz and Tawke field

Zewe field (red point)

Figure 1.1: Location map of the studied Field

1.2.1 Shiranish Formation

The Shiranish Formation was defined at northeast of Zakho close to the village of Shiranish Islam from the High Folded Zone of Iraqi Kurdistan by Henson 1940 in (Bellen, Dunnington, Wetzel, and Morton, 1959).

The shelf and shoal limestones of the Kolosh Formation (Paleocene-Eocene) overlying marine clastics constitute the major seal to the Cretaceous fractured reservoirs at a depth of roughly 1000m below sea level (BSL). The Jurassic age of the source rocks for Tawke oil has been demonstrated: this is consistent with regional research (Pitman, Steinshouer, and Lewan,2003). that reveal the Naokelekan and Sargelu Formations to be the principal source rocks in northern Iraq. Prior to the major compressional phase of Zagros folding, they began producing hydrocarbons in the Miocene (Ameen,1991).

The Shiranish Formation is the bottom section of a regional transgressive-regressive depositional sequence from the Upper Cretaceous (Campanian and Maastrichtian) that flooded much of Iraq (Dunnington, 1958). Abundant fossils corroborate the formation's Late Campanian-Maastrichtian age (Znad, Rabeea KH, Saddam Essa Mostafa, and Mahmood AH Al-Sumaidaie., 2020), and based on the identified foraminifera species in the Hijran area, the age of the Shiranish Formation may be stretched to the Paleocene (Hammoudi, 2011). Shiranish Formation is made up of fine-grained thin-bedded limestone with individual bed thicknesses ranging from 0.4 to 1.5m. In the lowest section, they are deep water marly limestone (Saadooni, 1996). There are multiple shallow-water intervals inside the centre of the formation at the type site in the Shiranish area (Al-Qayim, B, 1992).

The formation in the Mergasur area is mostly composed of mudstone, wackestone, and packstone microfacies deposited in a deep marine, pelagic (open sea) decreased depositional environment (Abdula, Balaky, Khailani, Miran, Muhammad, and Muhamad, 2018). The exposed 228m of the formation on the southwestern limb of the Sarah anticline is made up of six primary facies that depict depositional conditions ranging from the middle shelf to the middle bathyal (Malak, Z.A, 2015).

Shiranish Formation's top border with the underlying Tanjero Formation is conformable and gradational. According to (Karim, Ismail, and Ameen, B.M, 2008), the border with the overlying Tanjero Formation and the upper section of the Kometan Formation are part of the same depositional sequence and were all formed in a massive foreland basin that covered most of Iraq during the late Cretaceous.

Shiranish Formation is 225m thick in the type section, but varies from 100 to 400m thick in the other places , with a thickness of 1300m for the formation cited by (Homci, 1975) in the area between Hemrin and Mandali. The drilled wells in the Tawke Oilfield reveal Shiranish Formation thicknesses ranging from 220 to 355m (Awdal, Braathen, Wennberg, and Sherwani, 2013).

1.3 Previous Works

Bellen et al (1959): The Formation is composed essentially of bedded anhydrites with subordinate intercalations of brownish chemical limestones and of black calcareous shales and greenish marls, both with anhydrite nodules. And described type locality and locations, it is locality is in well X-1 lat. 30° 10° 30° N and long. 42° 49° 00° E, it is named after the well. The Formation represents an almostpure lagoonal evaporitic facies. Fossils were found exceptionally only. A detailed determination has not been made till now. The fossil assemblages consist of gastropod and echinoid debris, rare small *Ostracods, Lituolids Nodosaria sp. and Glomospira sp.*The exact age of the formation is uncertain. Based on regional correlation a Liassic (probably Upper) age was presumed.

Ponikarov et al (1967): Both the lower and upper contacts of the Formation are gradational and conformable. The Formation is distributed throughout the Foothill and Mesopotamian Zones of the Mobile Shelf and. along the edges of the Stable Shelf in Iraq and Syria to the north of and around the Euphrates River. On the remaining parts of the Stable Shelf of Iraq the Formation is missing. In the extreme southwest it is probably replaced by the equivalents of the terrigenous Marrat Formation.

Ditmar et ale (1971): Throughout the High Folded, Imbricated and Northern Thrust Zones of the Unstable Shelf the Formation is replaced by parts of the Sehkaniyan Formation. The boundary between these two facies is actually unknown.

Buday (1980): the studied intervals Shiranish, Mus, Alan, Sehkhaniyan Formations belong to theUpper Triassic-Middle Jurassic Cycle (Liassic-Doggerian Subcyclye) in Iraq.

Buday (1980) and Jassim (2006): The Formation presents in Mesopotamian and Foothill Zones and Anah graben and it is absent in Northwest Iraq. The Formation replaced by lower part of Sehkaniyan Formation throughout High Folded, Imbricated and Northern Thrust Zones.

Kaddouri (1989): determined the age of Butmah, Shiranish, Mus, and Alan in his stratigraphic study for the Mesozoic and Cenozoic in Sinjar depression, North West of Iraq.

Alsharhan and Nairn (1997): The Jurassic evaporites play only a minor role as cap rock, the Kolosh anhydrite is a tight seal for oil and gas accumulations in the Butmah limestone in Sufaya field of the Zagros basin.

Ziegler (2001): has argued that early evaporites (Shiranish and Alan) are interbedded with argillaceouslimestone and shallow-marine shales (Mus) on the edge of the Mesopotamian basin.

Pitman et al (2004): modified from verma et al (2004) gave the Shiranish Formation a doubted seal character and designate Mus Formation as both oil and gas reservoir.

Pitman et al (2004), Jassim and A1-Gailani (2006): There are no adequate previous studies of the geochemical characterization of the Alan, Mus, and Shiranish Formations, though reservoir characteristics of the Liassic interval.

Jassim et al (2006): The Formation has age equivalents in Western Iraq (upper part of Hussainiyat Formation) and High Folded, Imbricated and Northern Thrust Zones (Lower part of Sehkaniyan Formation) and in neighboring countries Syria (Upper Dolaa Group), Saudi Arabia (Marrat Formation); and Iranian Zagros (Neyriz Formation).

Jassim and Goff (2006): When North Arabian Plate subsidence slowed in Late Norian-Mid Toarcian evaporates (Alan, Mus, Shiranish) and shallow water lagoonal carbonates were deposited across the Mesopotamian basin.

Jassim and A1-Gailani (2006): The Alan, Mus, X, and Butmah Formations have some reservoir characteristics due to the presence of oil shows in the fractured part.

Jassim and Buday (2006): Determined the environment of the Shiranish Formation as sabkha environment.

Aqrawi et al (2009): The massive evaporites, associated shales, and argillaceous limestones in the Shiranish Formation potentially provide good seals although they have not acted as a seal for any hydrocarbon accumulation in the region.

Mustafa (2009): Believe that the Shiranish Formation contains type II kerogen oil prone.

1.4 Aims of Study

This study aims to demonstrate the petrophysical properties (lithology, shale content, and porosity) of the Shiranish Formation in kurdistan Field which is located in the north of Iraq area, and evaluate its quality from reservoir points of view. As a result, subdividing the examined formation into discrete reservoir units and then characterizing and analyzing each unit will be the best strategy to achieve the goal.

1.5 Methodology

The methods that used in this study can be classifieds into two main groups according to the obtained data.

1.5.1 Rock Sample

Rock sample is used to describe lithology of the formation. In this study, samples were taken from the lower part of the formation and the distance between two samples was 5 meters, therefore rock samples were taken for 50 m intervals at the lower part of the Shiranish formation and thin sections were made using blue resin to assess porosity and microfacies.

1.5.2 Well Log Data

In this study, different kinds of logs were used to determine, and estimate rock properties, indexes, and variables in order to evaluate the studied reservoir beds as precisely as possible. Various software, such as Logplot and Get Data Graph Digitizer, were used in digitizing and plotting log data. In addition to the conventional softwares like Excel, Grapher, Adob Illustrator, Geographic Information System (GIS) also were used in this study.

- Sonic Log
- Density Log
- Caliper Log
- Gamma Ray Log
- Neutron Log

CHAPTER TWO: LITHOLOGICAL ASPECT AND SHALE CONTENT

2.1 Lithology Determination from Porosity Logs

No single measurement of the tool will give an impression of lithology by itself. However, by integrating the measurements of more than one porosity tool, a lot of useful information can be gathered (Bateman, 1985). It is difficult to use both neutron and density logs separately for lithology identification, but if they are combined, they are likely to become the best available predictor (Rider, 2002). For the evaluation of a reservoir, determination of the lithology of the rock Formation is important. The solid (matrix) component of a rock is also defined by lithology (Hughes, 1992). Usage of the neutron log is to quantify the volume of hydrogen in the Formations, which is assumed to be related to porosity. The Density Log is used to calculate the density of electrons and from that, when the two logs are used, the Formation bulk density lithology can be calculated collectively (Asquith and Krygowski, 2004).

2.2 Neutron-Density Crossplot

Simply put, a cross plot is a set of multiple log measurements. For example, this plot is composed of density and neutron logs, with the neutron log expressed in limestone porosity unitsplotted on the (X axis) and the density log plotted on the (Y axis), with the scale reversed, this plot is traditionally called (N-D) cross plot. There are three diagonal lines plotted in this cross plot, each representing a different lithology type: Dolomite, calcite (limestone), and quartzmatrix with water filled porosity (Edmundson and Raymer, 1979).

It was found that lithologies are Limestone and sandstone in the Shiranish Formation (Figure 2.1 shows N-D crossplot chart.

The lithology of Shiranish Formation appears to be mostly Limestone, and Sandstone inparts, it found by cutting. That lithology are found by logs are like that lithology are found by rock sample. Figure 2.2 shows the lithology column that founded by the rock sample and N-D crossplot chart of the studied field.

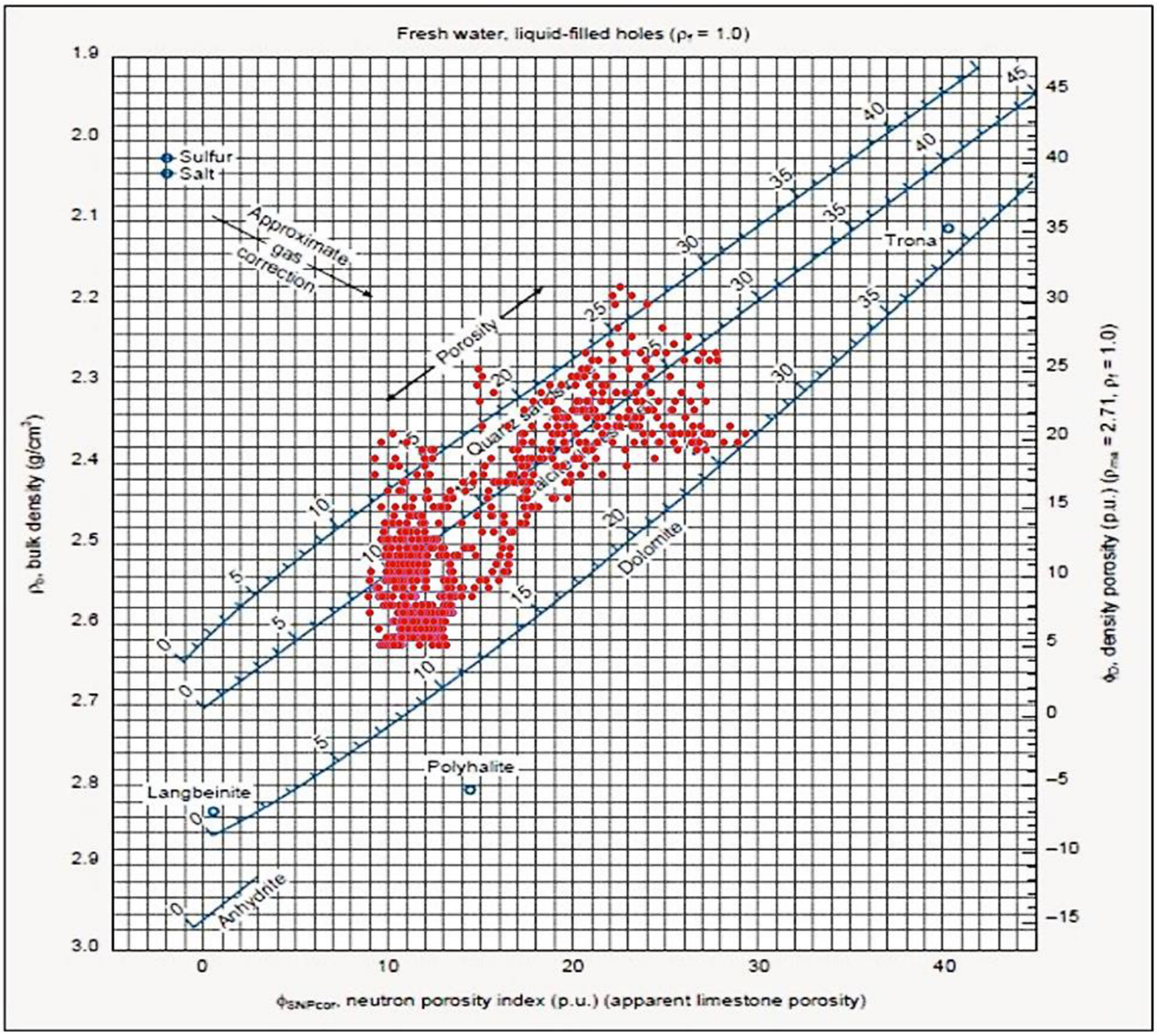


Figure 2.1: Neutron-Density crossplot to estimate lithology of the studied Formation

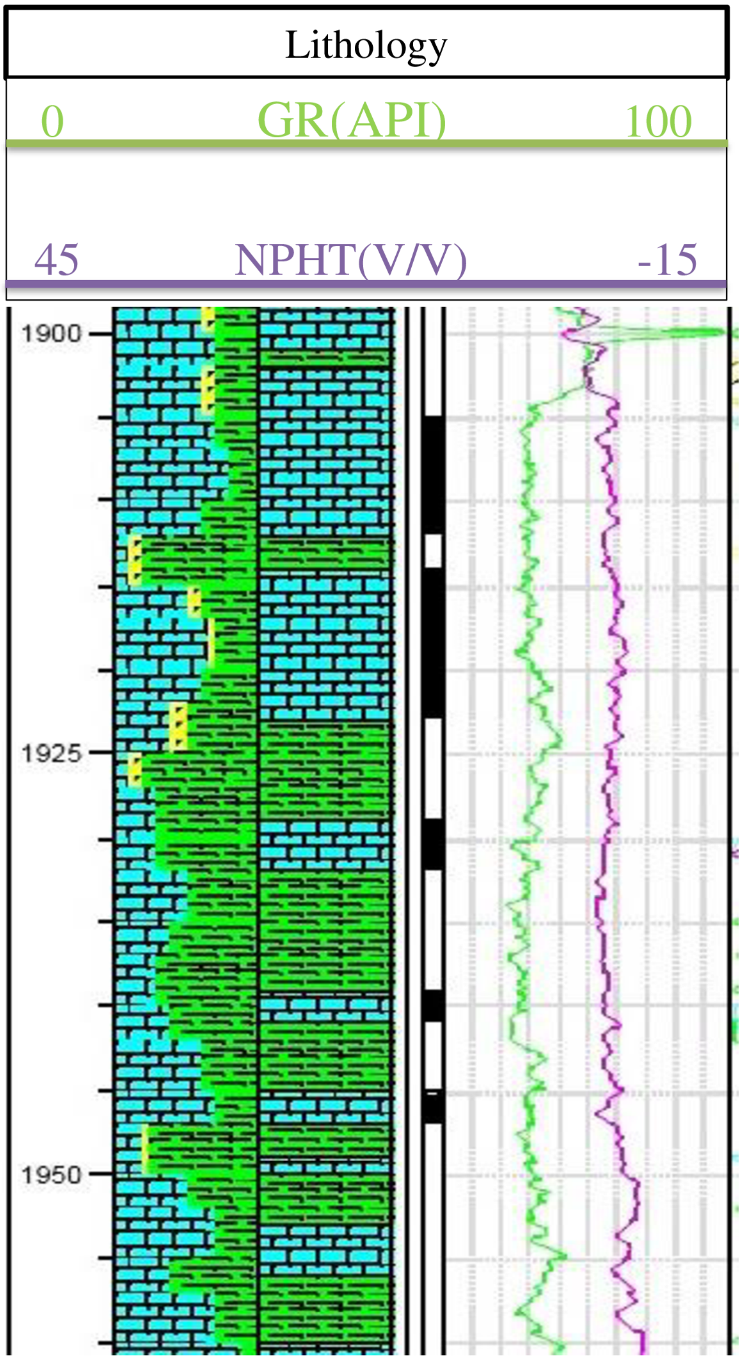


Figure 2.2: Lithology column from rock sample and log data to estimate lithology

2.3 Caliper Log

In well log analysis, the caliper log, or log of the borehole diameter, is important. A borehole cannot maintain the same drilled diameter from bottom to top due to the different physical properties of the lithologies being drilled and the various forces involved in drilling. Strata that are soft, friable, or fractured are prone to caving (James et al., 1916; Stefansson and Steingrimsson, 1990).

As the caliper arms are spring loaded the tool preferentially opens to the maximum hole diameter, in an ellipse along the major axis. It may, As a result, it could be useful to use a tool has four arms in order to get a more precise idea of the hole shape and volume. These influence the porosity and permeability of the rock and hence determine whether a mud cake will develop and its thickness, leading of course to a reduced hole diameter. Note here that while some caliper tools cut through the mud cake and therefore measure to the borehole wall, while others ride on it. The bedding, shale distribution, and the possibility of micro-fractures caused by drilling and radial cracking away from the borehole (as with consolidated shales and carbonate laminae) are all determined by the texture and structure of the Formation (Abbott and Haydn, 1984).

As the diameter of the borehole varies up the hole, the arms of the tool will expand or contract to record the changes. This expanding and contracting motion is transmitted to a rheostat within an oil-filled chamber, where the change in resistance of the rheostat is always proportional to the change in average borehole diameter. The change in resistance of the rheostat is then picked up as a signal and transferred to a recorder (James and Stephen , 1916).

In this study the caliper log is used as lithology indicator. There is a huge enlargement that showed by caliper log (Fig.2.3) in the borehole wall, so the borehole enlargement and presence of fresh based mud can be a good indicator to present soluble Formation. This can be used to validate the lithologies that derived from rock cutting samples and log data.

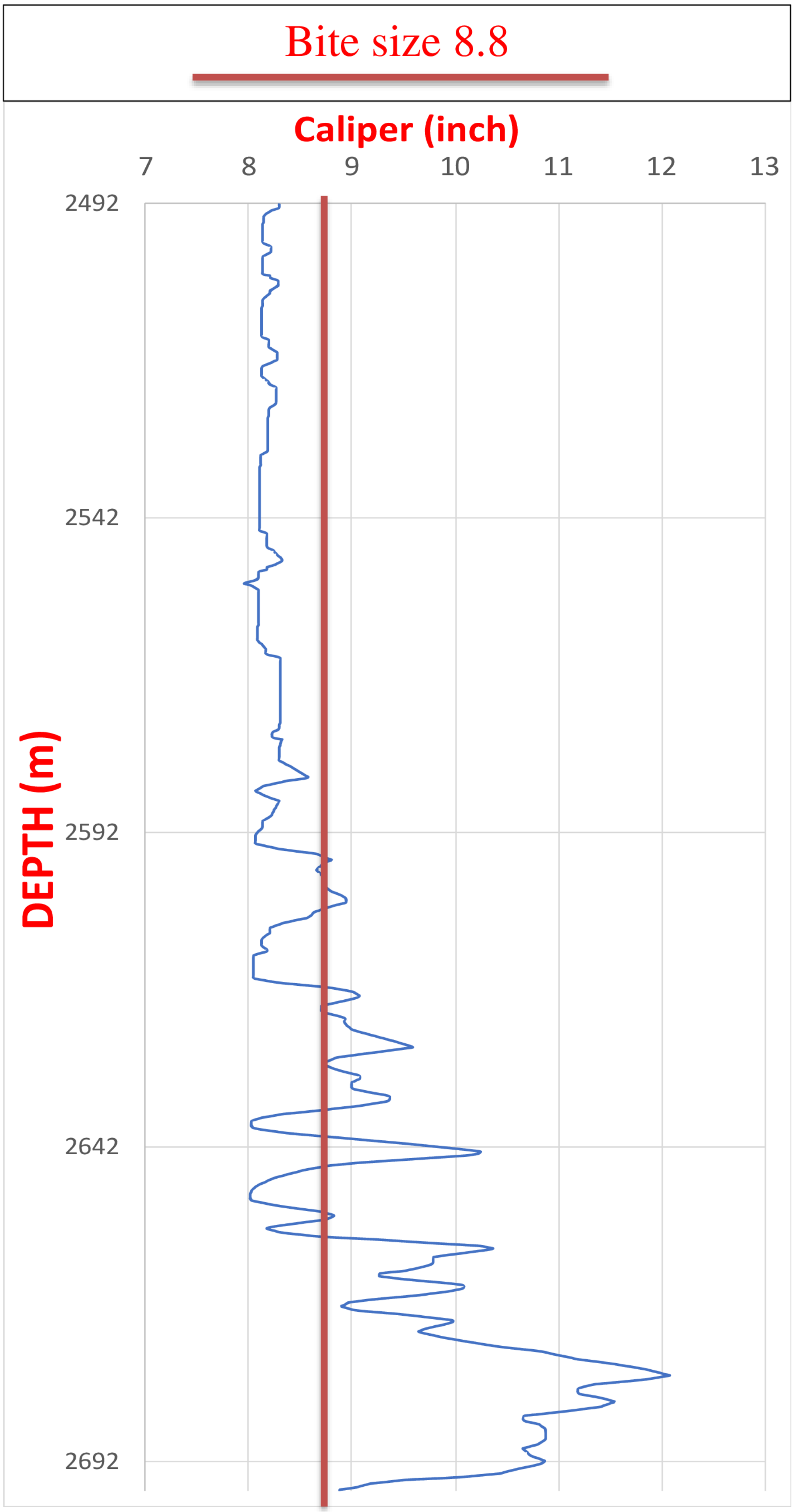


Figure 2.3: Caliper Log of Shiranish Formation

2.4 Gamma Ray Log

In the oil field, gamma ray log is used to detect rock types and can be used to detect the source of radioactivity in Formations. Shale and non-shale can be differentiated using gamma rays and SP (sandstone) (John and Holt, 2015). They can be used to define lithology and correlate between Formations, as well as to correlate zones and calculate shale volume. Natural gamma radiation is emitted in various amounts and spectra by various forms of rock (Petrogav, 2009). Low concentrations of radioactive material in shale-free sandstones and carbonates result inlow gamma ray readings. Natural occurring radioactive materials include the elements uranium, thorium, potassium, radium, and radon, along with the minerals that contain them if a zone has a high potassium content coupled with a high gamma ray log response, the zone may not be shale (George and Charles, 1982).

The gamma ray log, like other types of well logging, is done by lowering an instrument down the drill hole and recording the difference in gamma radiation with depth. American Petroleum Institute (API) units, a measurement developed by the petroleum industry, are widely used to measure gamma radiation (Petrogav, 2009).

This research created a gamma ray (GR) curve for identifying lithology and shale volume, and using gamma ray logs to measure the volume of shale in a sandstone or carbonate. Since radioactive material is concentrated in shale, gamma ray logs are lithology logs that measure the Formation's natural radioactivity. Shale has high gamma ray readings (Fakhry, 2009). Figure 2.4A shows the Gamma Ray Log in studied field.

2.4.1 Shale Volume Calculation

The first preferred approach to become with a preliminary shaliness indicator is to estimate the rocks shale volume linearly from the gamma ray log (Oscar and Jesus, 2012). Due to the fact that shale is more radioactive than sand or carbonate, gamma ray logs can be used to calculatethe volume of shale in porous reservoirs (George and Charles, 1982).

The gamma ray log has traditionally been used for shale Formation research, with shale volume estimation based on this calculation. The procedure is simple and straightforward, and it has the potential to produce reasonable results for some deep reservoirs (Oscar and Jesus, 2012).

V shale is the volume of shale expressed as a decimal fraction or percentage. The shale volume is the volume fraction of shale in the formation, as the title suggests (Asquith and Krygowski, 2004).

Using a GR log to measure the gamma-ray index (IGR), (Schlumberger, 1974) formula and (George and Charles, 1982), as shows in Equation 2.1.

$$I_{GR} = \frac{GRlog - GRmin}{GRmax - GRmin} \qquad (2.1)$$

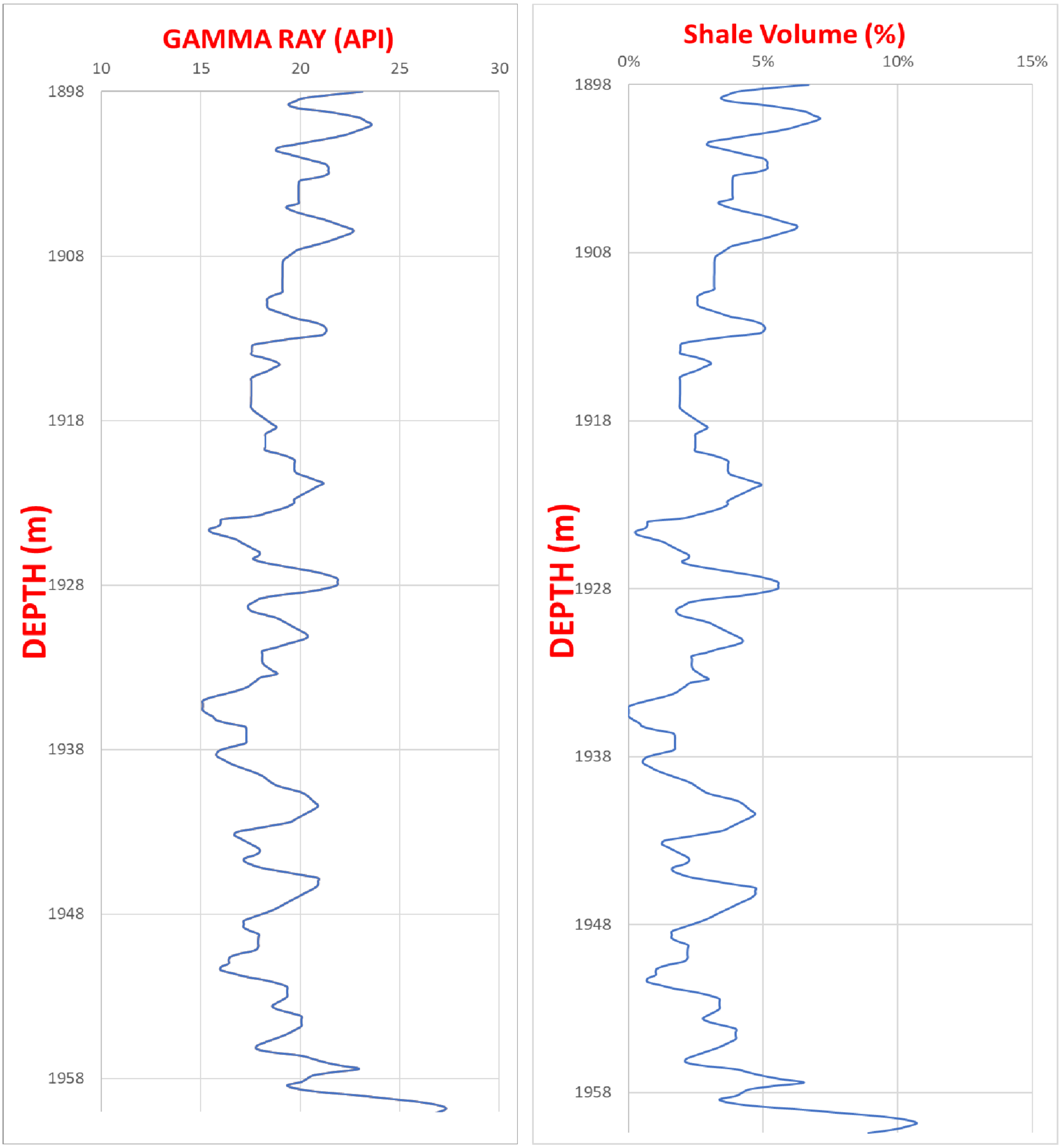
Based on the age of the studied formation, the larionov older rock equation is used to determine shale voleum (Eq. 2.2)

$$V_{sh} = 0.33[(2^{2*IGR} - 1)] \text{ for hard formation or (Older Rock)} \qquad (2.2)$$

Where:

(I_{GR})is Gamma ray index, (GR_{log})is Gamma ray log reading of formation, (GR_{min}) is Minimum gamma ray reading in clean zone (Clean sand or carbonate), (GR_{max}) is Maximum gamma ray reading in shale zone and (V_{sh}) is Volume of shale.

In our result it used the gamma ray maximum (30 API) and gamma ray minimum (3.359API). The result of shale volume in shairanish Formation is Non-shale formation. Figure 2.2B shows the shale volume curve in the studied field.



A B

Figure 2.2: A) Gamma ray log, B) Shale volume curve in the studied field

2.5 Microfacies of Shiranish Formation

Microfacies analysis is the microscopic evaluation of all paleontological and sedimentological properties of carbonate rocks using thin slices, peels, and polished slabs (Flugel, 1982).

In this study, microfacies analysis was employed to examine the type and distribution of microfacies and determine rock types; determine the type and distribution of pore spaces and their relationship to formation characterization; calculate the characteristics of the components; Determine the (fossils).

Thin sections have been prepared in 8 sample with 2.5x microscope lenss.

Limestone

This composed of 15% - 25% of foraminifera (figure 2.3-sample 2, 3, 4, 5, 8) light gray color, but if it is less calcareous, then the color is dark gray.

Marlstone with Microfossils

Microfossils are mainly foraminifers (40-60 %). Foraminifera appear in laminated layers sample 1 in figure 2.3.

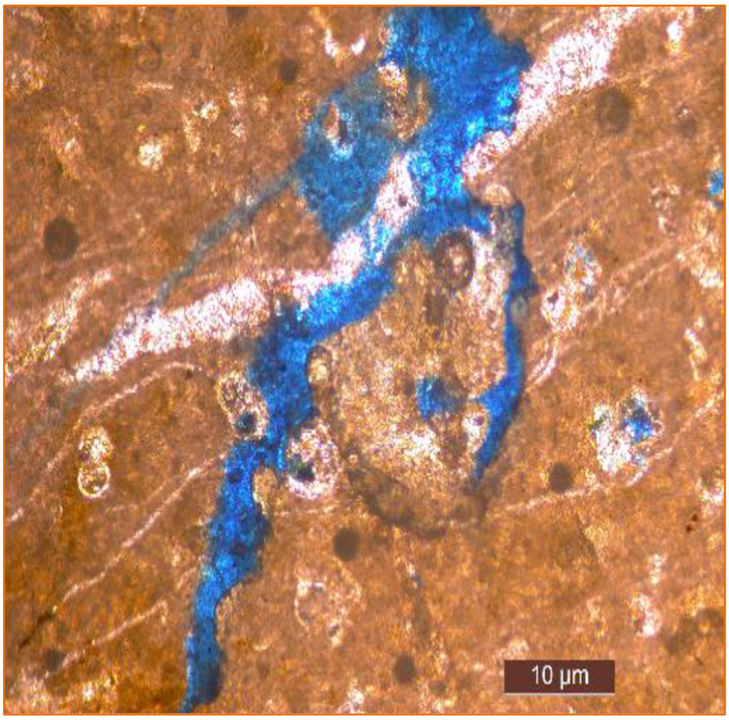
Thin section analysis was conducted to characterize the rock material. The thin section analysis showed that the rock had a fractured structure with fractures extending along the bedding planes. In addition, it could be seen that there were fractures perpendicular to bedding plane covering significant area of the sample .

Using imaging processing we determined that in samples 01, 02, 03, 04, 06, 07, 08 porosity is between 0.01-15 %. For more accuracy, sample 01 includes a formation with 11.34%, sample 02 with a very low porous area about 0.02% subjected to the imaging results, No. 03 with percentage of 3.41 is porous, Sample 04, 05, 06, 07, 08 have porous area of 1.125%, 0.02%, 3.15%, 0.08%, 1.18%, and 4.96 % respectively (Figure 2.3).

According to the standard qualitative table of porosity we interpreted that all samples are in three classes of negligible (0-5%), poor (5-10%) and fair (10-15%).

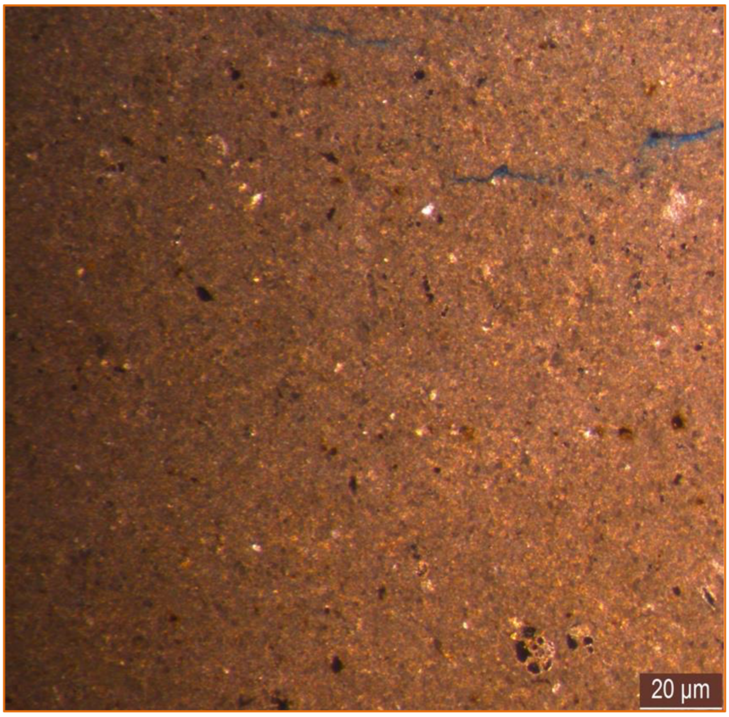
Sample 1

Porosity 11.3%



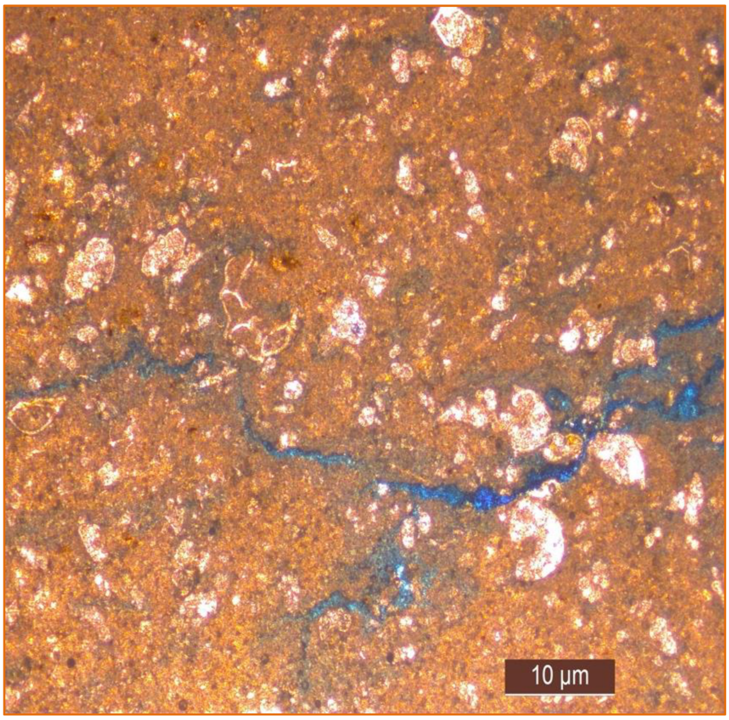
Sample 2

Porosity 0.2%



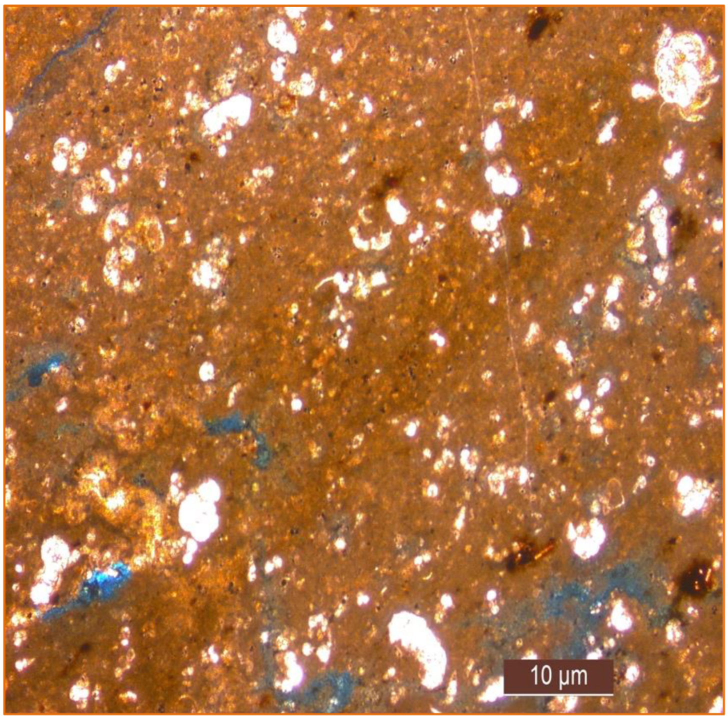
Sample 3

Porosity 2.4%



Sample 4

Porosity 1.1%

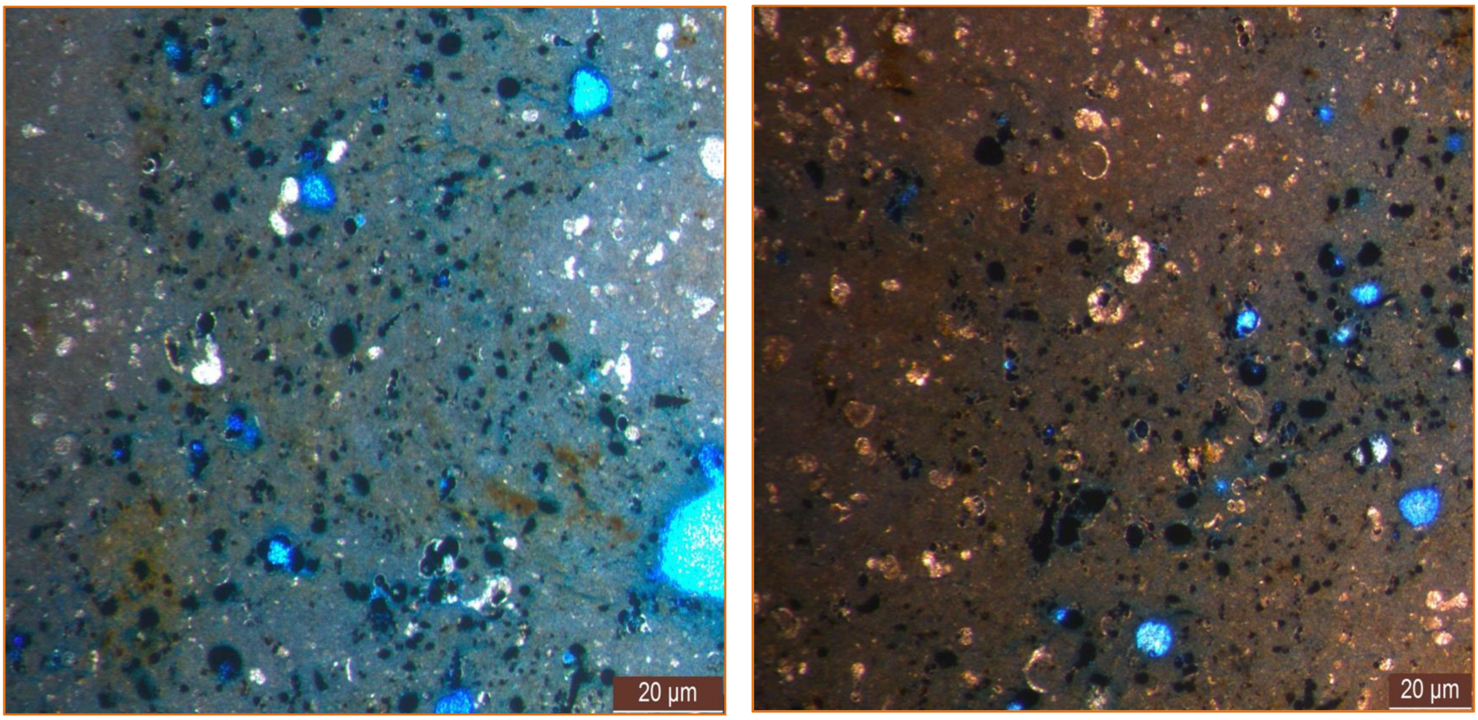


Sample 5

Porosity 3.1%

Sample 6

Porosity 1.1%



Sample 7

Porosity 0%

Sample 8

Porosity 4.9%

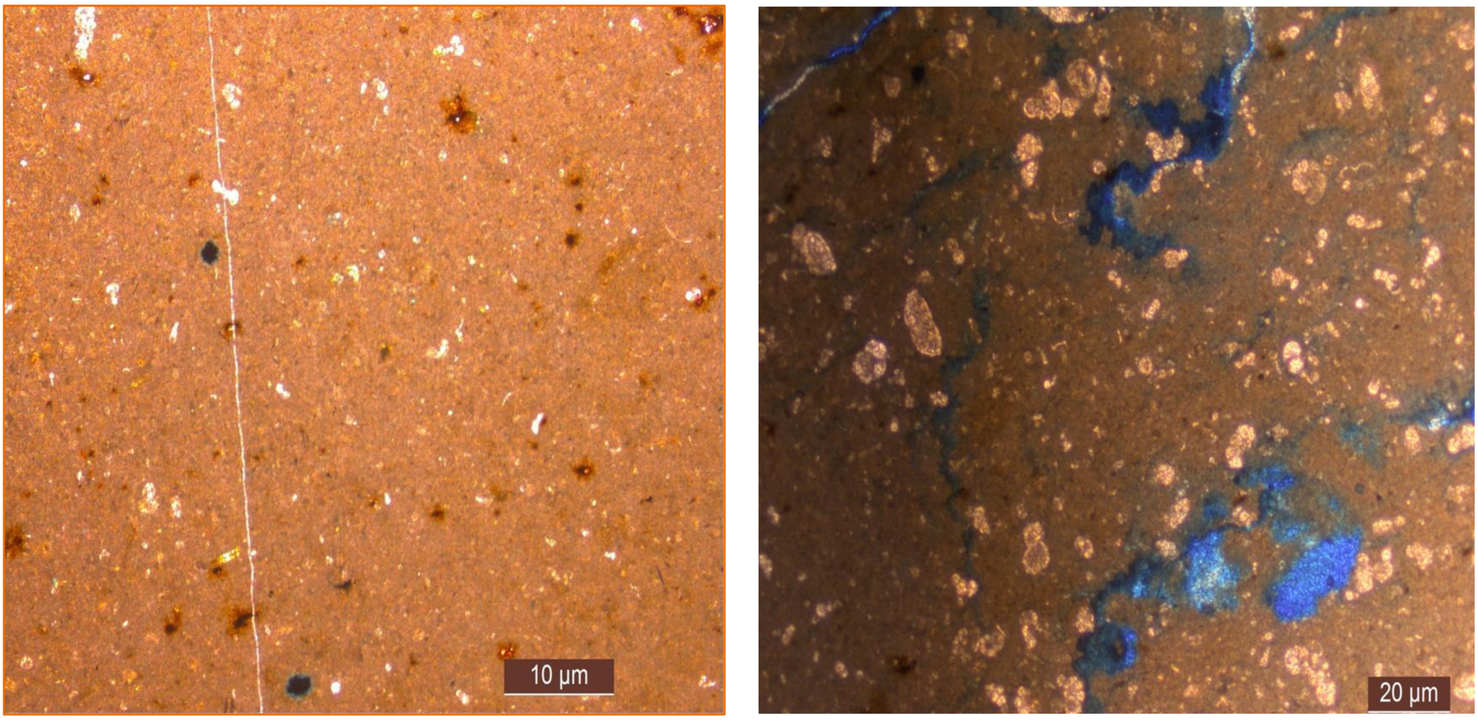


Figure 2.3: 8 samples thin sections of the studied formation

CHAPTER THREE: POROSITY ESTIMATION AND POROSITY UNITS

3.1 Sonic Log

The sonic log, also known as a sonic tool, is a type of porosity log that measures the interval time (Δt) it takes for a sound wave to travel one foot (one meter) through a Formation. This tool consists of one or more sound wave transmitter and even two or more receiver (George and Charles, 1982).

The relative speed of this sound is depended of the density of the medium, which is depended of the rock and pore space volumes, so that if there are pores filled with liquid hydrocarbon or gases, or if there is no solid medium, the sound can slow down and take longer to move through one foot (meter) of Formation, because the interval transit time (Δt) is recorded by microsecond pre foot unit and this is reciprocal to the of velocity of sound wave in feet per second. Modern sonic tools are borehole compensated devices (BHC). This technology has the advantage of reducing the effect of borehole size variations (George and Charles, 1982). Equation 3.1 used to calculate sonic porosity.

$$\emptyset_S = \frac{\Delta t \log - \Delta t\ ma}{\Delta t\ fl - \Delta t\ ma} \qquad (3.1)$$

Where:

(Øs) is sonic porosity corrected for shale, (Δt log) is interval transit time of formation, (Δt ma) is interval transit time of formation's matrix and (Δt fl) is interval transit time of fluid.

Sonic log can be used to calculate porosity, It has used to determine porosity of the studied Formation. The determined porosity is very low, and may be due to composition of the Formation which formed of from limestone, and the secondary porosity is also very low. Figure 3.1 shows that the graph A is sonic log data and graph B is sonic porosity. Table 3.1 shows the interval transit time of the matrix and fresh water which was used to determine sonic porosity.

Figure 3.1 illustrates sonic log (blue curve) in (us/ft) units and sonic porosity (Green Curve) presented as percentages. The sonic porosity has been derived from the Sonic Log.

From the depth of 2492 to 2592 meters , the curves have no major changes , meaning that the porosity is approximately constant. However, starting between the depths of 2592 meters and 2692 meters which is the last depth, the curves increase meaning that there is more porosity and that is due to the borehole enlargement which showed by the caliper log (Figure 2.3).

From 2492 depth and until the depth where the increase starts, there is an average sonic log of about 85-95 us/ft. However once the increase starts, it reaches a maximum of 130 us/ft towards the last depth resulting in a maximum porosity of 57% . The increase is due to the enlargement of the well and that is what the caliper log (Figure 2.3) proves. The results of these figures show that the Shiranish Formation can be divided into 2 units, one unit having low porosity and the other having high porosity.

Table 3.1: Matrix densities of Common Lithologies and fresh base mud (Schlumberger, 1972).

Lithology / Fluid	**Δt matrix or Fluid (Wyllie) $\mu s/ft$**
Dolomite	43.5
Anhydrite	50
Limestone	47.6
Shale	62.5
Fresh Water Mud Filtrate	189

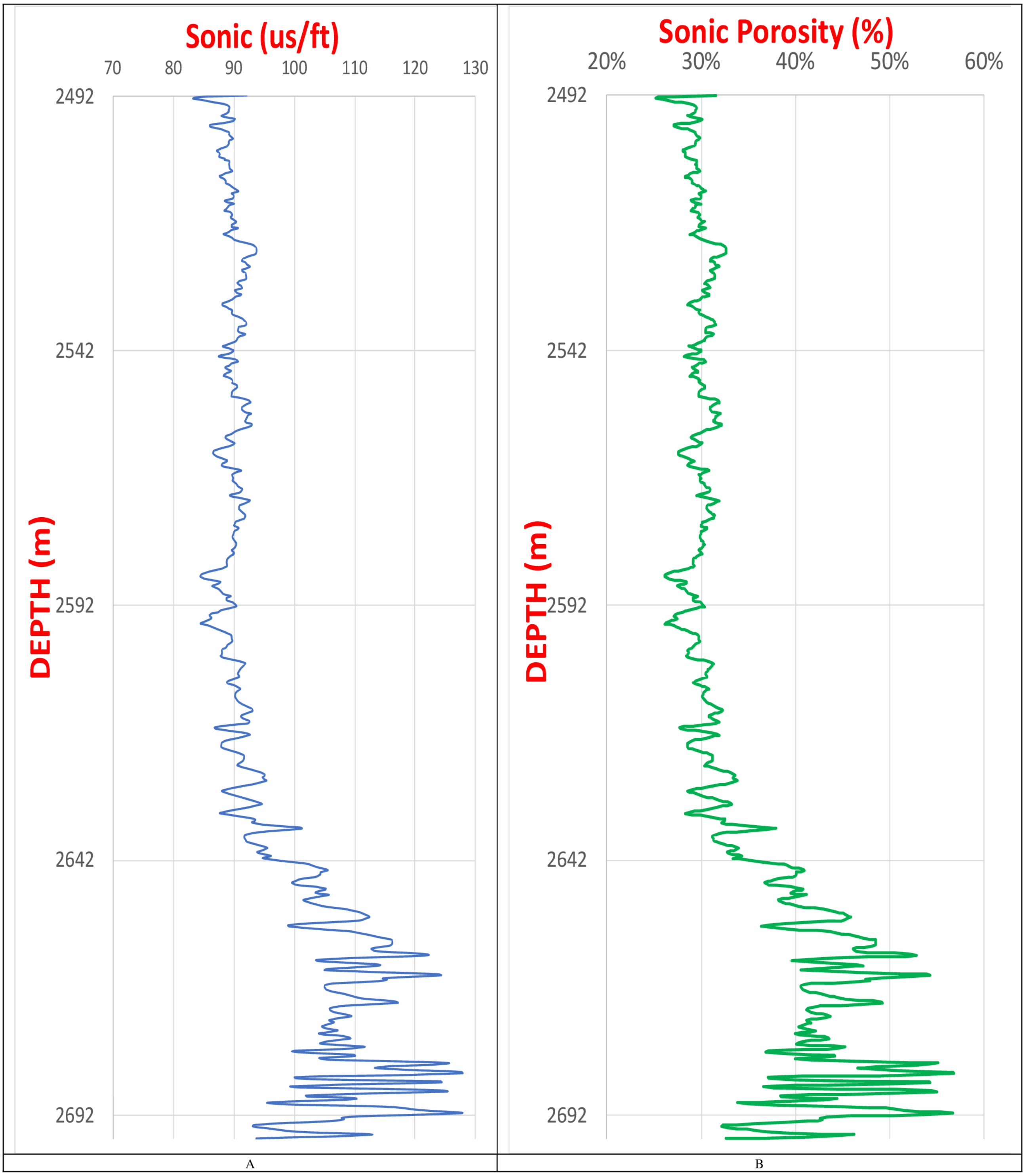


Figure 3.1: (A) (blue) sonic log data, B) (green) sonic porosity of the studied formation

According to the logging data of acoustic log we obtained that maybe in depth of 2650 to 2690 maybe data are not accurate because the rate of changing in porosity is not logical.

3.2 Density Log

The Formation density log is a porosity log that determines a Formation's electron density. Density logs were used by geologists to identify evaporite minerals, detect gas bearing zones, calculate hydrocarbon density, and evaluate shale sand reservoirs and complex lithology (George and Charles, 1982).

The bulk density of a Formation is recorded in the density log. This is the overall density of a rock, which includes the solid matrix as well as the fluid contained inside the pores. The log is scaled linearly (Horsfall and Tamunobereton-ari, 2013). The physical phenomenon of gamma ray scattering as a function of the bulk density of an environment irradiated by a gamma ray source is the basis for density logging (Bhagwan, 2001).

The density log can be used to measure porosity quantitatively and indirectly to determine hydrocarbon density. It can be used qualitatively as a Lithology indicator, as well as to identify of certain minerals, determine source rock organic matter content, and identify overpressure and fracture porosity (Horsfall and Tamunobereton-ari, 2013). Equation 3.2 used to calculatingdensity porosity

$$\emptyset_D = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}} \tag{3.2}$$

Where:

($\emptyset_D$) is density derived porosity, (ρ_{ma}) is matrix density, (ρ_b) is formation bulk density and (ρ_{fl}) is fluid density.

Figure 3.2 shows that graph (A) density log values (bulk density) and graph (B) show density porosity, The Density log is one of the most important techniques that can be used to identify or propose fracture, Table 3.2 shows matrix densities of lithologies that used in density porosity equation.

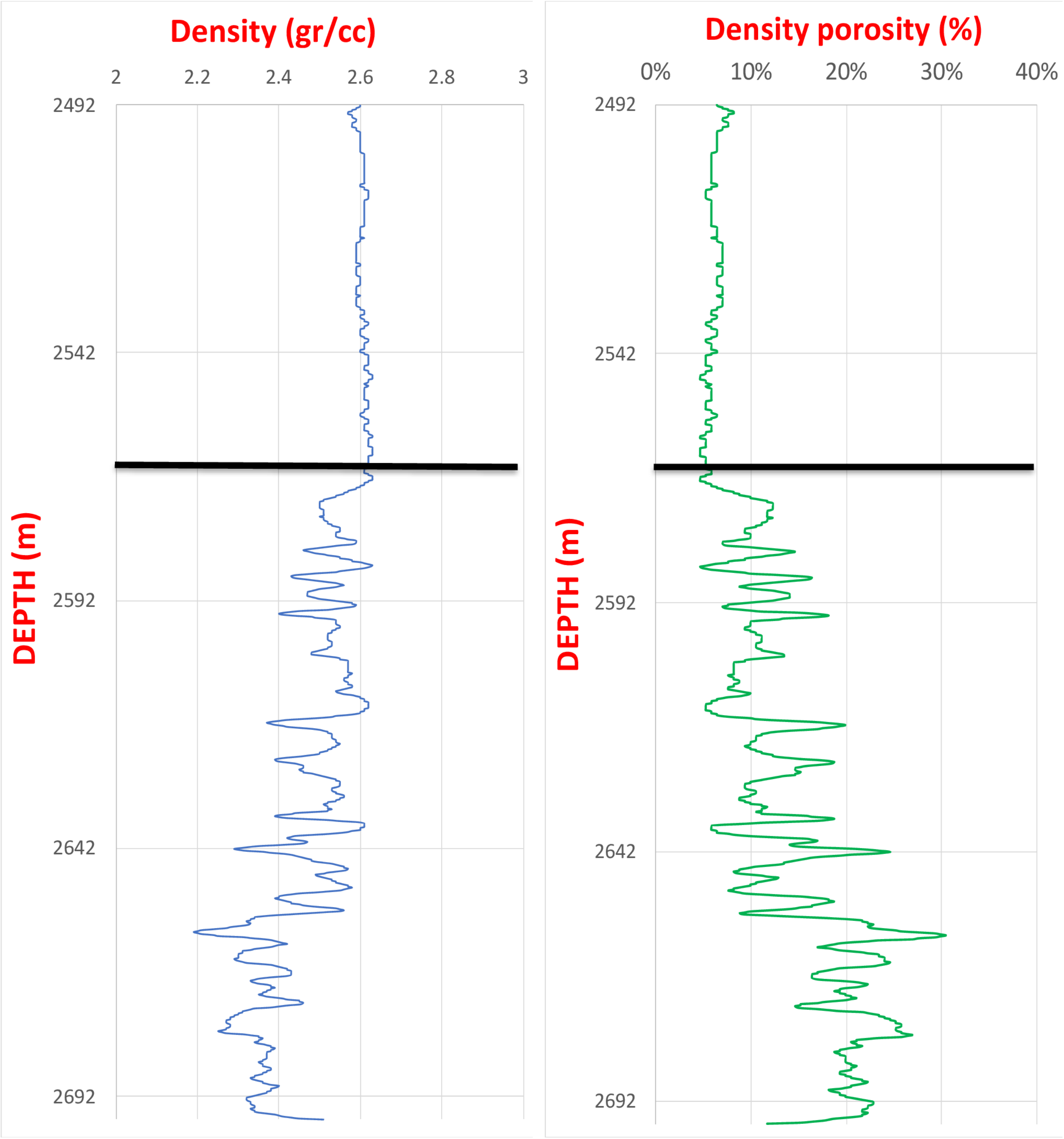
Figure 3.2 illustrates the Density Log (Green Curve) expressed in gr/cc, which has been used to derive the Density Porosity (Blue Curve) expressed as percentages.

Starting from 2492 meters depth, the density is approximately an average of 2.6 gr/cc until around 2570 meters. From that point, the density starts to decrease reaching a minimum of 2.2 gr/cc towards the last depth.

Knowing that porosity increases when density decreases, the green curve shows that porosity increases at around 2570 meters and reaches a maximum of 30% towards the end. The high porosity indicates a good quality of the reservoir. Thus, by observing the data, the Shiranish Formation can be divided into 2 units, one having low porosity where the density is constant, and another one having higher porosity where the density decreases.

Table 3.2: Matrix densities of Common Lithologies (Schlumberger, 1972).

Rock Type (Lithology)	Grain Density ρma (gr/cc)
Fresh Water	1
Limestone	2.71
Dolomite	2.87
Anhydrite	2.98
Shale	2.65



A B

Figure 3.2: (A) Density Log data, (B) Density porosity Log for Tawke Oil Field

In the figure 3.2 the porosity of density log show that we can obtain two section of changing density and porosity.

3.3 Fracture Identification

Identifying the fracture and its location, as well as the fracture morphology and fluid-flow characteristics in the fracture network, are all important aspects of characterizing reservoirs that produce primarily from fracture networks. Numerous oil fields in the Middle East and Near East produce from carbonate reservoirs; this activity is critical (Minne and Gartner, 1979). So, there are many tools and techniques can be used for this purpose including (Iverson, 1992):

1. Micro Resistivity log
2. Sonic log (acoustic log, using interval transient time)
3. Nuclear log
4. Vertical Seismic profile
5. Caliper log

The acoustic log is being used to identify fractures in this case. The identification of fractures using a compressional acoustic log is hard because it is dependent on the angle of the fracture. As such, a fracture is described as a discontinuity that causes acoustic refraction, reflection, as well as a shift or conversion in display mode. As a result, both of these events waste or lose acoustic energy. Several types of waves, such as compressional and shear waves are subjected to attenuation or, to put it another way, are affected by the presence of fractures. Oblique fractures, defined as those with a dip angle between 15° and 85°, are the fractures that have the greatest impact on compressional waves. Shear waves, on the other hand, are sensitive to horizontal or near horizontal fractures (Morris et al, 1964).

3.3.1 Fracture Quantification

A common analytical method is to use logs to identify fractures. Although it is qualitative at best but there can be semi-quantitative fracture intensity indices based on the frequency of occurrence of particular produce on log curves (Brief, 2004). Secondary porosity and lithology interpretation is an approach that can be used with a variety of tools and laboratory measurements. Estimating total porosity and secondary porosity, as well as calculating mineral content using well log data, is the most accessible and easiest method (Wyllie et al., 1956; Wyllie et al., 1958). There is no direct method to calculate fracture porosity from a well log.

While several log suites have been developed to detect natural fracture systems, none of them can directly calculate ($\emptyset f$) (Nelson R.A et al., 2001).

Secondary porosity is classically estimated from well logs as the difference of total density porosity minus total sonic porosity (John, 1983). Equation 3.3 used to calculate fracture porosity.

$$\emptyset_f = \emptyset_D - \emptyset_S \qquad (3.3)$$

Where:

($\emptyset_f$) is Secondary porosity, ($\emptyset_D$) is Density porosity and ($\emptyset_S$) is Sonic porosity.

Fracture porosity values ranges from (0 to 6.3 %) that shows in Figure 3.3, value of fracture porosity in studied Formation is poor.

It can be applied to either carbonate rocks or clastic rocks with or without clays. The difference in porosity should be equivalent to the difference between $^{\text{effective}}$ density porosity and effective sonic porosity. If fractures are the only source of secondary porosity, the porosity difference may be a strong predictor of fracture porosity. (Oscar and Jesus, 2012).

Here, we have fractured rock, and the more the fracture the more the porosity. Also, the more porosity, then there will be more permeability because the fracture causes easier flow.

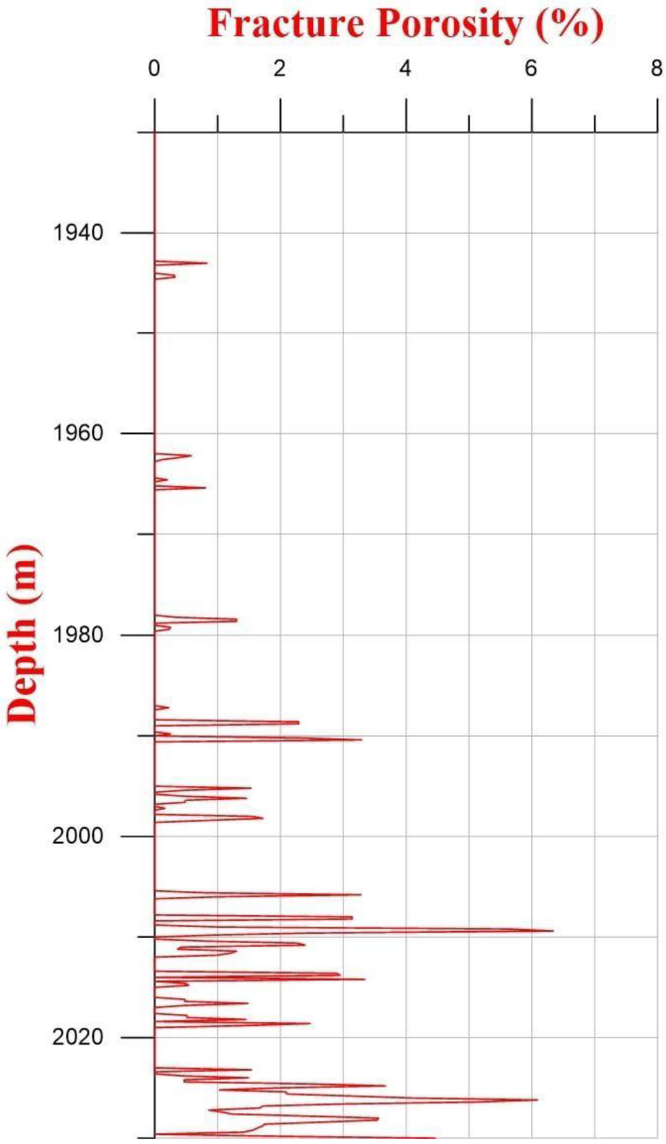


Figure 3.3: Fracture Porosity on Shiranish Formation in the Oil Field

3.4 Porosity Units

In the definition of the porosities of the studied formation, the standard proposed by (North, 1985) for evaluating porosities (Table 3.3) was used.

The distinguished reservoir units in Shiranish Formation have been termed as three units. In this Formation, three different reservoir units were noticed from the values of the used reservoir porosity. In porosity unit-1, minimum and maximum range values for sonic porosity were recognized in the one studied well are 0.0 and 3.39 %, and for density porosity, ranges are 0.0 to 3.67. The porosity unit-2 showed the different criteria of being the range maximum porosity values compare with reservoir unit-1 but showed the same range porosity value, from sonic porosity the ranges are 0.0 to 5.99 %, and from density porosity ranges are 0.0 to 5.05 %. Maximum porosity range from sonic porosity at unit-2 has high porosity range than unit-1 and unit-3 and the porosity unit-3 from sonic porosity the ranges are 0.0 to 1.99 %, and from density porosity ranges are 0.0 to 9.72 %, and maximum porosity range from density porosity at unit-3 has high porosity range than unit-1 and unit-2. Also, the minimum ranges porosity of the three units has the same range. As a general view, the following has been recognized about the porosity of the studied formation in the one studied well, our value porosity is poor. Figure 3.4 shows the porosity units of the studied field.

Referring to a log of porosity based on the effect of the formation on fast neutrons emitted by a source. Hydrogen has by far the biggest effect in slowing down and capturing neutrons. Since hydrogen is found mainly in the pore fluids, the neutron porosity log responds principally to porosity. However, the matrix and the type of fluid also have an effect. The log is calibrated to read the correct porosity assuming that the pores are filled with fresh water and for a given matrix (limestone, sandstone or dolomite). It is presented in units of porosity (vol/vol or p.u.) for the matrix chosen. Older logs were presented in counts per second or API units. The depth of investigation is several inches, so that the log reads mainly in the flushed zone. The neutron porosity log is strongly affected by clay and gas. Hydrogen occurs in clays and hydrated minerals as well as pore fluids. Gas has a low hydrogen density, so that gas zones have a very low apparent porosity. The measurement is based on either thermal or epithermal neutron detection. Thermal neutrons have about the same energy as the surrounding matter, typically less than 0.4 eV, while epithermal neutrons have higher energy, between about 0.4 and 10 eV. Being a statistical measurement, the precision is greatest at high count rates, which in this case occurs at low porosity. Neutron porosity logs were introduced in the early 1940s. The first tools were known as neutron-gamma tools, since the detector measured the gamma rays emitted on capture. Neutron-neutron tools, using a thermal neutron detector were introduced in about 1950.

Table 3.3: Qualitative description of porosity as proposed by (North, 1985).

Percentage Porosity (%)	Qualitative Description
0 – 5	Negligible
5 – 10	Poor
10 – 15	Fair
15 – 20	Good
20 – 30	Very Good
> 30	Excellent

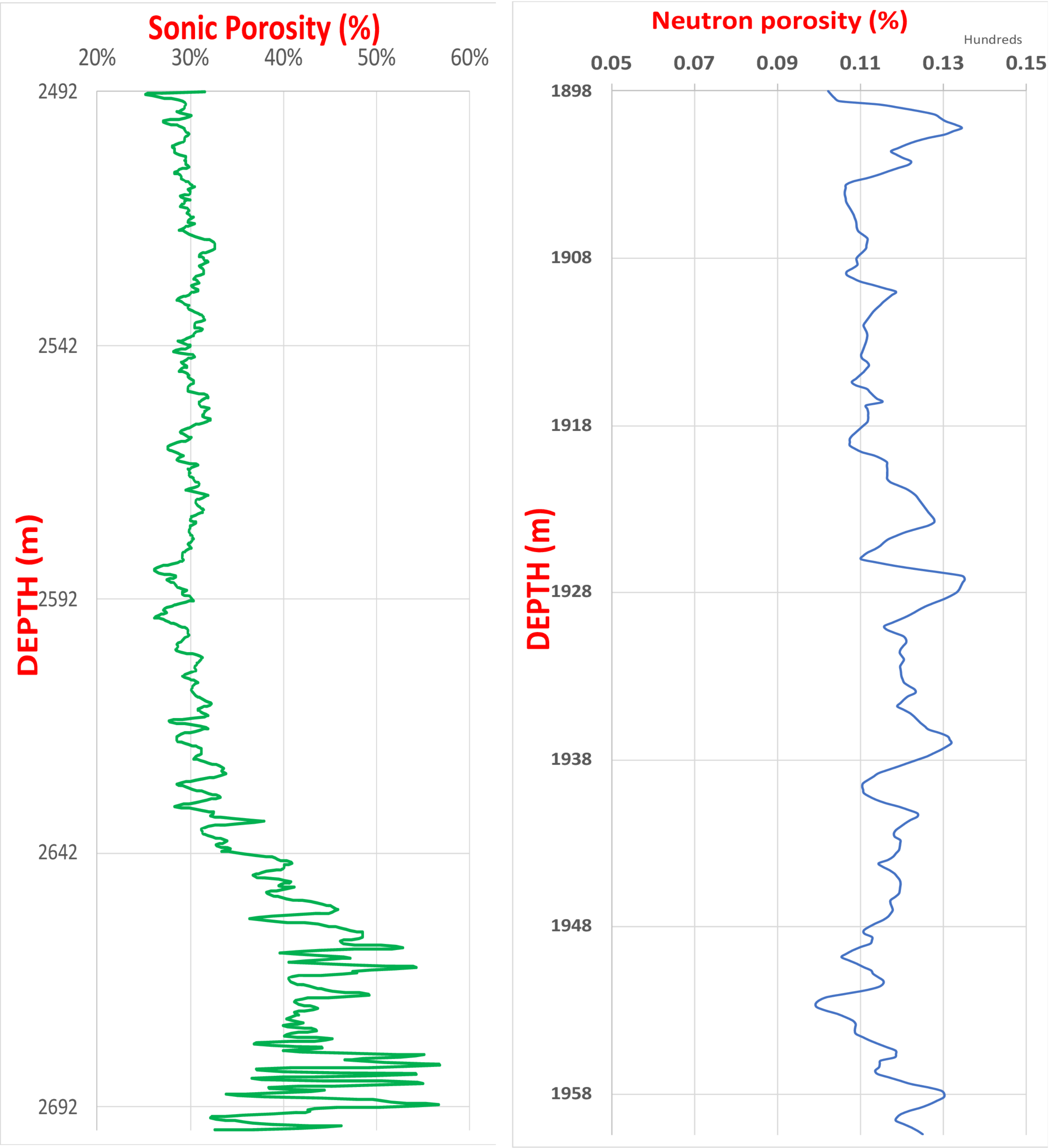


Figure 3.4: Porosity Units of the Studied Field

CHAPTER FOUR: CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

After tracking the porosity and gamma ray logs, we concluded:

- ✓ The data shows two zones which first one has a range between 2492 to 2625 metres, and the second one is starting from 2625 to 2695 meters, according to the gamma ray log of the top layers, obtained that the formation has a low value of gamma ray which is around 20 API and low shale volume in the first zone, but for the second zone the volume of shale increases to 28% and maybe the formation is not pure and includes clay minerals.

- ✓ For the porosity logs almost are similar in properties and in the first zone the porosity reaches 20% that is a good quality for the formation, but in the second zone according to the caliper log which illustrates wash out around the well and the range of porosity is too much, so we cannot trust the data in this area.

- ✓ After all consideration and understanding from the well logging data we obtained that formation is a very low shale formation and has a good quality.

- ✓ After analysis of the sections obtained that the rock of this formation has a good porosity and includes a high number of micro- fractures and we estimated the porosity of the sections is around 15-20 % .

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