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Several Basic Methods to Evaluate Petrophysical Properties of Yamama Formation in Ratawi oil Field, South of Iraq

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Abstract

This paper studying the Evaluation of the Petrophysical Properties of Yamama Reservoir in Ratawi oil Field which locats about 70 kilometers west of the city of Basra and to the west of the North Rumaila where away about 12 kilometers, and to the south of Hor Al-Hammar reality along the Euphrates River in Mesopotamia zone in Zubair subzone.The study includes a petrophysical evaluation by using several basic methods for each unit especially the three reservoir units comprising the Yamama Formation in eight boreholes which are Rt-3, Rt-4, Rt-5, Rt-6 , Rt-7, Rt-13, Rt-14, and Rt-15 distributed on the crest and flanks of the Ratawi structure that are carried out in the present study. Yamama formation boundaries were determined using well logs , available core intervals and Petrophysical data and found that it can be subdivided into three main reservoir units that separated by two insolate (non – reservoir) units.Petrophysical analysis of Yamama rocks revealed that YB unit has the best properties comparing with the other two units because the majority of total porosity is primary through the whole succession within the studied area and water saturations are significantly affected by the volume of shale which was greater than 10% into the core intervals of the studied wells.

Introduction

Yamama reservoir is heterogeneous and the reservoir quality is highly variable both laterally and vertically and can consider one of the important productive formations that deposited into shallow marine environments during (Tithonian – Early Turonian) period in the Tithonian – Hautervian sequence within the Stratigraphic column of Lower Cretaceous in south of Iraq[3].Intelligent reservoir characterization using soft computing is considered one of the most powerful techniques currently widely used by geoscientists. It relies on the ability to locate and extract hydrocarbons from beneath the ground's surface and is tied directly to the evolution of technologies, concepts, and interpretative sciences. The technologies that are commonly used in such domain are the mainly basic methods for imaging features beneath the ground's surface and supported by petrophysical well log data and available core data to optimize the highest production rates in the Yamama Formation.

Petrophysical Evaluation

Well log interpretation is an important tool to understand and provides the information about lithology, petrophysical analysis, fluid saturation.As well as its use in the comparison between different wells and help in drawing structural maps, equal thickness of reservoir units, also used in describing the facies relationships of sedimentation environments.Well logs interpretation give moreaccurate results when the log data is combined with core data [1].

The present study depicts an interpretation of Open hole logs responses such as Gamma ray logs (GR), spontaneous potential logs (SP), and caliper logs were used for the correlation of depth and determine the boundaries of the study formation and identification of permeable zones ,also can calculate the permeability zones for intervals has no core in reservoir units by using Wyllie equation [5]., in addition to identifying the same lithofacies in the wells, which have a lack of core data with helping of Porosity logs (density logs, neutron logs, sonic logs) were used to calculate total and effective porosity after correcting its values at each point by knowing and calculating the ratio ofshale volume (Vsh) to get more accurate results.

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Resistivity logs were used to obtain water saturation. After obtaining water saturation, hydrocarbon saturation can be calculated, Then, permeable zones identification by using porosity and water saturation, to get more reliable results, these calculations were compared and corrected with core data, and thus will help to evaluate the reservoir units in the study wells of Ratawi field.Moreover, density logs and neutron logs Crossplots method were used to define the lithology of the formation rocks types and its direction in the field, M-N Plot were used to determine the mineralogy of the study wells.

Petrophysical interpretation for Yamama formation reservoir (CPI)

Before entering an interpretation of the reservoir characteristics of each unit, it should be noted here that is done calculated the effective porosity values and found its correspond to the values of the total corrected porosity (which includes the total porosity of the clean interval depths, i.e. those in which the ratio of Vsh is less than 10% plus the total corrected porosity from the effect of the shale volume of the dirty interval depths which are having Vsh more than 10%) for all wells in the study area and for all units.

The formation is divided into three reservoir units from up to down which are YA at the top, YB in the middle, and YC at the bottom of the formation. The following is the petrophysical interpretation of the reservoir units of Yamama formation from top to bottom according to the arrangement and according to the location of each well of the study area in Ratawi field by using petrel software 2017.

1- **Petrophysical interpretation for reservoir unit – YA**

According to the locations of the distribution of the study wells in Ratawi field (see the locations of the distribution of the study wells in the figures of surface maps for the reservoir units1,2 , and 3),Whereas the wells are located near the center of the field (near Crest); RT-3, RT-13, RT-14, and RT-15 have good reservoir characteristics at this unit where they have good hydrocarbon saturation (Sh), porosity, and permeability, but the ratio of shale volume (Vsh) increases at the bottom of YA unit. The reservoir characteristics worsen as we head towards the east of the field at RT-4 well, where it has a high water saturation rate, fair to poor porosity, and almost negligible permeability, and Vsh ratio increases at the bottom of this unit for this well.

The reservoir properties improve towards the west of the field at RT-6 well, where the ratio of hydrocarbon saturation, porosity and permeability is somewhat better than the reservoir characteristics in the east of the field, but the percentage of Vsh increases in the lower part of YA than the upper part of it.

As for the north of the field at RT-5, it has low reservoir characteristics than it is in the wells located near the center of the field and has high water saturation and a high Vsh ratio in the lower part of this unit, while at the south of the field represented here by RT-7 well, it has poor reservoir characteristics and very high shale volume ratio in almost all of the unit compared to the ratio in the rest wells of the field for YA unit.

2- **Petrophysical interpretation for reservoir unit – YB**

This reservoir unit (YB)can be considering have the best petrophysical properties in Yamama formation, whereas the wells are located near the center of the field (near Crest); RT-14 and RT-15 have very good reservoir characteristics at this unit where they have very good hydrocarbon saturation (Sh), porosity, and permeability, low ratio of shale volume (Vsh) compared with YA unit. while, RT-3 has less petrophysical properties compared with Rt-14, RT-15, whereas the best characterization in Rt-14. For RT-13 has the lowest ratio of petrophysical properties for the wells are located near the crest or center of the field, where has lower hydrocarbon saturation (Sh) and a higher ratio of water saturation (Sw) with good porosity and less permeability compared with other wells near the crest, and the percentage of shale volume increases in the lower part of this unit; and this is evidence that Yamama formation was deposited during several small sedimentary cycles (multiple transgression -

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regression stages) associated by clastics and mud deposits that transported from the basin's adjacent positive areas and eventually caused to variation in petrophysical properties for the formation.

The reservoir characteristics worsen as we head towards the east of the field at RT-4 well, where it has a very high water saturation rate, poor porosity, and almost negligible permeability. The reservoir properties improve towards the west of the field at RT-6 well, where the ratio of hydrocarbon saturation, porosity, and permeability is very good.

As for the north of the field at RT-5, it has good reservoir characteristics in the upper part of this unit (YB), while the properties become worse in the lower part where has high water saturation and a high Vsh ratio in the lower part of this unit.

In the south of the field represented here by RT-7 well, it has very good reservoir characteristics compared with the ratio in YA unit for this well.

3- Petrophysical interpretation for reservoir unit – YC

For the petrophysical properties in Yamama formation of reservoir unit (YC), the wells are located near the center of the field (near Crest); RT-14 and RT-15 have good reservoir characteristics at this unit but less compared with the properties in the unit YB, where they have good hydrocarbon saturation (Sh), porosity, and permeability, low ratio of shale volume (Vsh). while, RT-3 has good petrophysical properties but less compared with Rt-14, RT-15, whereas the best characterization in Rt-14. For RT-13 has the lowest ratio of petrophysical properties for the wells are located near the crest or center of the field, where has good hydrocarbon saturation(Sh), porosity, and permeability just in the lower part of this unit (YC); this is because of the multiple transgression - regression stages of Yamama formation (the type of deposition during several small sedimentary cycles).

The reservoir characteristics worsen as we head towards the east of the field at RT-4 well, where it has a low hydrocarbon saturation rate, and poor to almost negligible porosity and permeability. The reservoir properties towards the west of the field at RT-6 well has a low ratio of hydrocarbon saturation, and poor to almost negligible porosity and permeability, but in general the properties of the west part of the field better than the east part of the field.

As for the north part of the field at RT-5, it has very bad reservoir characteristics and a high Vsh ratio in this unit.

The characteristics improved in the south part of the field represented here by RT-7 well compared with the north part and east part of the field.

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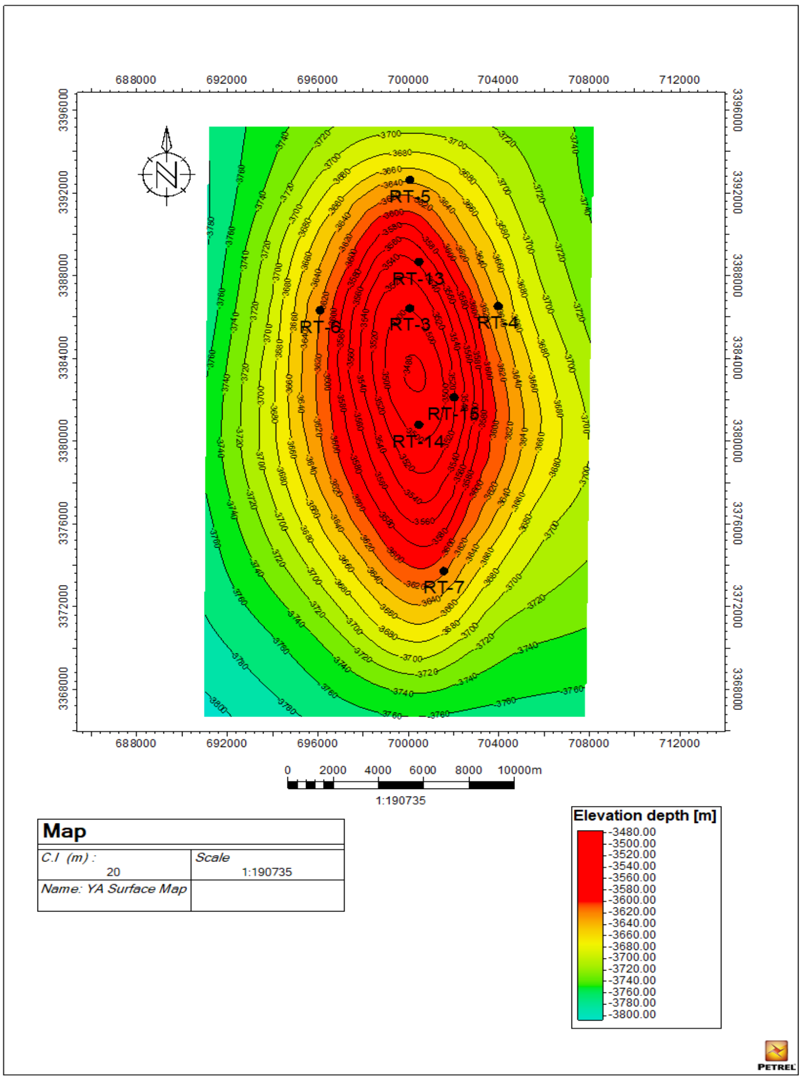

Fig. (1): Surface map of top of YA of the formation and distributed of studied wells.

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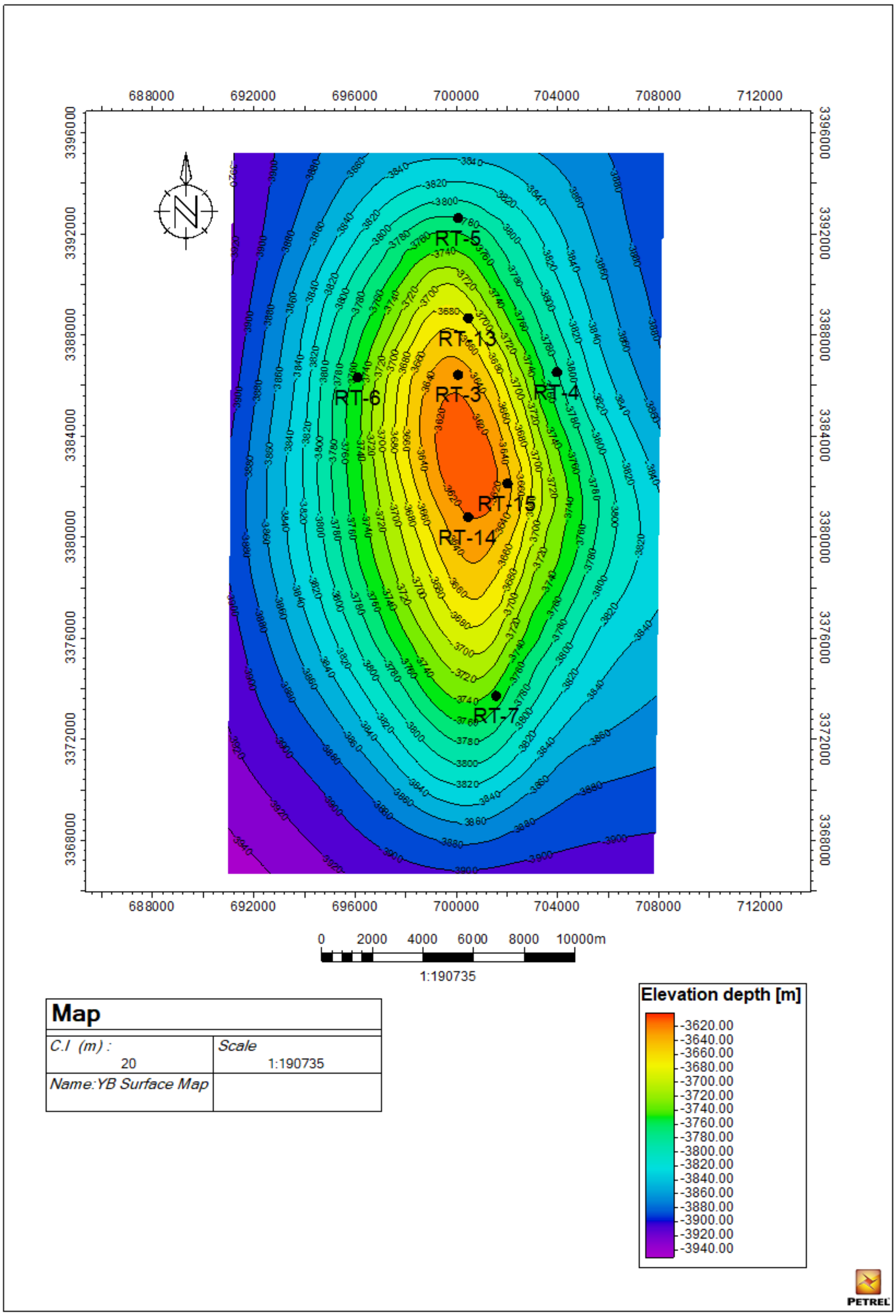

Fig. (2): Surface map of top of YB of the formation and distributed of studied wells.

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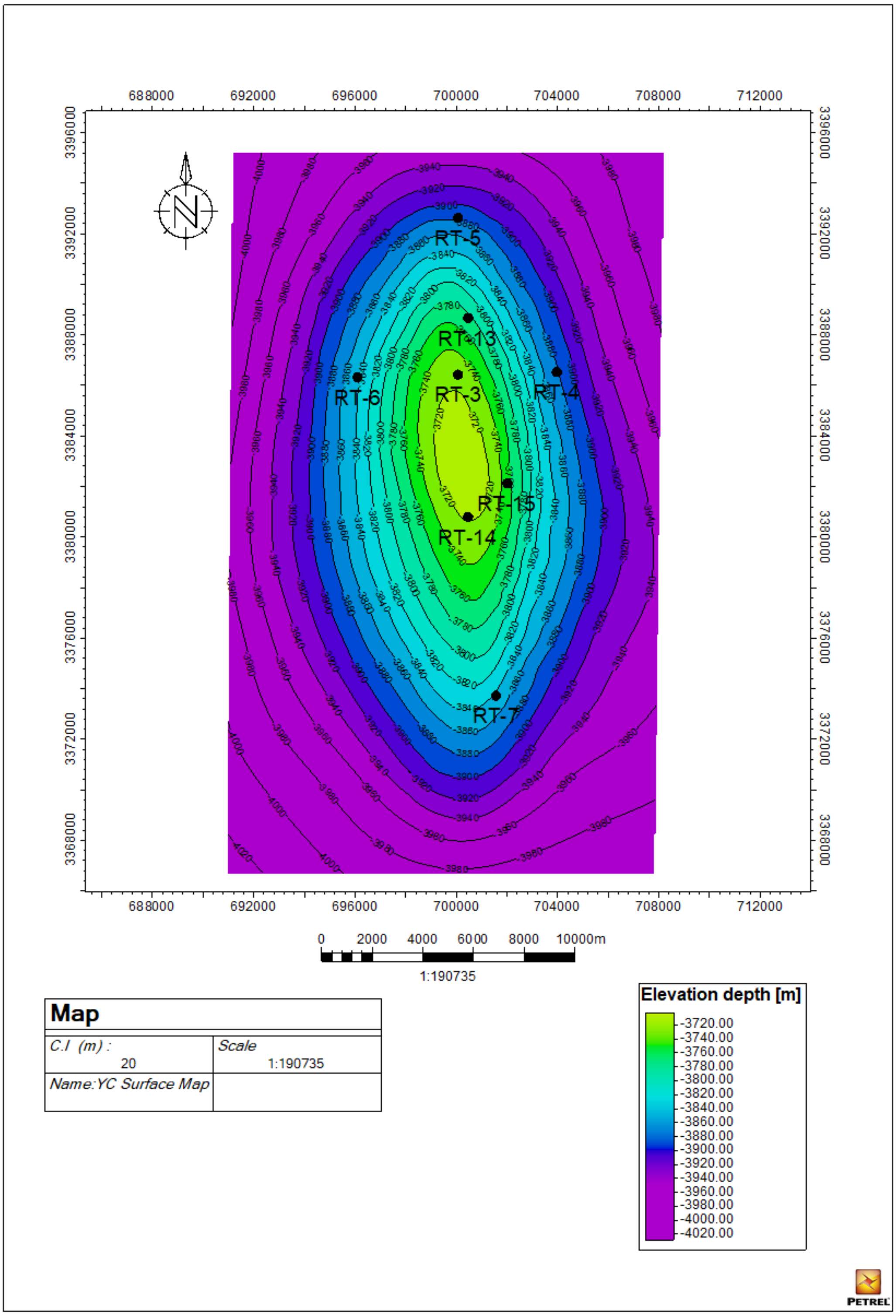

Fig.(3): Surface map of top of YC of the formation and distributed of studied wells

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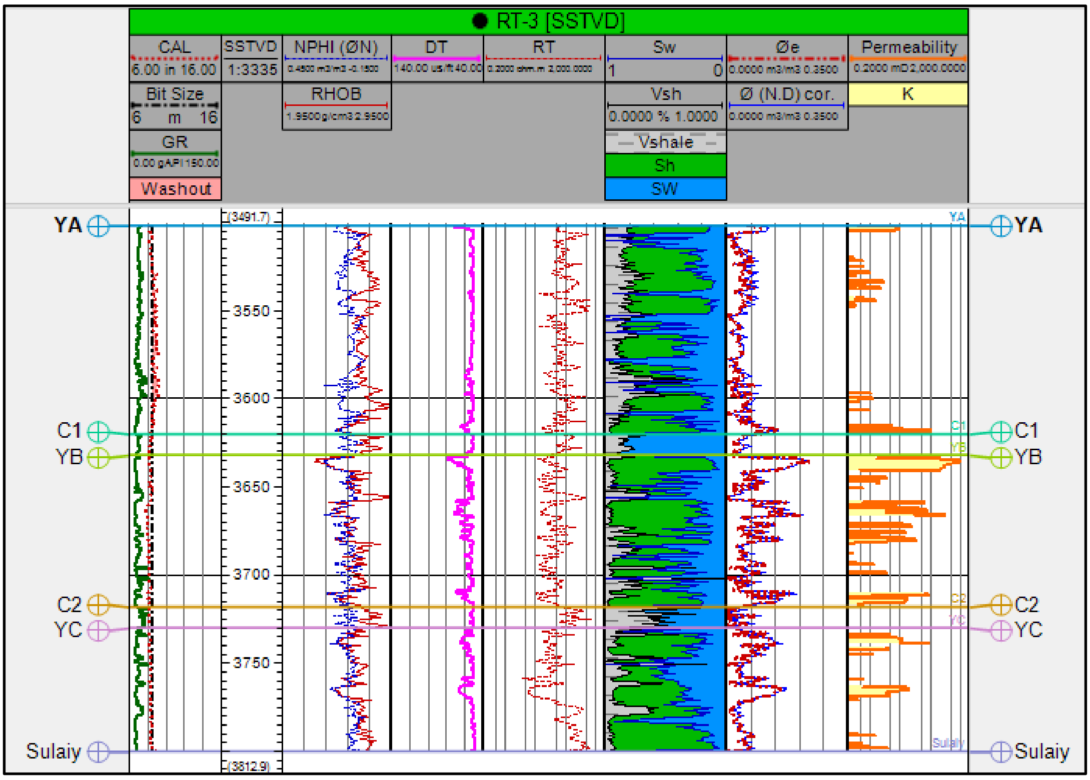

Fig. (4) (CPI) - Petrophysical characteristics of Yamama Formation in Ratawi field, well (Rt-3)

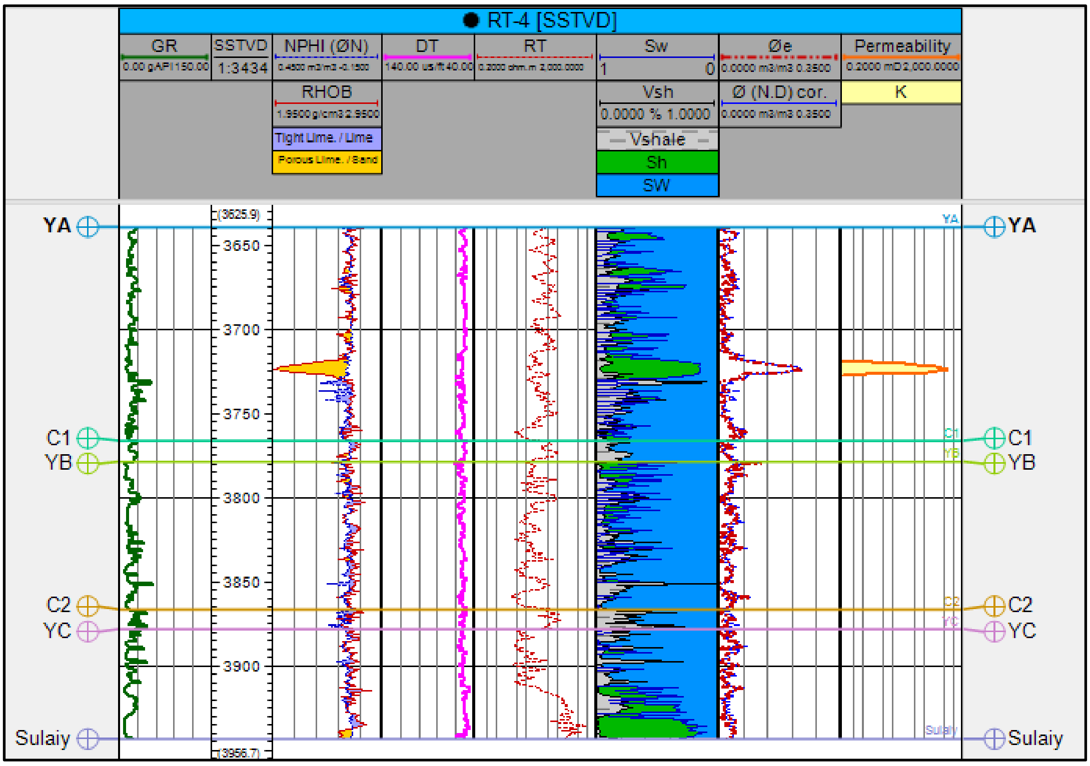

Fig. (5) (CPI) - Petrophysical characteristics of Yamama Formation in Ratawi field, well (Rt-4)

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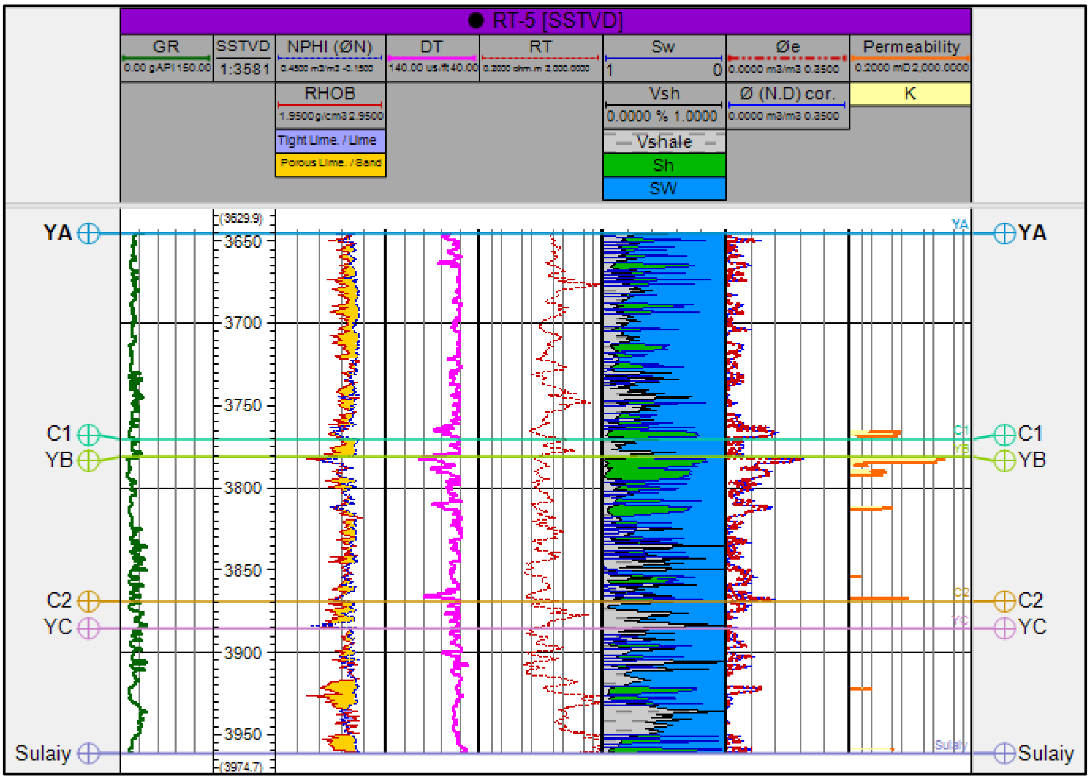

Fig. (6) (CPI) - Petrophysical characteristics of Yamama Formation in Ratawi field, well (Rt-5)

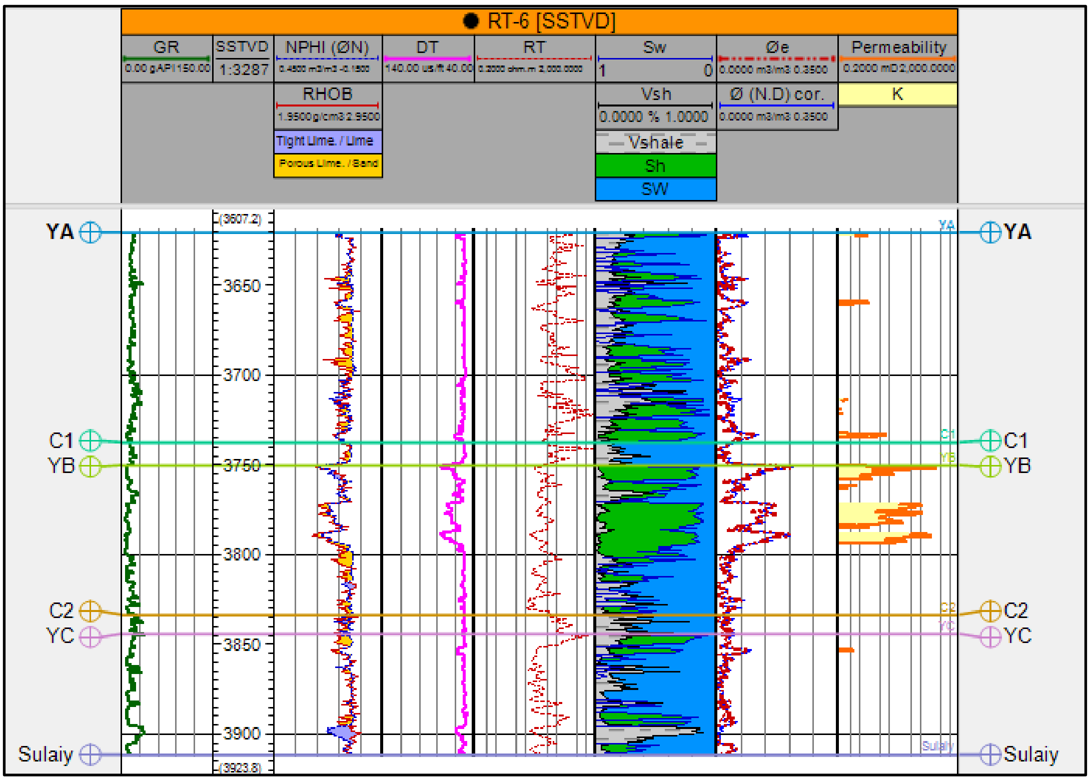

Fig. (7) (CPI) - Petrophysical characteristics of Yamama Formation in Ratawi field, well (Rt-6)

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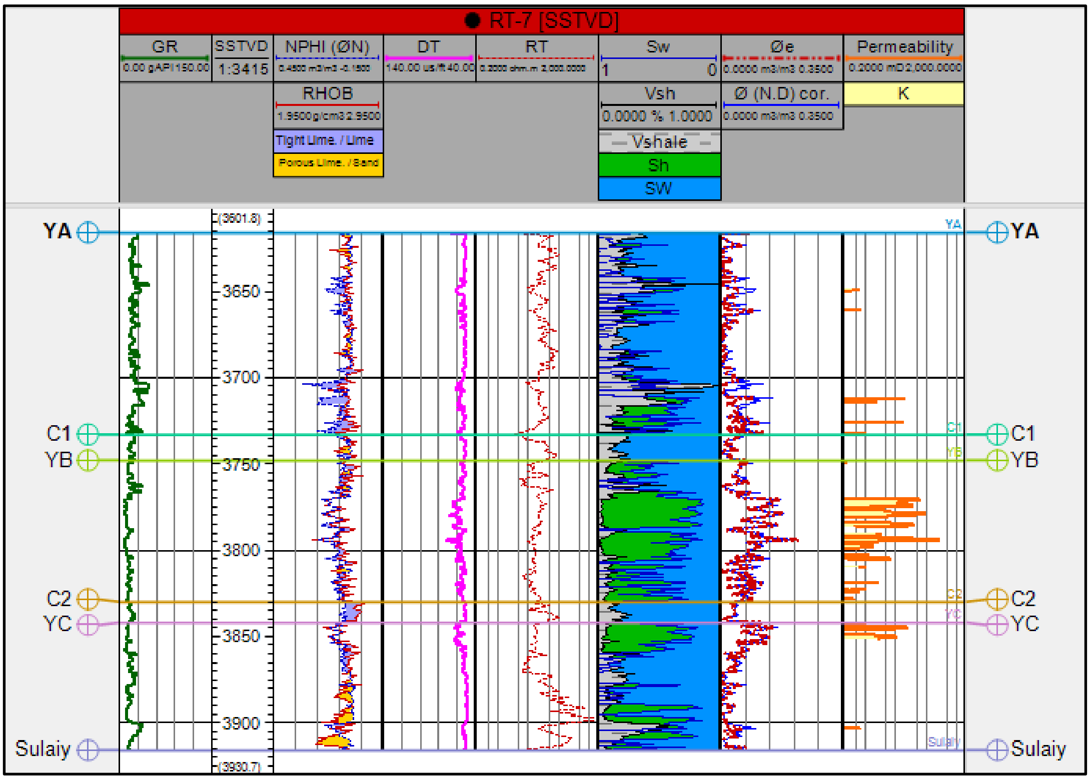

Fig. (8) (CPI) - Petrophysical characteristics of Yamama Formation in Ratawi field, well (Rt-7)

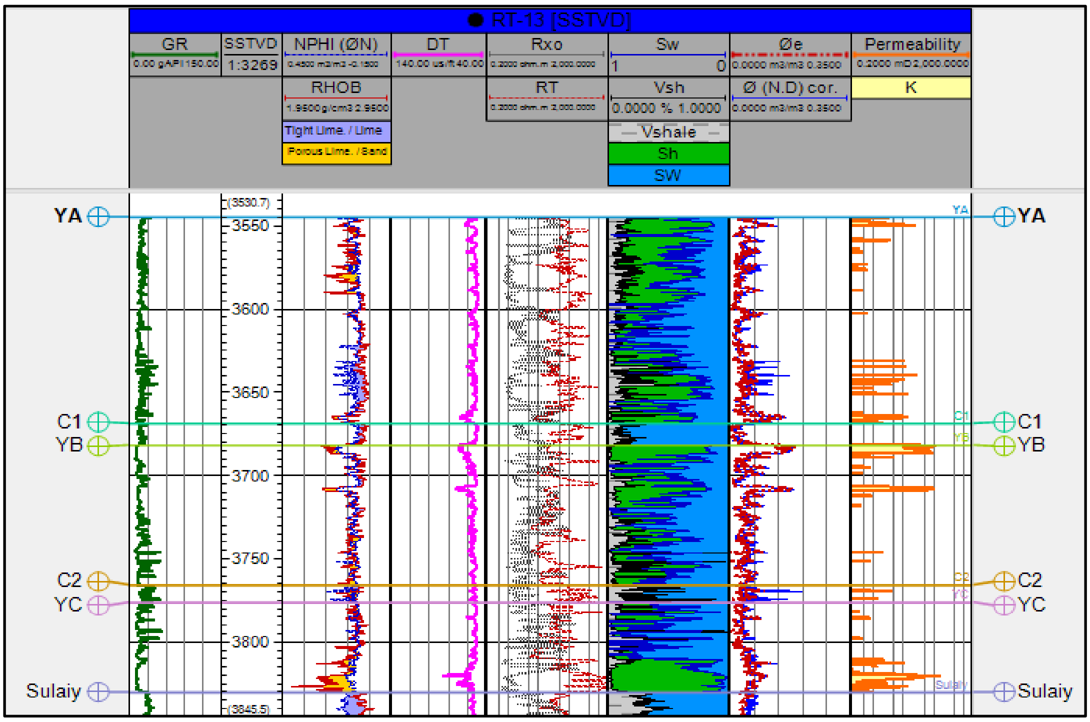

Fig. (9) (CPI) - Petrophysical characteristics of Yamama Formation in Ratawi field, well (Rt-13)

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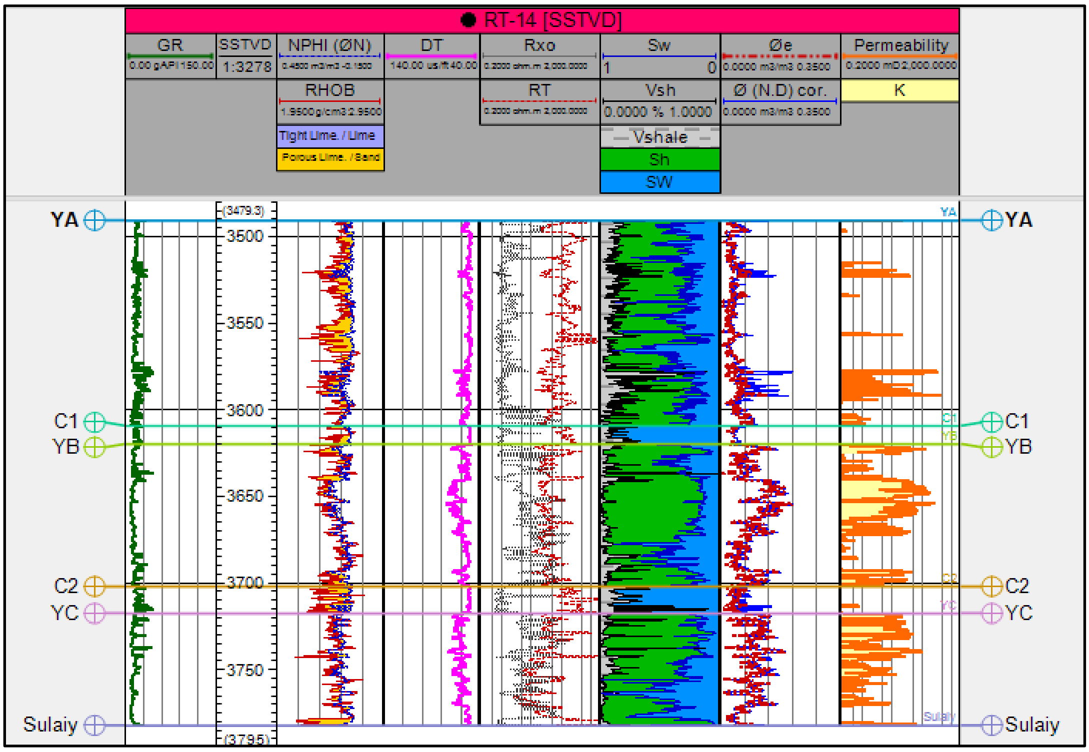

Fig. (10) (CPI) - Petrophysical characteristics of Yamama Formation in Ratawi field, well (Rt-14)

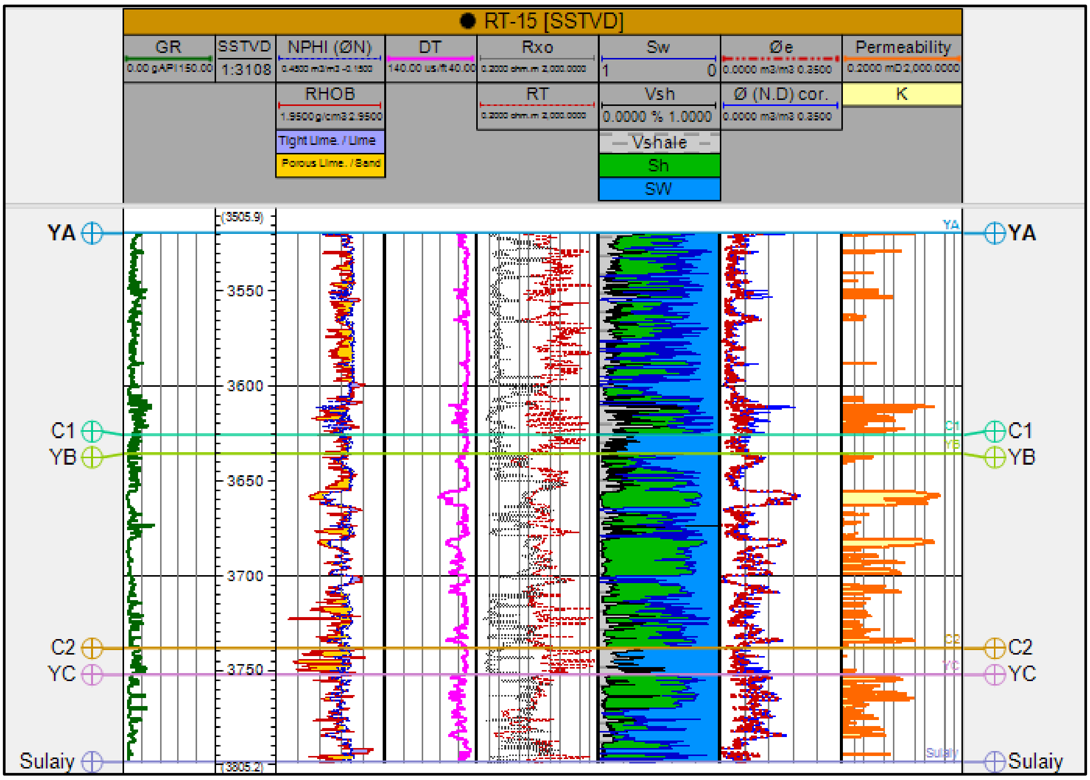

Fig. (11) (CPI) - Petrophysical characteristics of Yamama Formation in Ratawi field, well (Rt-15)

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Determination the lithology, mineralogy by using crossplots

Crossplots are a convenient graphical way to solve complex relationships using two or(three) porosity measurements. All crossplots have the same format , one measurement is displayed along the y-axis and another is displayed along the x-axis[1].*S*o, it considers an important application that can be used to determine lithology, the diagnosis of rock, mineralogy. These crossplots are only useful in limestone, sandstone, and dolomite, but are imprecise in the case of the presence some anomalous minerals[2]. Below are the main types of these applications:

Density-Neutron plot

This crossplot used for the formation consists of only two known minerals in unknown proportions [4]. Determination of lithology and porosity requires to plot the reading values of neutron log(ØN) and density log(ρb) on this crossplot. The intersection of those values on the plot determines both lithology and porosity of the point[1].

As it is noticed through fig. (12, and 13) for the wells of the study area (RT-5, RT-6, RT, 4, RT-7, RT-14, RT-15) that most of the points fall in the range of Mainly limestone with some sandstone intrusions. while, for the wells RT-3, RT-13 which are located near the center of the field to the north, it was found that the formation contains limestone rocks with some intrusions of sandstone and little interference from dolomite. This indicates the flow of clastic sediments to the basin are coming from the positive areas near Yamama basin through air sediments or rivers, and these sediments vary in thickness from one well to another according to the location of the well to the basin, as well as the chemical water of seawater that controls carbon precipitation, in addition to the tectonic status of the regions that surrounding Ratawi field.

M-N plot

Lithology interpretation is facilitated by use of M-N plot figure(11,12) in more complex mineral mixtures[4]. This crossplot requires sonic log, density log and neutron log to calculate the lithologydependent variables M and N. M and N values are largely independent of matrix porosity. (M) and(N) values are calculated by the equations[1].

As it can be seen through fig. (14, and 15) for the wells of the study area (RT-6, RT, 4, RT-7, RT-14, RT-15) that most of the points fall in the range of Mainly calcite with some silica intrusions. while, for the wells RT-3, RT-13 which are located near the center of the field to the north, it was found that the formation contains calcite with some intrusions of silica and little interference from dolomite. Whereas the crossplot of well RT-5 which is located in the north of the field shows a mix of silica and calcite with few points towards shale zone and this indicates to the tidal flat and lagoon sediments with are content of silica with comes from clastic sediments with shale which is precipitates during this kind of environments and because of the multiple transgression - regression stages of Yamama formation.

The figures (14, and 15) for the wells of the study area (RT-5, RT-6, RT, 4, RT-7, RT-14, RT-15) show that most of the points fall in the range of Mainly calcite with some Quartz intrusions. while, for the wells RT-3, RT-13 which are located near the center of the field to the north, they were found that the formation contains calcite with some intrusions of Quartz and little interference from dolomite.

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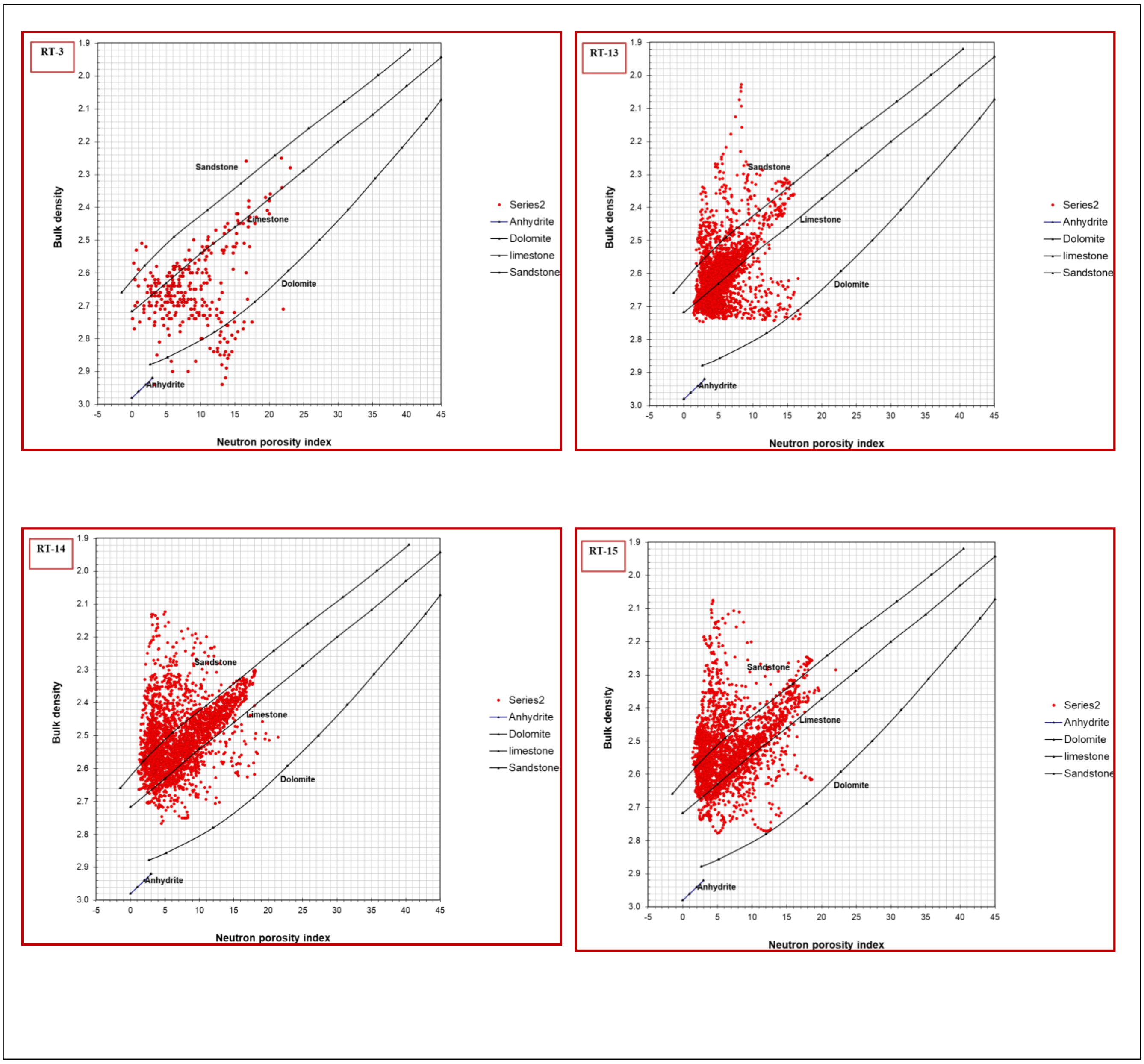

Fig. (12) Density -porosity cross plots for study wells (RT-3,RT-13.RT-14,and RT-15)

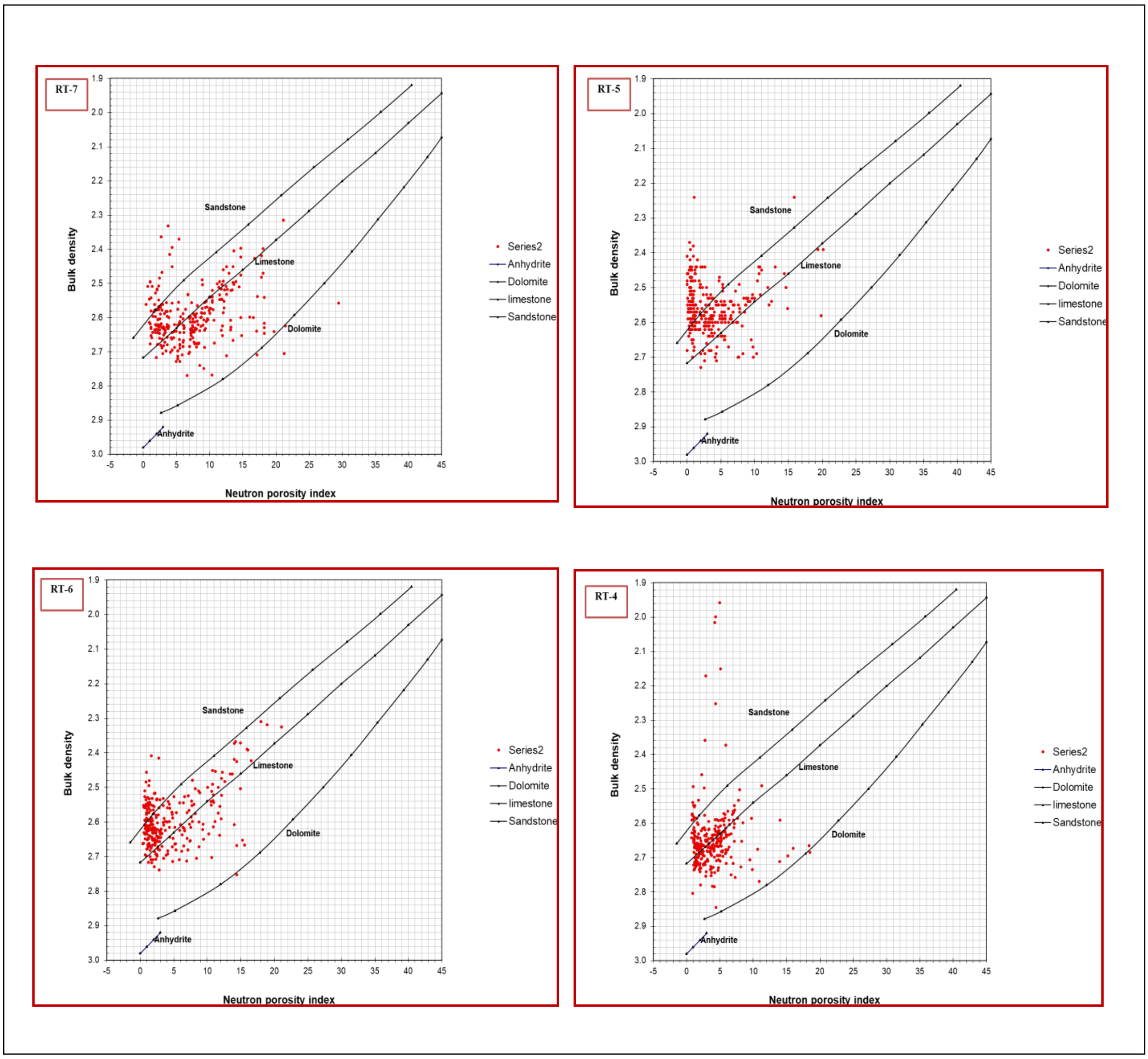

Fig. (13) Density -porosity cross plots for study wells (RT-7,RT-5.RT-6,and RT-4)

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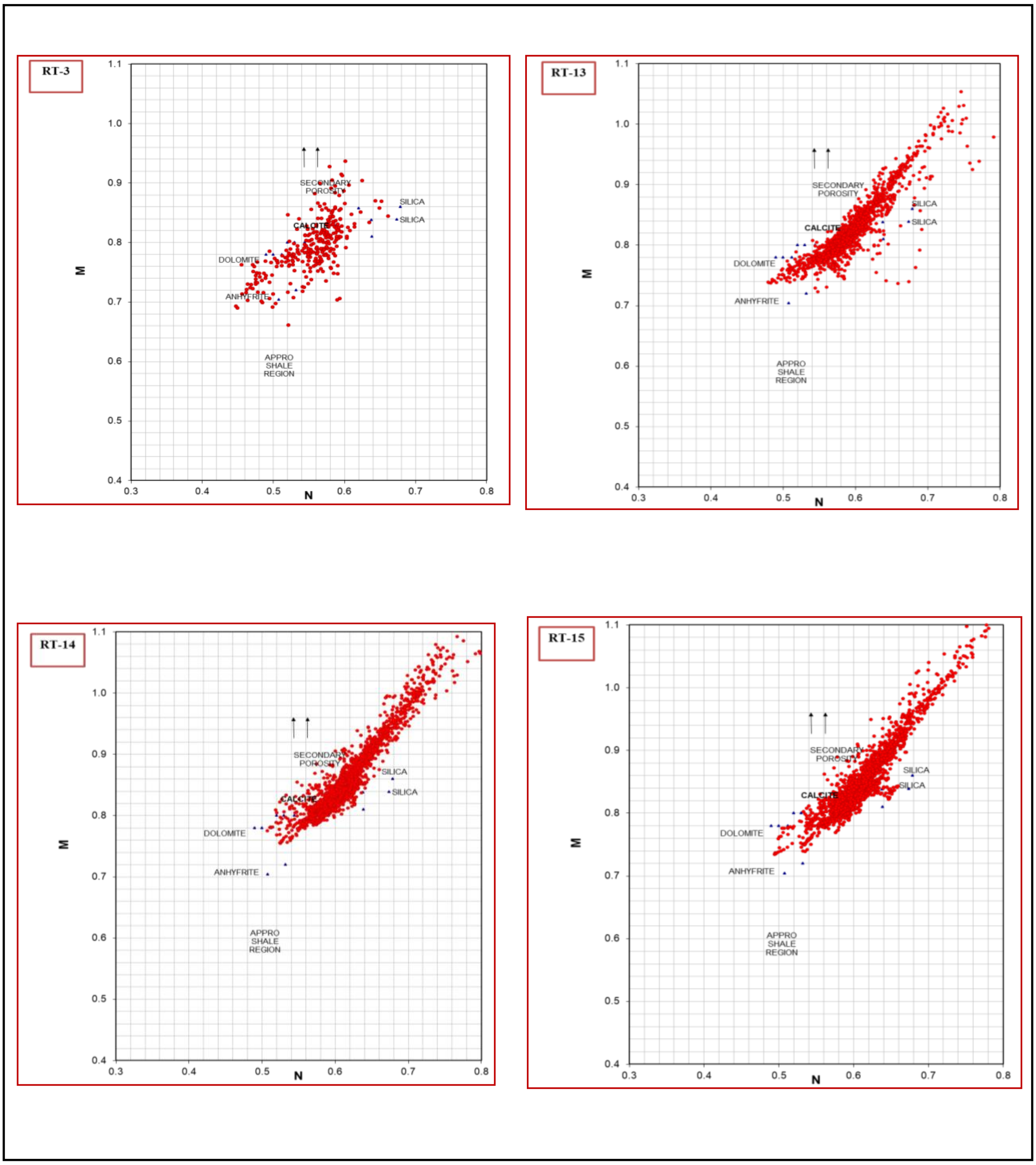

Fig.(14) M-N Plot to determine complex mineral mixtures for study wells (RT-3,RT-13.RT-14,and RT-15)

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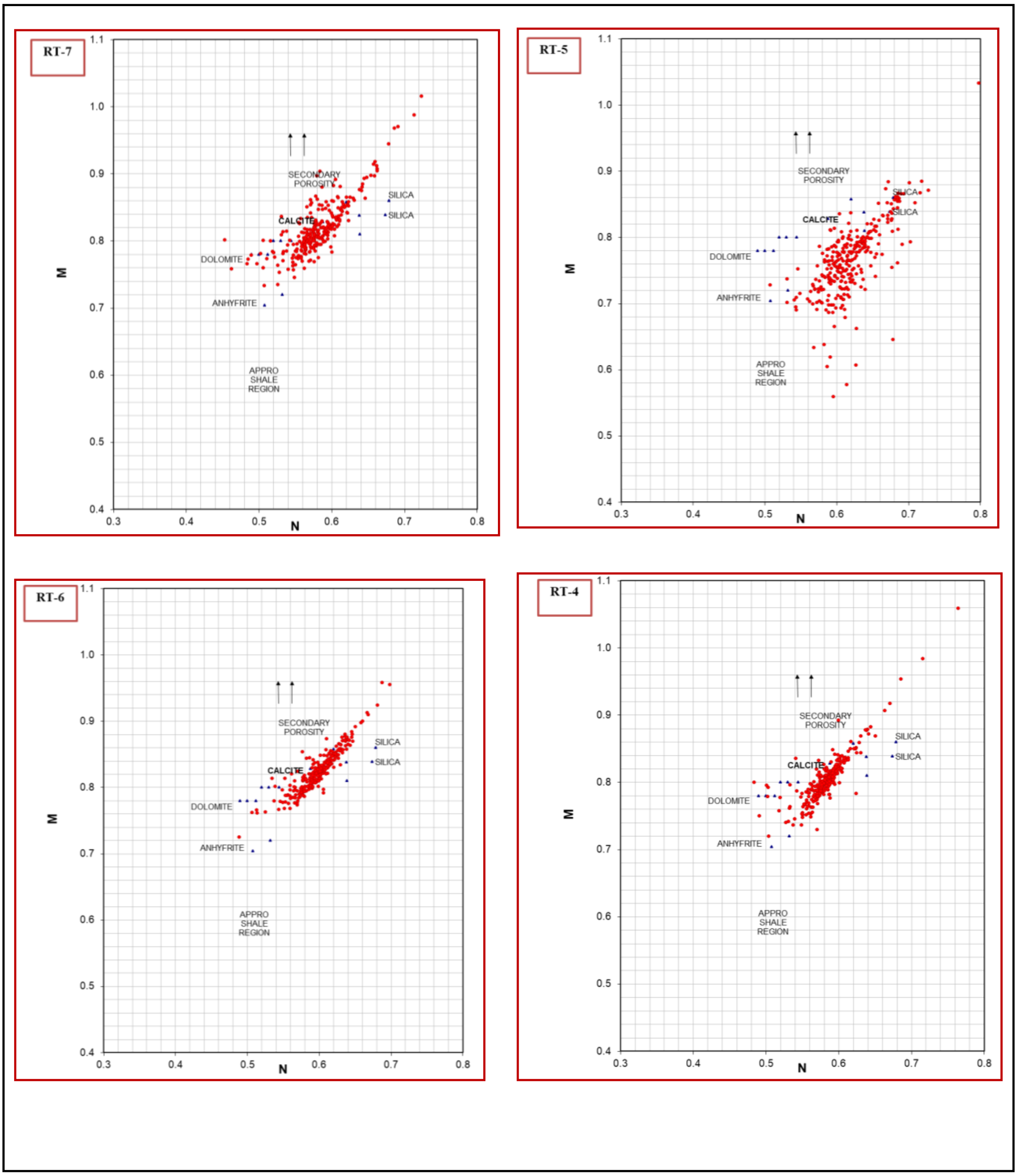

Fig.(15) M-N Plot to determine complex mineral mixtures for study wells (RT-7,RT-5.RT-6,and RT-4)

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Conclusions

1- Basically, it can be said that the reservoir characteristics of the first reservoir unit which is YA is better near the center of the field and towards the west, and the characteristics deteriorate more we head towards the east of the field (See figures (3,4,5,6,7,8,,9,10,11)).
2- As a summary for reservoir properties in unit (YB), it can be said is better near the center of the field and towards the south part of it at RT-14, and RT-15, and toward the west at RT-6, while the characteristics deteriorate towards the north at RT-5 and the wells of the near center of the field toward the north at RT-13; while the properties become more worse we head toward the east of the field at RT-4 (See figures (3,4,5,6,7,8,,9,10,11)).
3- The summary for reservoir properties in unit (YC), it can be said is better near the center of the field and towards the south part of it at RT-14, and RT-15, and in the south of the field at RT-7 and toward the west at RT-6, while the characteristics deteriorate towards the north at RT-5 and the wells of the near center of the field toward the north at RT-13; while the properties become more worse we head toward the east of the field at RT-4 (See figures (3,4,5,6,7,8,,9,10,11)).
4- Lithological and mineralogical study using ($\emptyset N - \rho b$) and (M-N) cross plots showed that Yamama formation is mainly consists of limestone with mudstone intercalations and the essential mineral components are varying between Calcite to Silica ,but tend to be dominantly calcite with small amounts of dolomite.

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