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Petrophysical Properties and Reservoir Modeling of Mishrif Formation at Amara Oil Field, Southeast Iraq

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Abstract

Petrophysical properties of Mishrif Formation at Amara oil field is determined from interpretation of open log data of (Am-1, 2 ,3 ,4 ,5 ,6 ,7 ,8 ,9 ,10 ,11 ,12 and13) wells. These properties include the total, the effected and the secondary porosity, as well as the moveable and the residual oil saturation in the invaded and uninvaded zones. According to petrophysical properties it is possible to divided Mishrif Formation which has thickness of a proximately 400 m, into seven main reservoir units (MA, MB11, MB12, MB13, MB21, MC1, MC2) . MA is divided into four secondary reservoir units , MB11 is divided into five secondary reservoir units , MB12 is divided into two secondary reservoir units , MB13 is divided into two secondary reservoir units and MB21 is divided into five secondary reservoir units. The seve units are separated by seven cap rocks (Bar1,2,3,4,5,6 and 7).A three-dimensional reservoir model is created by using (Petrel, 2014) software for all reservoir unit. The results show that the first and the second reservoir units represent important reservoir units of Mishrif Formation. Variables of thickness and reservoir properties are consider of Amara oil field.

Keywords: Petrophysical properties, Reservoir modeling, Mishrif Formation .

الخصائص البتروفيزيائية والموديل المكمني لتكوين المشرف في حقل العمارة النفطي جنوب شرق العراق

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الخلاصة

جرى في البحث الحالي تحديد الخصائص البتروفيزيائية لتكوين المشرف في حقل العمارة من خلال تفسير بيانات المجسات البئرية لإبار الدراسة (Am-1,2,3,4,5,6,7,8,9,10,11,12 and13) والتي من خلالها جرى حساب المسامية الكلية والفعالة والثانوية والتشبعين المائي والنفطي بجزئيه القابل للحركة والمتبقي وللنطاقين المكتسح وغير المكتسح . واعتماداً على الخصائص البتروفيزيائية المحسوبة قسم تكوين المشرف في حقل العمارة الذي يتراوح سمكه 400 م تقريبا الى سبعة وحدات مكمنية رئيسية (MA, MB11,MB12,MB13,MB21,MC1,MC2) وقسمت MA الى اربع وحدات ثانوية وMB11 الى خمس وحدات ثانوية وMB12 الى وحدتين ثانوية وMB13 الى وحدتين ثانوية وMB21 الى خمس وحدات ثانوية تفصلها سبع وحدات عازلة (Bar1,2,3,4,5,6,7). جرى تمثيل المعطيات البتروفيزيائية

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المكمنية من خلال بناء نموذج مكمني ثلاثي الابعاد للتشبع النفطي وذلك باستخدام برنامج (Petrel, 2014) لتوضيح توزيع تلك الخصائص البتروفيزيائية لكل وحدة مكمنية ضمن ابار الحقل . بينت النتائج ان افضل الوحدات المكمنية هي الوحدة المكمنية MA و الوحدة المكمنية MB11 اخذين بنظر الاعتبار تغاير سماكة تلك الوحدات واتجاه زيادتها ونقصانها .

Introduction

Mishrif Formation is considered as an important middle Cretaceous carbonate formation deposited during the Cenomanian-Early Turonian. The Cenomanian-Early Turonian interval is also regarded as an early subcycle within a larger cycle (megasequence) of Cenomanian- early Campanian [1]. The contact between Mishrif and Rumaila Formations is gradational, the Mishrif Formation is unconformably overlain by the Khasibe Formation where the Kifil Formation is absent [2].

The Study Area

Amara Oil Field is located in southeastern Iraq in Missan province, about 10 Km southwestern Amara city and about 25 Km east of Al-Rafedain structure (Abu-Amoud structure), and about 30 Km southeastern Al-Kumait structure Figure- 1.There are thirteen wells penetrated Mishrif Formation in Amara Oil Field (Am-1,2,3,4,5,6,7,8,9,10,11,12 and 13) .

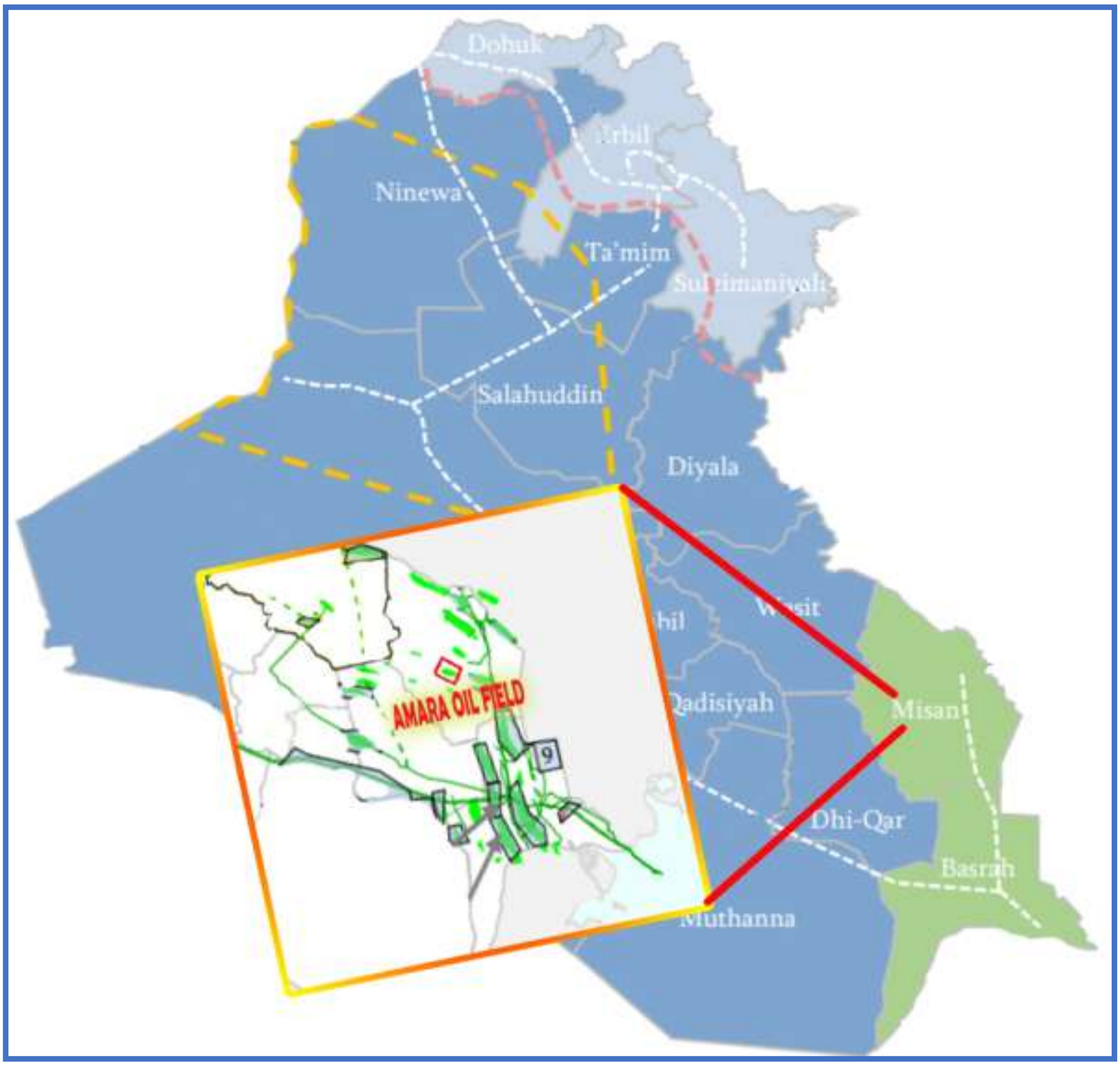

Figure 1- Location map of the study area

Aims of the Study

The following objectives are aimed to be achieved for Mishrif Formation in

Amara Oil Field:
1. Definition of petrophysical properties of Mishrif Formation .
2. construct a three-dimensional geologic model that will show the distribution of the different reservoir properties within the Mishrif Formation.

Methodology
1. Using interactive petrophysical software IP (V3.6) for analyze the full set of logs to determine the environmental correction, lithology and mineralogy identification , V_{clay}, Φ, Rw,BVW and CPI.
2. Utilization Petrel 2014 software for building 3D structural, petrophysical models.

Results

Petrophysical Properties Estimation

Log interpretation, or formation evaluation, requires the combining logging tool response, physics, geological knowledge and additional measurements or information to extract the maximum petrophysical information concerning reservoir [3] .

Clay Volume Determination from GR

To determine the volume of clay (Vclay) from a gamma ray log, the following formula for older rocks from the gamma-ray index (GRI) equations (1&2) [4].

$$GRI\ \% = \frac{GR\ log - GR\ min}{GR\ max - GR\ min} \quad (1)$$

$$V_{clay} = 0.33(2^{(2*IGR)} - 1) \quad (2)$$

Where,

GRI: is the gamma ray index، GR log: is the gamma ray log reading in the zone of interest, API units، GR min: is the minimum gamma ray reading in a clean zone, API units, and GR max: is the maximum gamma ray reading in shale zone, API units . Figure -2 shows the results of Vclay in well Am-11.

Porosity Determination

The porosity of a rock is defined as the ratio of the pore volume to the bulk volume of the reservoir rock on percentage basis The measurement of porosity is important to the petroleum engineer since the porosity determines the storage capacity of the reservoir for oil. It is necessary to distinguish between the types of porosity.

A. The Total porosity

By combination of Neutron-Density logs, the total porosity within the Mishrif Formation was determined. Schlumberger in1974 proposed an equation to compute the total porosity from neutron and density logs that may be expressed as [5] :

$$\Phi_{total} = \frac{\Phi N + \Phi D}{2} \quad (3)$$

B. The Effective porosity

The effective porosity (Φ_e) has been determined from the total porosity by discounting the volume filled by clay-bound and irreducible water and it is therefore always less than or equal to the total porosity depending on the volume of shale [6] . A common and simpler equation corrects the total porosity, Φt, to the effective porosity, Φe by:

$$\Phi_e = \Phi_{total} - (1 - V_{clay}) \quad (4)$$

Where:

$\Phi_{total:}$ is the total porosity . $V_{clay:}$ is the volume of clay .

Determination of Formation Water from (SP) Log method

Water resistivity has been estimated relies on SP log methods .This method depends on the following relationship between (Rw) and (SSP) can be expressed by the equation (5) [7].

$$SSP = -k\ \log g\left(\frac{Rmf}{Rw}\right) \quad (5)$$

Where,

SSP: is the Static Spontaneous Potential (mv)، Rmf: is the mud filtrate resistivity (ohm-m)، K: is the SP Coefficient and، Rw: is the formation water resistivity (ohm-m).

Determination of Archie's parameters using Pickett's method

Pickett's (1966) suggested a method that depends on a cross plot between the resistivity and the porosity to calculate (m) and/or (a) from well logs [8].

In a water-bearing zone ($S_w = 1$)

$$Log(R_t) = - m \log (\Phi) + \log (a. R_w) \quad (6)$$

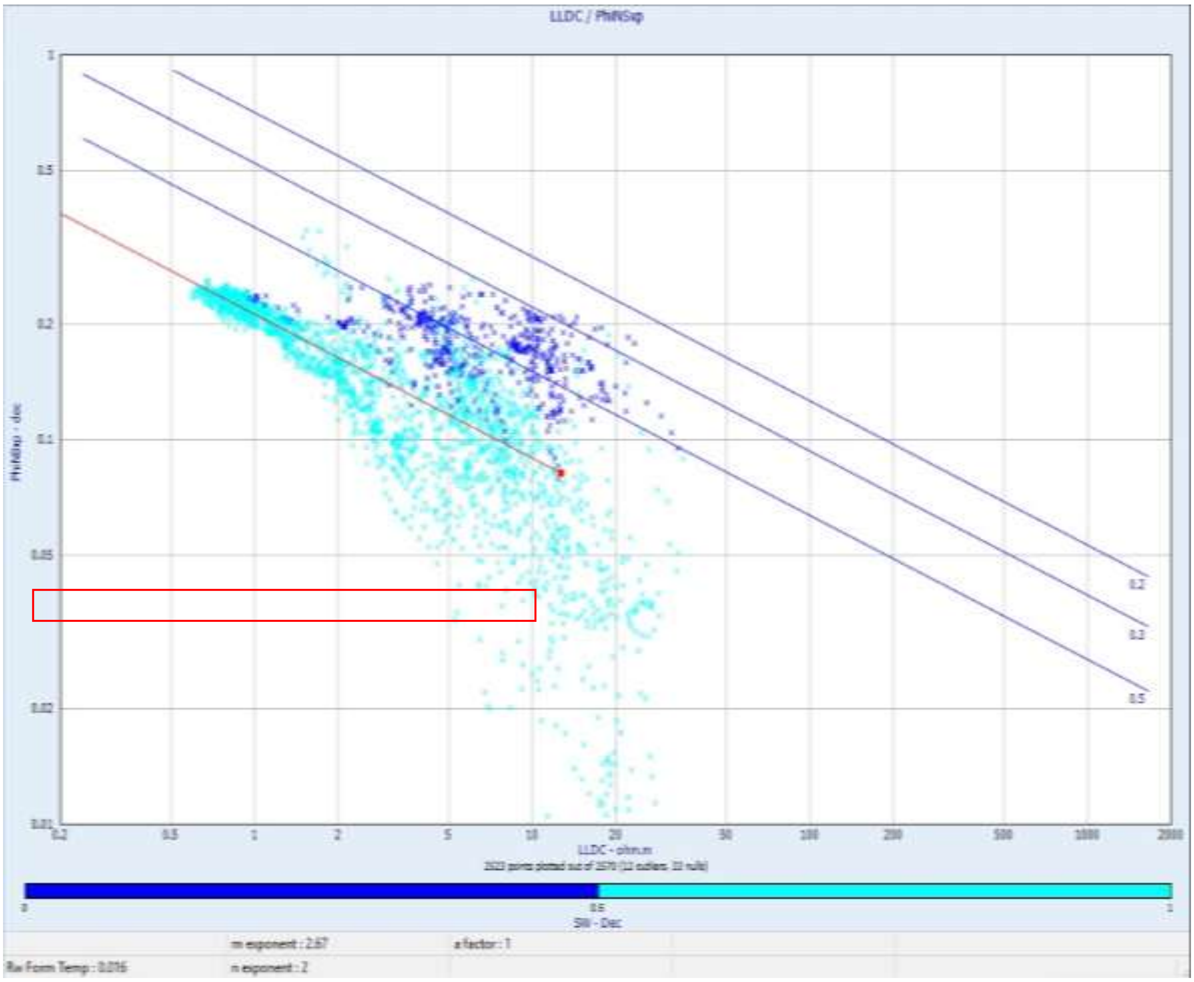

Figure 2-shows the results of Pickett plot in well Am-13.

Determination of Water and Hydrocarbon Saturations

The water saturation has been calculated by using Archie's equation which can be expressed as the following equation [9]:

$$Sw= [\frac{aRw}{\Phi mRt}]^{1/n} \quad (7)$$

From the above equation, the water saturation can be calculated relies on Rw value from sp log method, and the coefficient (a, m, n) from Pickett plot. And the hydrocarbon saturation has been calculated from the following equation:

$$Sh = 1-Sw \quad (8)$$

Sh= is the hydrocarbon saturation

When Archie's equation is used in the flushed zone resistivity (Rxo) and mud filtrate resistivity (Rmf), the value of water saturation in flushed zone can be computed from the following equation:

$$Sxo= [\frac{a\, Rmf}{m\Phi\, Rxo}]^{1/n} \quad (9)$$

Where Sxo: is the water saturation in the flushed zone, fraction .

Beyond assuming the water saturation in the flushed zone and the water saturation in the virgin zone the residual oil saturation and the moveable oil saturation can be calculated from the following equations [10].

$$MOS = Sox - Sw \quad (10)$$

$$ROS = 1 – Sxo \quad (11)$$

$$BVO= Sh * \Phi_{N-D} \quad (12)$$

Where, MOS =is the moveable oil saturation, MOS= is the residual oil saturation, BVO= is the bulk volume of oil in un invaded zone.

Bulk Volume Analysis

The product of a formation's water saturation (Sw) and its total porosity (Φtotal) is the bulk volume of water (BVW). The bulk volume of water for the uninvaded zone and flashed zones have been calculated by these equations [6] :

- For the uninvaded zone:

$$BVw = Sw * \Phi_{total} \tag{12}$$

- For the Flashed zone:

$$BVxo = Sxo * \Phi_{total} \tag{13}$$

Computer Processed Interpretation

The computer processed log interpretation allows analysing and evaluating numerous types of logs with ease and presenting the results as functions of depth in graphical forms for visualization [11]. According to petrophysical properties it is possible to divided Mishrif Formation wich has thickness of a proximately 400 m, into seven main reservoir units namely (MA, MB11, MB12, MB13, MB21, MC1, MC2) .Unit MA is divided into four secondary reservoir units , MB11 is divided into five secondary reservoir units , MB12 is divided into two secondary reservoir units , MB13 is divided into two secondary reservoir units and MB21 is divided into five secondary reservoir units. The seve units are separated by seven cap rocks (Bar1,2,3,4,5,6 and 7). Explained in Figure-3.

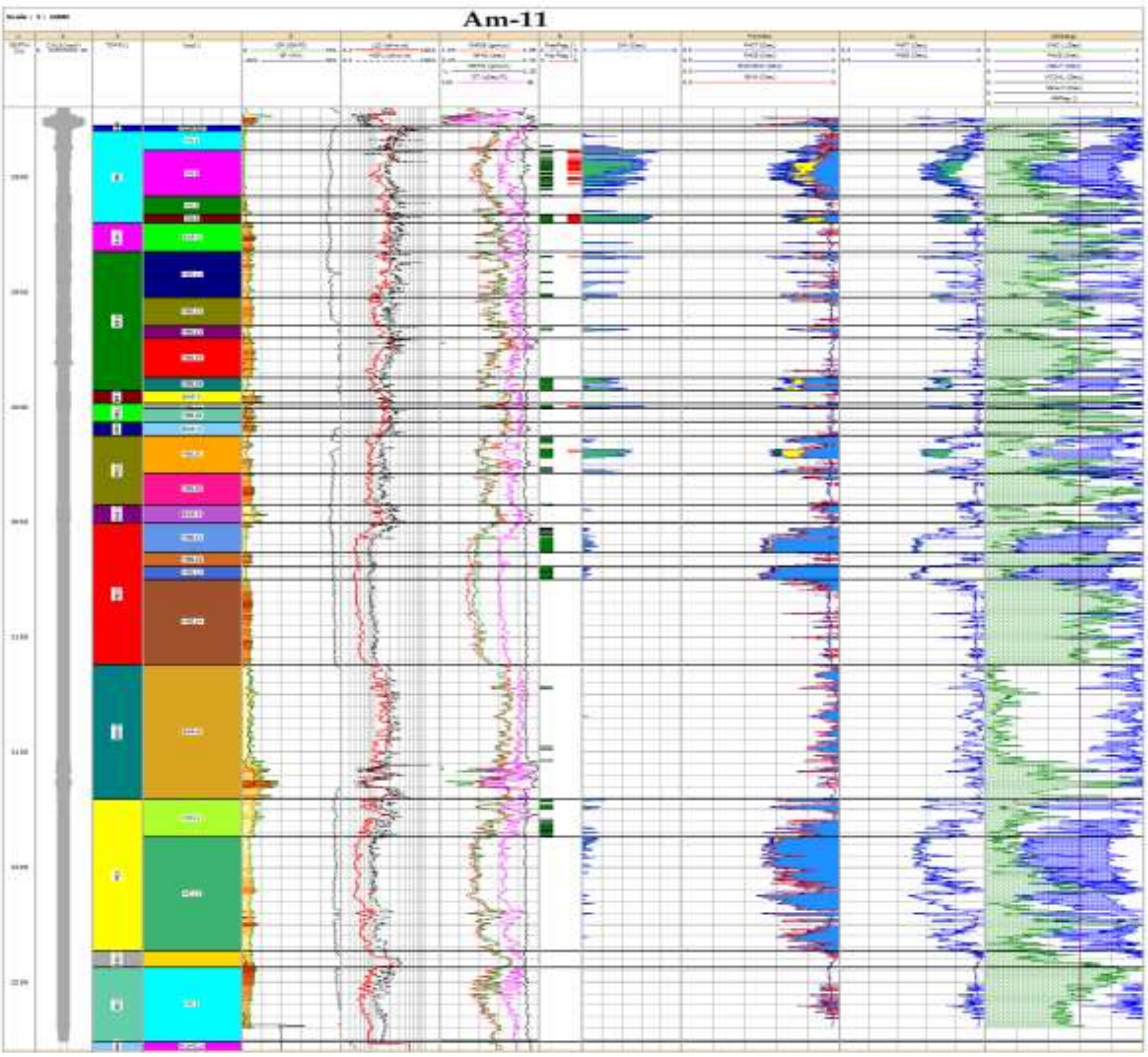

Figure 3-The computer processed log interpretation of Am-11.

Reservoir modeling

Structural modeling

Structural modeling is used for building geological model. A structure contour map is one of the most important tools for three-dimensional structural interpretation. 3D Structural maps were built depending on structural contour map and the well tops for all Amara wells as well as the available structural map for the top of Mishrif Formation from 2D seismic map. 3D contour structures have been built to each zone of the Mishrif reservoir as seen in Figure -4 [12].

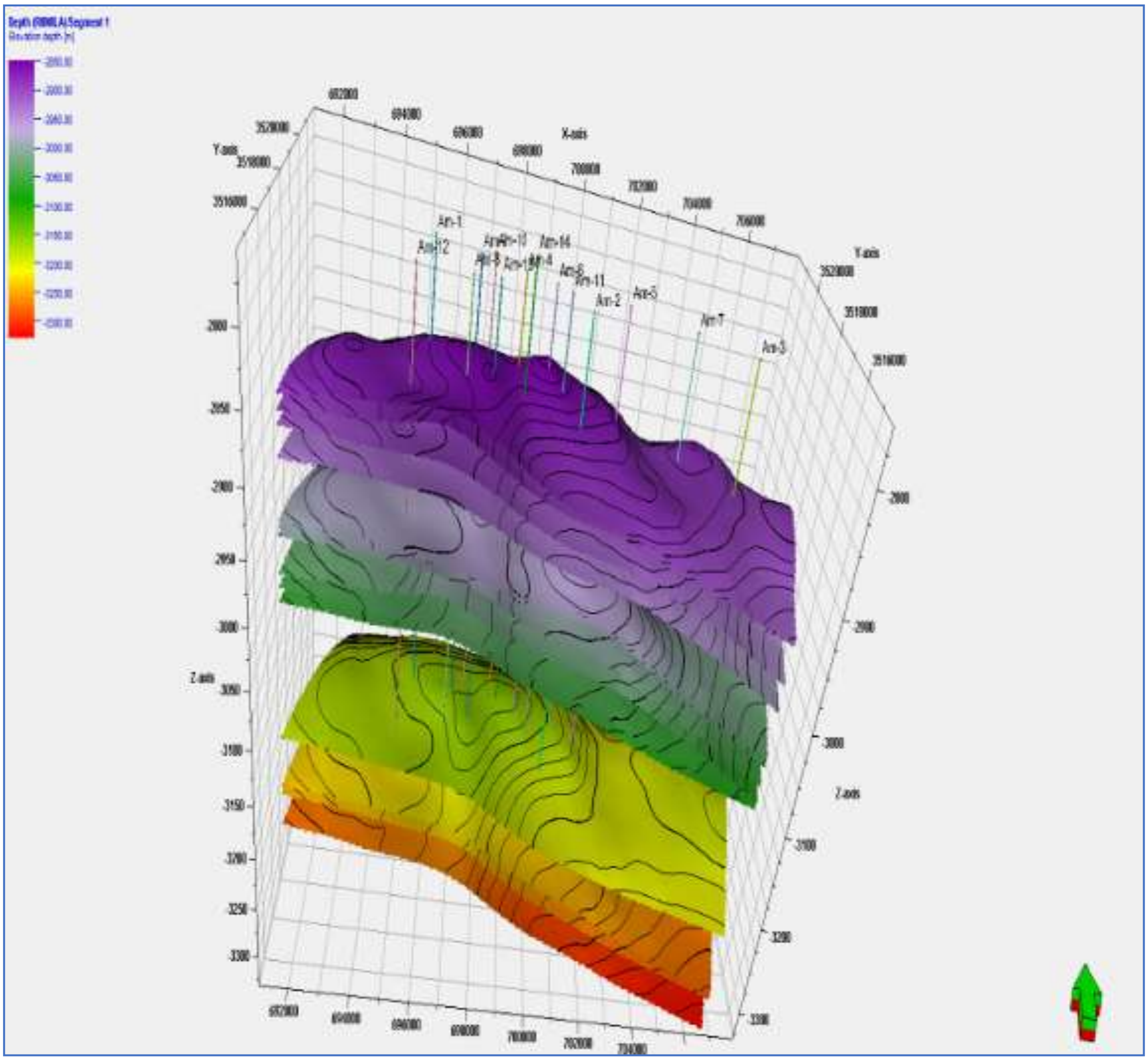

Figure 4- Represents 3D structural modeling of Mishrif units.

3D Grid Construction

A 3D grid construction is the first step to build the 3D model. It is a network of horizontal and vertical lines used to describe a three-dimensional geological model. In simple terms, a 3D grid divides a model up into boxes. Each box is called a grid cell and will have a single rock type, one value of porosity, one value of water saturation, etc. These are referred to as the cell properties [13].

Pillar Gridding

Pillar gridding is the process of generating the grid, which represents the base of all modeling. The skeleton is a grid consisting of top, mid and base skeleton grids [14]. The grid which used in Mishrif Formation was represented by three-dimensional grid systems of (100) grid along the X – axis and (100) grid along Y – axis. The size of grid was chosen depending on the area of the field and to specify the variation of the petrophysical properties. The result from pillar gridding is the main skeleton in top, mid and base skeletons as shown in Figure-5. This figure shows a 3D grid or three skeletons of Mishrif reservoir model in Amara oil field.

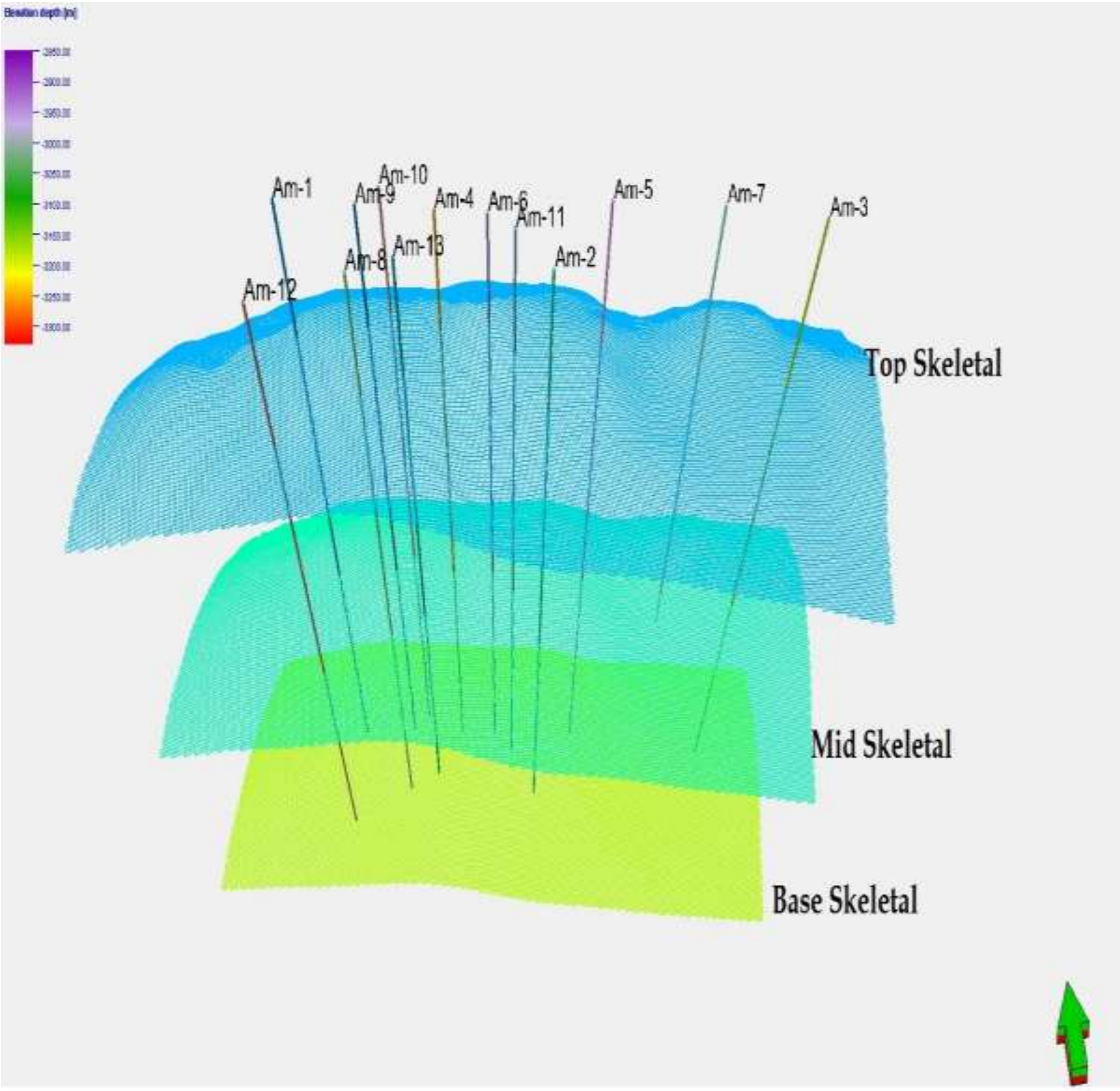

Figure 5-The skeletons of Mishrif reservoir in Amara oil field.using petrel 2014.

Scale up Well logs

The Scale up well logs process averages the values of the properties in the cells in the 3D grid that are penetrated by the wells. Each cell gets one value per up scaled log. These cells are later used as a starting point for property modeling . When modeling petrophysical properties, a 3D grid cell structure is used to show the volume of the zone. The cell thickness will normally be larger than the sample density for well logs. As a result, the well logs must be scaled up to the resolution of the 3D grid before modeling based on well logs can be done. This process is also called blocking of well logs [15]. There are many statistical methods used to scale up such as arithmetic, harmonic, and geometric method. The porosity and water saturation values in the current model have been scaled up using the arithmetic average. Figure-6 shows the scale up of porosity and water saturation for select well Am-11 that is used in the Mishrif Formation model.

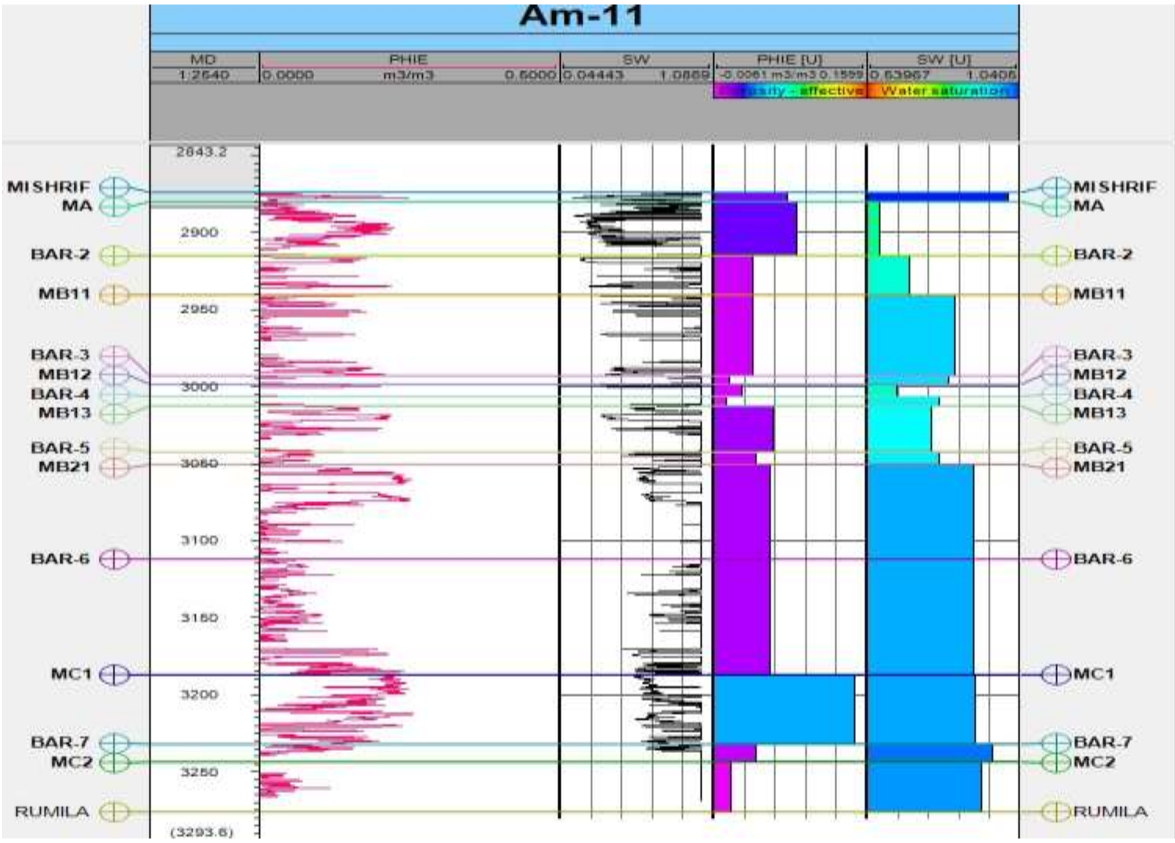

Figure 6- Scale up of porosity and water saturation for Am-11 using petrel 2014

Petrophysical modeling

process Petrophysical property modeling is the process of assigning petrophysical property values (porosity and water saturation) to each cell of the 3D grid. Petrel offers several algorithms for modeling the distribution of petrophysical properties in a reservoir model. Petrophysics model was built using geostatistical methods. Porosity and water saturation models were built depending on the results of porosity and water saturation values which have been corrected and interpreted in the IP software.The Sequential Gaussian Simulation algorithm was used as a statistical method [15] .

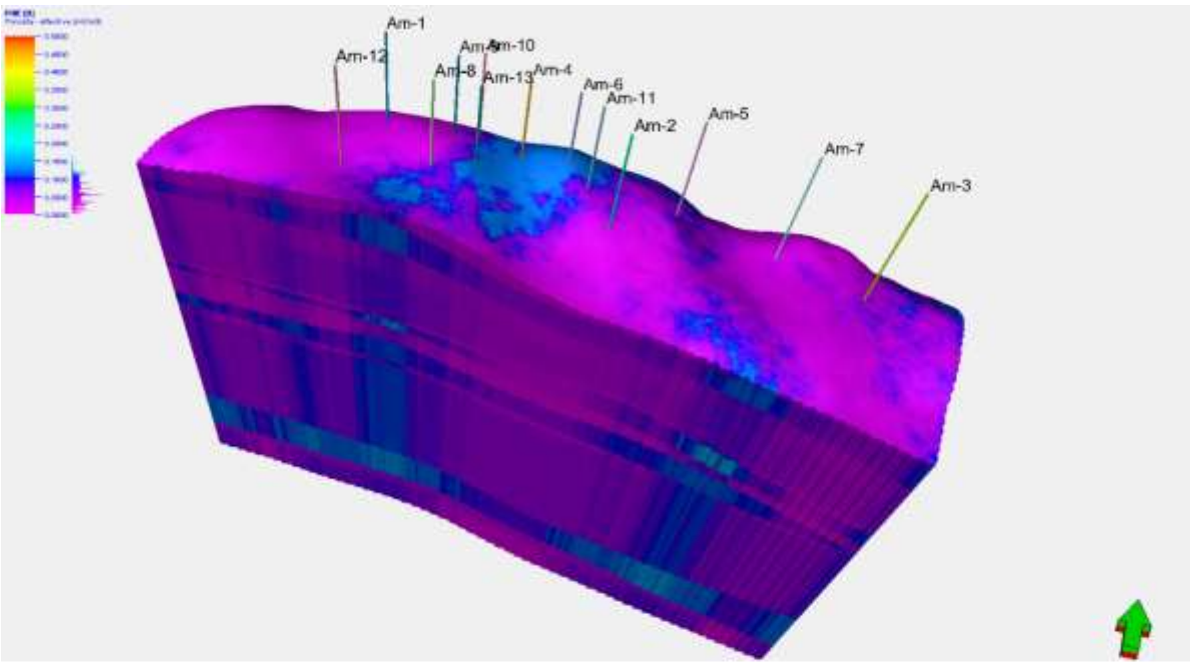

Figure 7-Porosity model of Mishrif Formation in Amara oil field using petrel 2014.

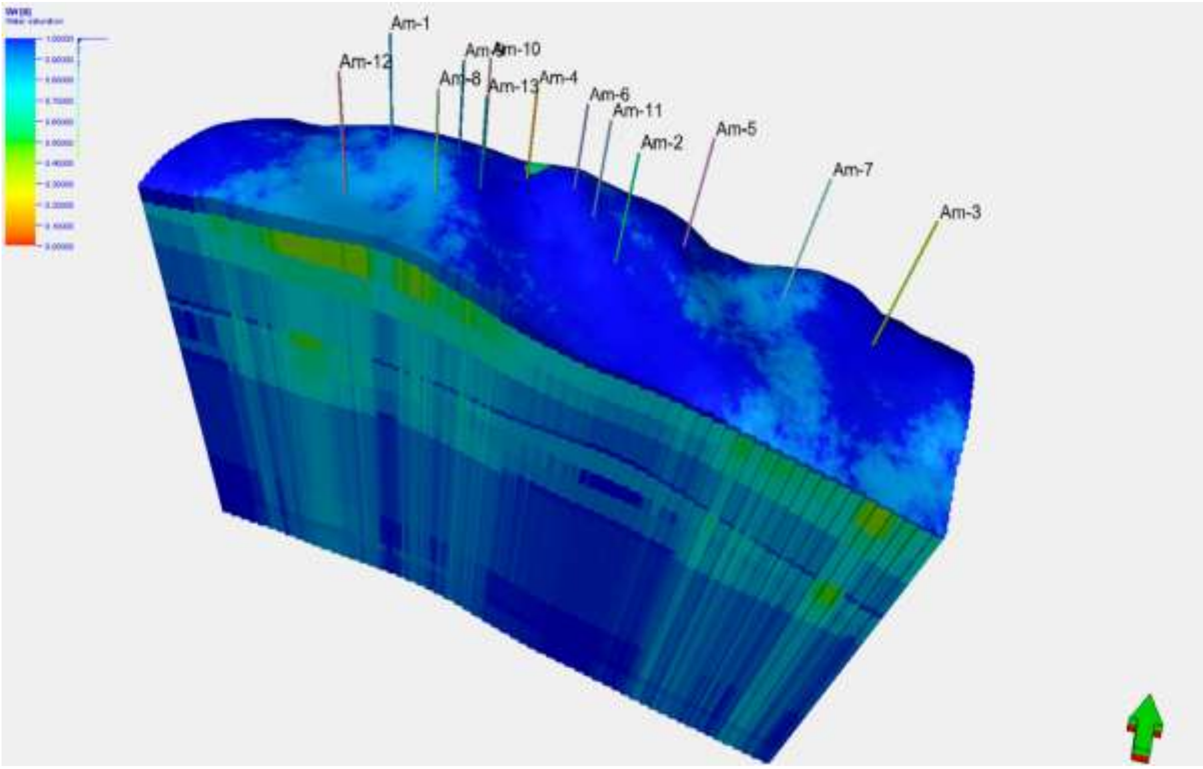

Figure 8-Water saturation model of Mishrif Formation in Amara oil field using petrel 2014.

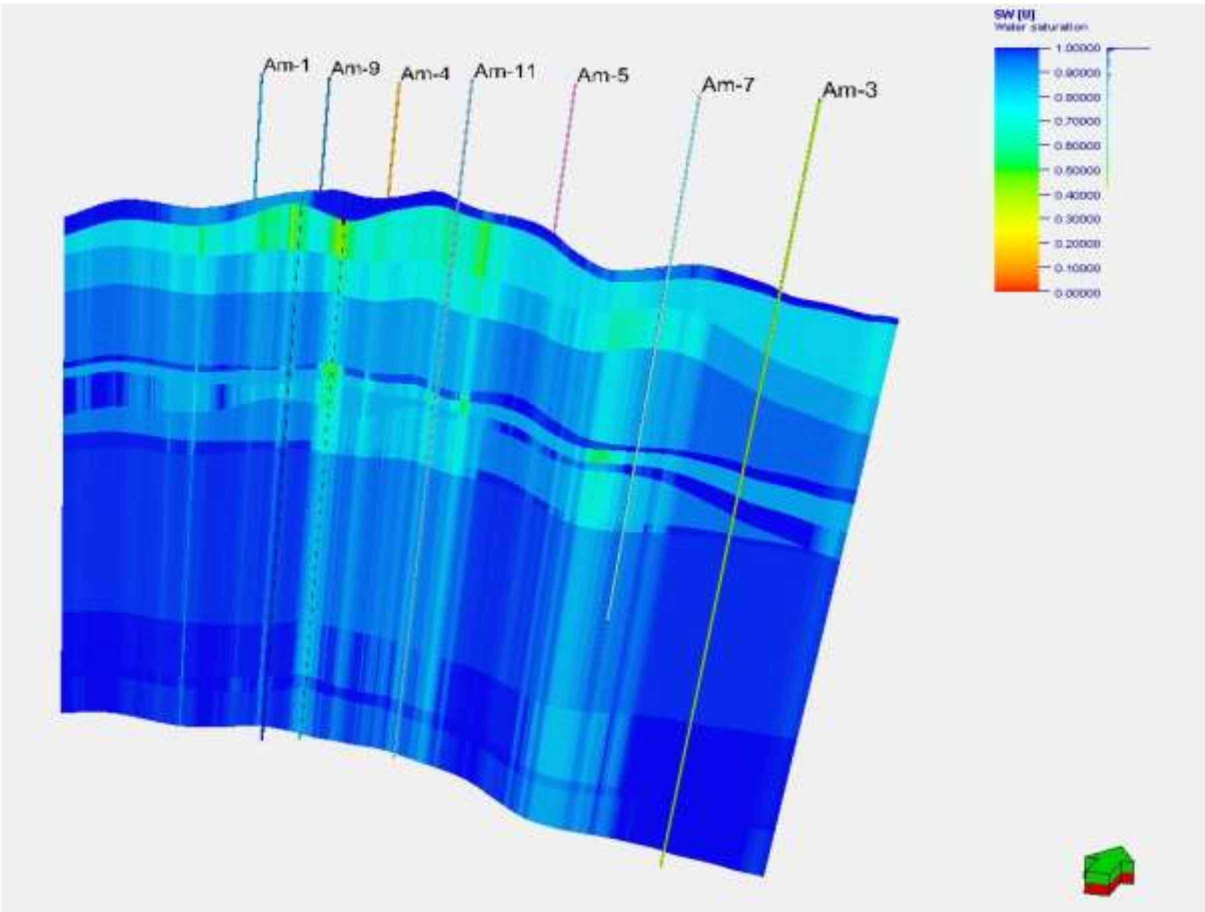

Figure 9- Well section window of Mishrif Formation shows variation in Sw values using petrel 2014.

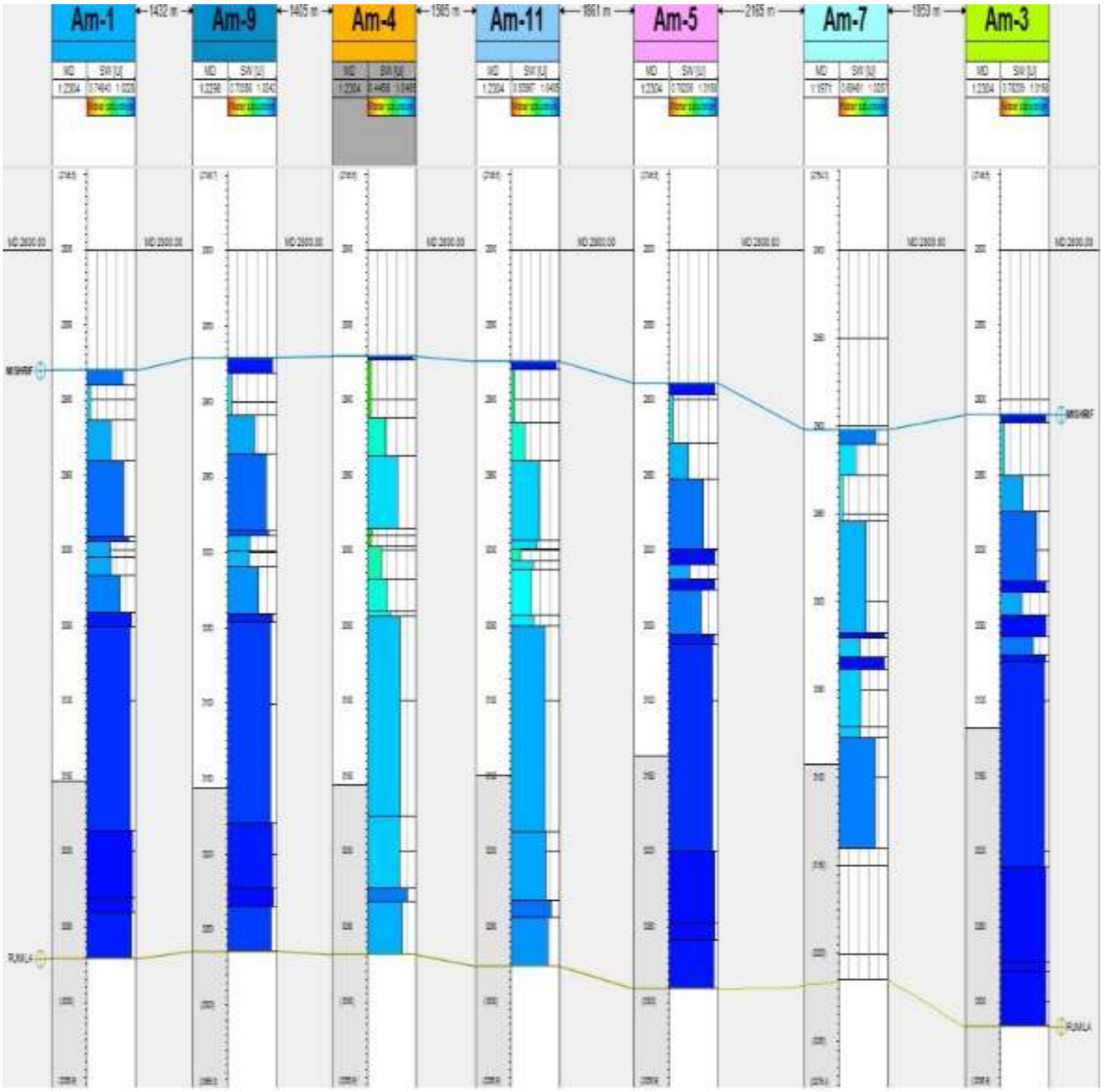

Figure 9- Correlation section of Mishrif Formation shows variation in Sw values.

Discussions and conclusion:

From porosity and water saturation models for each zone of Mishrif Formation the following conclusion can be shown:

1. Petrophysical model (porosity and water saturation) for Mishrif reservoir in Amara Oil Field was built from porosity and water saturation values using Sequential Gaussian Simulation algorithms as a statistical method after scale up of porosity and water saturation.
2. This model presents that the high porosity and low water saturation are occurred in the secondary reservoir unit MA2 which represents the important oil bearing unit.
3. The secondary reservoir units Mb11, Mb12, Mb13 are characterized by moderate petrophysical properties.
4. Mb21 unit has good porosity and high water saturation. From water saturation modeling investigation, the oil water contact reaches the top of Mb21.
5. From cross sections of porosity and water saturation models which are built in E-W direction its found that the best location characterized by good reservoir properties is in wells (Am-11) and (Am-4) which are located in the crest Amara structure shows in Figure-9 .

References

1. Al-mohammad, R. A. H. **2012**. Depositional Environment and Petrophysical Properties Studyof Mishrif Formation in Tuba Oilfield , Southern Iraq. *Journal of Basrah Researches ((Sciences))*, **38**(1): 25–50.
2. Aqrawi, A. A. M., G. A. Thehni, G. H. Sherwani, eta B. M. A. Kareem, **1998**. Mid-cretaceous rudist-bearing carbonates of the Mishrif formation: An important reservoir sequence in the Mesopotamian Basin, Iraq. *Journal of Petroleum Geology*, **21**(1): 57–82 .
3. Ellis, D. V., eta J. M. Singer, 2008, *Well Logging for Earth Scientists*. John Wiley & Sons, Ltd Registered, 256 p.
4. Pramanik, A. G., V. Singh, R. Vig, A. K. Srivastava, eta D. N. Tiwary, **2004.** Estimation of effective porosity using geostatistics and multiattribute transforms. A case study: *Geophysics*, **69**(2): 352–372 .
5. Doveton, J. H. **2014**. *Principles of Mathematical Petrophysics*. Black willy,p267
6. G.Asquith, C. G. **1982**. Basic Well Log Analysis For Geologists: *The American Association of Petroleum Geologists*, 232 p.
7. Cannon, S. **2016**. *Petrophysics*: *A Practical Guide*: John Wiley & Sons, Ltd Registered, 209 p.
8. Pickett, G. R. **1966**. A Review of Current Techniques for Determination of Water Saturation From Logs. *Journal of Petroleum Technology*, **18**(11): 1425–1433.
9. ARCHIE, G. E. **1941**. The Electrical Resistivity Log as an Aid in Determining Some Reservoir Characteristics. *Journal of Petroleum Technology,* : 54–62.
10. Schlumberger. **2009**. *Log Interpretation Charts*: Texas, 310 p.
11. Desbrandes, R. **1985**. *Encyclopedia of Well Logging: Editions* ,OPHRYS, :406-410.
12. Schlumberger. **2010.** *Petrel Seismic to Simulation Software*: Schlumberger, 3417 p.
13. Schlumberger. **2013.** Petrel Geology and Modeling, Petrel Introduction Course: 559 p.
14. Schlumberger. **2008.** Seismic- to-Simulation Software,Petrel Introduction Course:Schlumberger, 50-334 pp.
15. Schlumberger. **2007.** Petrel Introduction Course 2007,p1244.