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Spatial Data Analysis for Geostatistical Modeling of Petrophysical Properties for Mishrif Formaiton, Nasiriya Oil Field

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Abstract

Spatial data analysis is performed in order to remove the skewness, a measure of the asymmetry of the probablitiy distribution. It also improve the normality, a key concept of statistics from the concept of normal distribution "bell shape", of the properties like improving the normality porosity, permeability and saturation which can be are visualized by using histograms. Three steps of spatial analysis are involved here; exploratory data analysis, variogram analysis and finally distributing the properties by using geostatistical algorithms for the properties. Mishrif Formation (unit MB1) in Nasiriya Oil Field was chosen to analyze and model the data for the first eight wells. The field is an anticline structure with northwest- southeast general trend. Mishrif Formation is the important middle cretaceous carbonate formation in the stratigraphic column of southern Iraq. The result of applying spatial data analysis showed the nature and quantitative summary of data and so it would be easy to remove the skewness and improve the normality of the petrophysical properties for suitable distribution by the algorithms. It also showed that unit MB1 in Mishrif Fromation contains good properties in which high porosity (0.182) and permeability (7.36 md) with low values of water saturation (0.285) that make it suitable for the accumulation of oil.

Key words: Spatial data analysis, variogram, geostatistics

Introduction

Geoff Bohling [1] declared that geostatistical algorithms give best results when input data are normally distributed and stationary where mean and variance do not vary in space.

Schlumberger [2] in its manual mentioned that Data analysis process enables detailed analysis for both discrete and continuous properties through histograms and function windows, which visualize the distribution and correlation between these properties.

Holdaway [3] classified data analysis into two types, which work side by side: exploratory and confirmatory.

The exploratory section visualizes the characteristics and nature of data to the statistician. On the other hand, confirmatory data analysis shows the quantitative deviation that used common statistical evidence of significance or confidence.

Ameer [4] performed three steps to complete data analysis; descriptive statistics in which it provides information about the nature of data, variogram analysis which defines the behavior of variation in a property and finally the spatial prediction using geostatistical algorithm.

Area of Study

Amnah [5] mentioned that Nasiriya oil field is located in Thi-Qar governorate about (38 km) north-west of Nasiriya. It is an anticline structure with northwest-southeast general trend. Many exploration wells had been drilled in the field and had discovered three reservoir (Mishrif, Yamama & Nahr Umr formations).

Atiaa, et. al [6] declared in their paper that the field is located in south of Iraq between latitudes (34 80' -34 60') N and longitudes (57 50' -60 10') E, figure as shown in Fig.(1). The Mishrif formation is considered heterogeneous formation originally described as organic detrital limestones with beds of algal, rudist, and coral-reef limestones, capped by limonitic fresh water limestones.

Jreou [7] mentioned that the studied formation is Mishrif which is divided into two main units (upper Mishrif, MA & lower Mishrif, MB). They are separated by thin shale unit (about 10 m in thickness). The lower Mishrif is subdivided into MB1 & MB2 with barrier rocks in some areas of the field.

The hydrocarbon is concentrated in MB1 and unit MB21. The study is focused only on unit MB1. The thickness of unit MB1 in Mishrif Formation ranges from 53m to 70m for the first eight wells as given in table (1).

Descriptive Statistics

Using histograms with quantitative summary or descriptive statistics can give precise information for formation data. Histograms with their statistical summary for the properties in unit MB1 are discussed here. The total number of points in unit MB1 is 320. The minimum value of porosity is (0.0001) and the maximum one is (0.294). The average porosity is (0.182) which is less than the highest portion or the most frequent points in the distribution, mode. This reflects the shape of data which is negatively skewed (to the left) as shown in Fig. (2a) and as given in table (2).

Water saturation in the unit is (o.022) as a minimum value and 1 (totally saturated) as as maximum value. The data of Sw is positively skewed where the mode value is less than the average water saturation value (0.285) as shown in Fig. (2) and as given in table (2).

A large difference between the min. value (2.46 md) and the max. one (57 md) for the permeability unit MB1 with the range of (54 md). The average value of permeability is (7.36 md) as shown in Fig. (2c) and as given in table (2).

Data Transformation

It can be noted from previous histograms that most of the petrophysical properties in the units are skewed. Data transformation is applied to remove the skewness and improve the normality of data.

Box-Cox transformation technique, available within data analysis in PETREL package software, is applied to the petrophysical properties of the studied formation.

The power factor Lambda (λ) represents the degree of skewness. Lambda value for porosity data in unit MB1 is (1.6) as shown in Fig.(3) while for water saturation it is (0.1) as shown in Fig.(4). The permeability lambda value in this unit is (0.4) approaches to the square root transformation and as shown in Fig.(5).

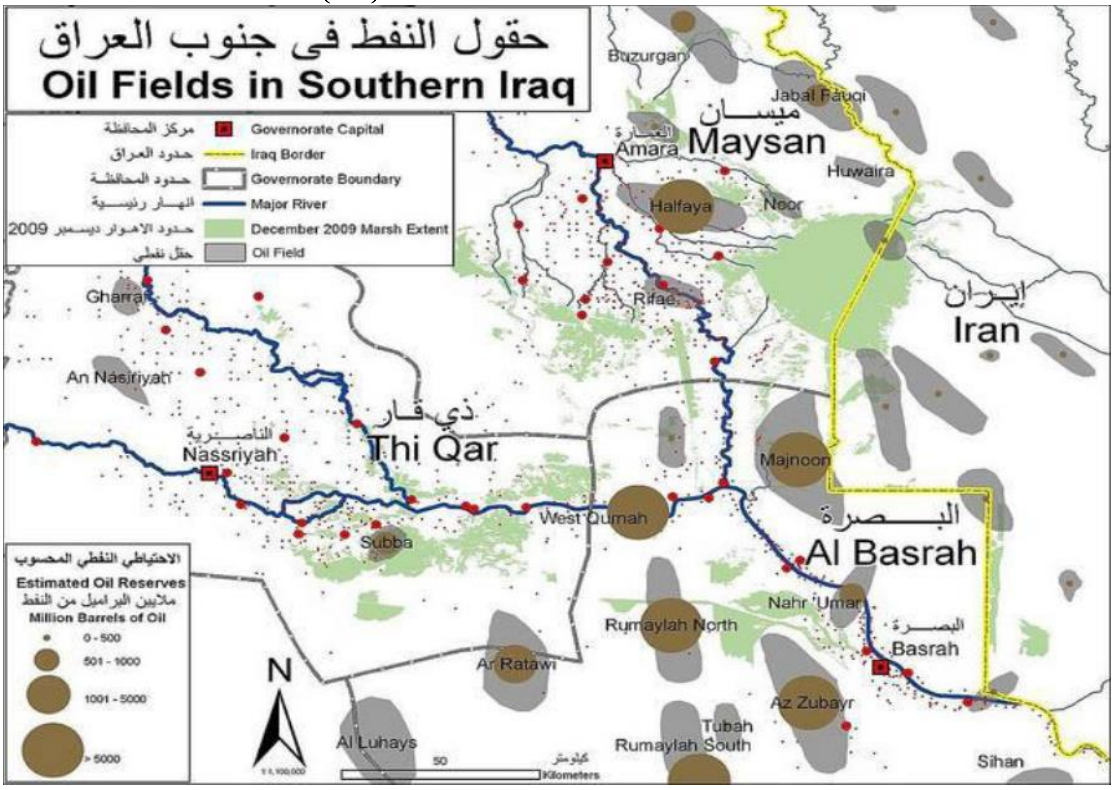


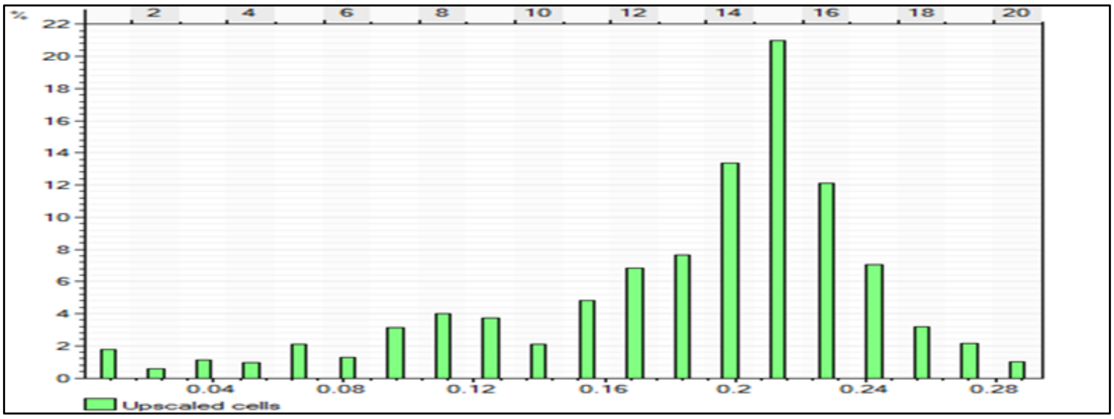
Fig.1, Geographical location of Nasiriya Oil Field [5]

Table 1, Top of Unit MB1 of Mishrif fm. for the first eight wells (MD, RTKB)

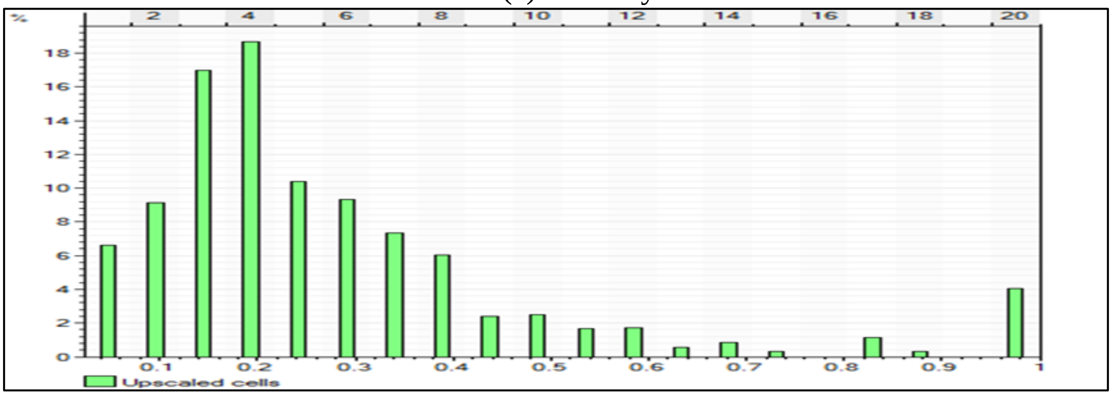
well/unit	Top of MB1 (M)	Top of MB2 (M)	Thickness of MB1 (M)
NS -1	2010	2063	53
NS -2	1991	2051	60
NS -3	2007	2063	56
NS -4	2000	2059.5	59.5
NS-5	1998	2057	59
NS-6	2006.5	2065.5	59.5
NS-7	1991	2058	67
NS-8	1985	2055	70

Table 2, statistical summary for unit MB

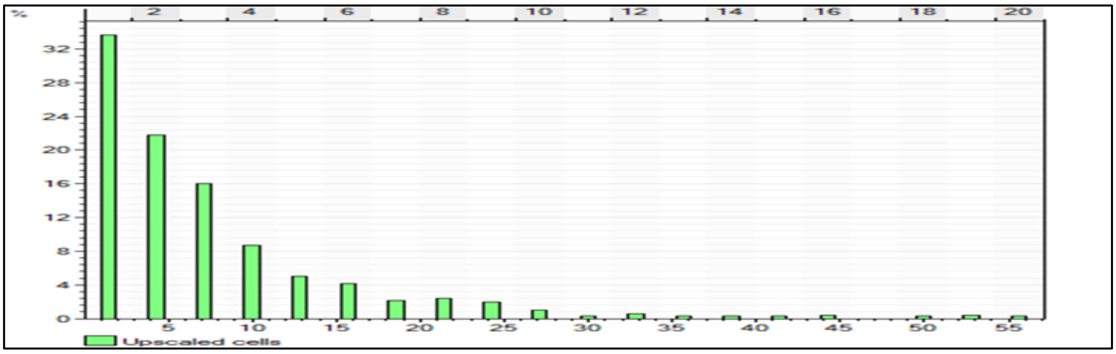
Property	No. of points	Min. value	Max. value	Average	St.dv.	C.V
PHIE (v/v)	320	0.0001	0.294	0.182	0.061	0.335
Sw (fraction)	320	0.022	1	0.285	0.215	0.765
K (md)	320	2.45	57	7.36	8.79	1.19



(a) Porosity



(b) Water Saturation



(c) Permeability

Fig.2, Petrophysical Properties Histograms for Unit MB1

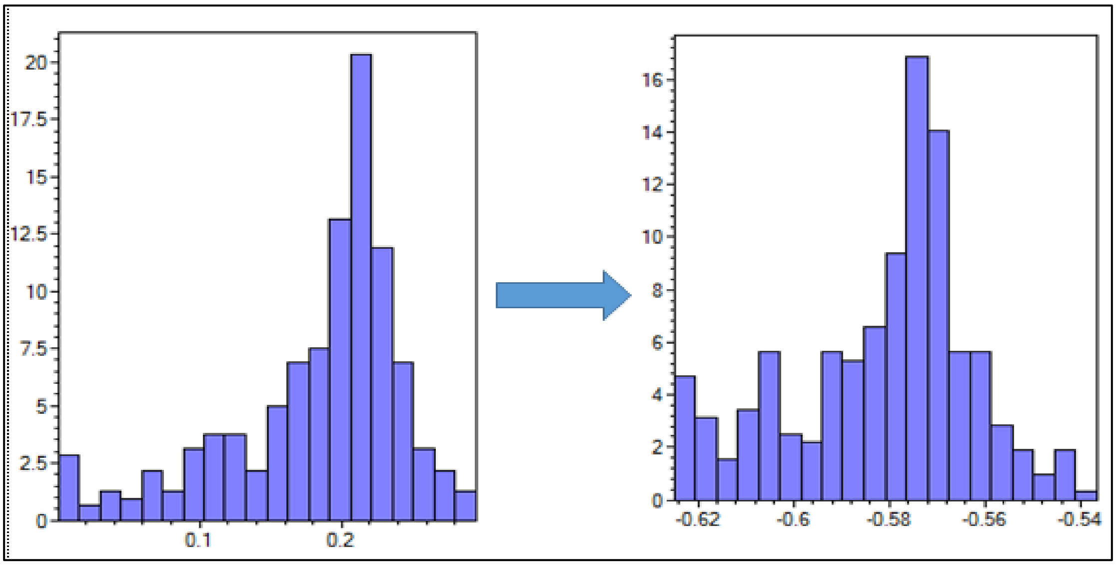


Fig.3, Porosity Transformation for Unit MB1

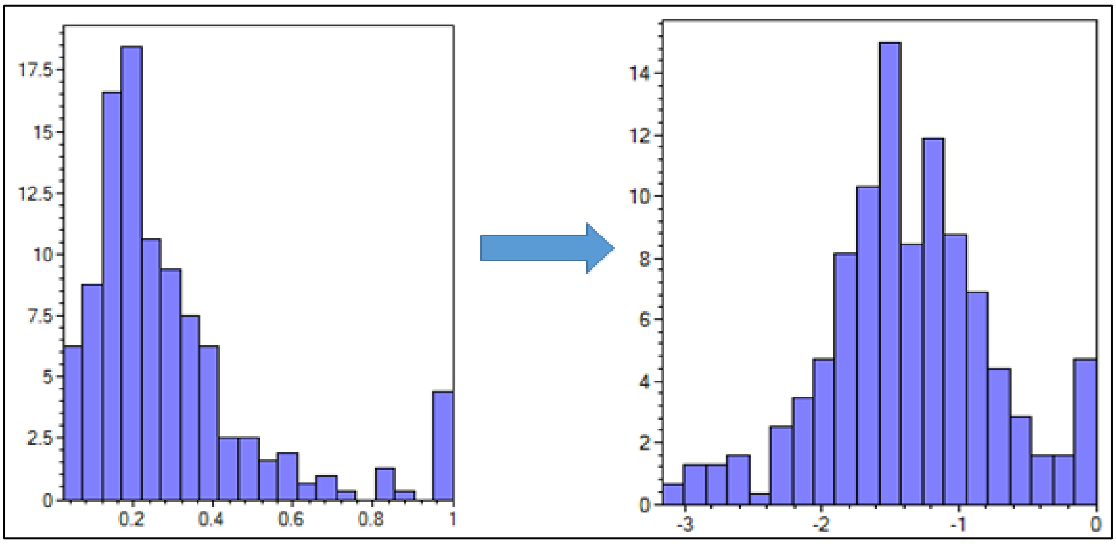


Fig.4, Water Saturation Transformation for Unit MB1

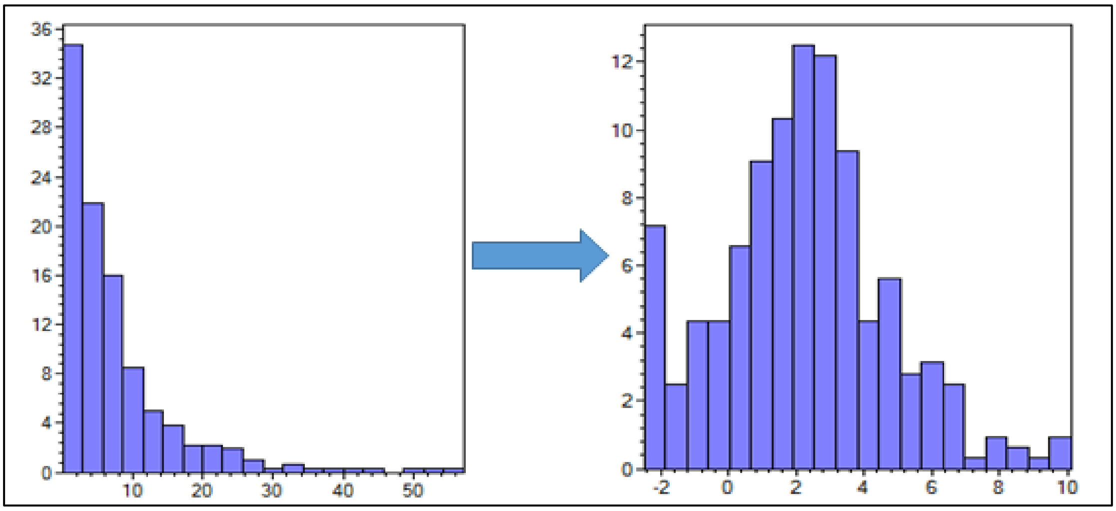


Fig.5, Permeability transformation for Unit MB1

Variogram Analysis

Variogram analysis is used to define the behavior of variation in a property where it is considered as a key parameter in many geostatistical algorithms. Simply, a variogram is a plot of variability between semi-variance (y-axis) versus separation distance (x-axis) in a specific direction

Two valuable steps are performed in analyzing variogram:

1- Determining the directions of the variogram, major, minor and vertical direction where each of them are perpendicular on the other.
2- Calculating the experimental variogram and then creating the variogram model based on the experimental one for each direction

2D variogram map defines the direction of sample points as shown in Fig.(6). The major and minor directions of the variogram analysis are based on the 2D variogram map in which major direction is in 300 azimuthal angle while the minor one is 210 in azimuth (perpendicular on the major one) and as shown in Fig.(7).

Schlumberger [2] mentioned in her petral software manual that the following parameters are also taken into consideration in order to analyze variogram:

1- Search Radius: which is the maximum separation distance used in the search for sample pairs (no. of lags * lag distance).
2- Bandwidth: It is half the width of the search cone used as a cut-off to prevent the search area from becoming too wide at large separation distance.
3- Tolerance Angle: It is the width angle measured from the search cone main axis. Search cone parameters define the major and minor directions reflect directly on values of variogram ranges and as given in table (3).

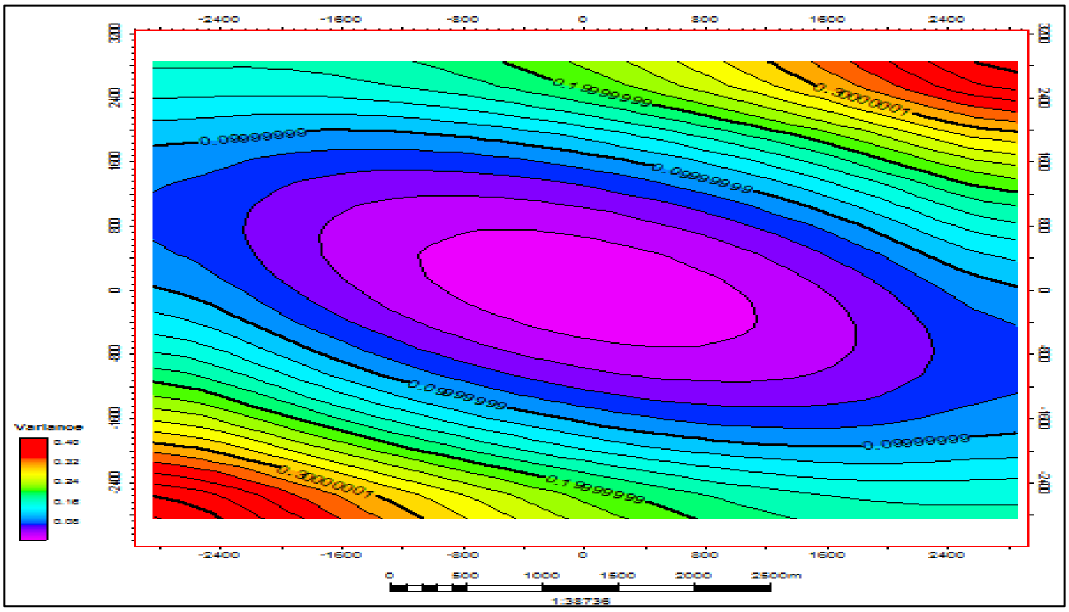


Fig.6, 2D Variogram Map for Mishrif Formation

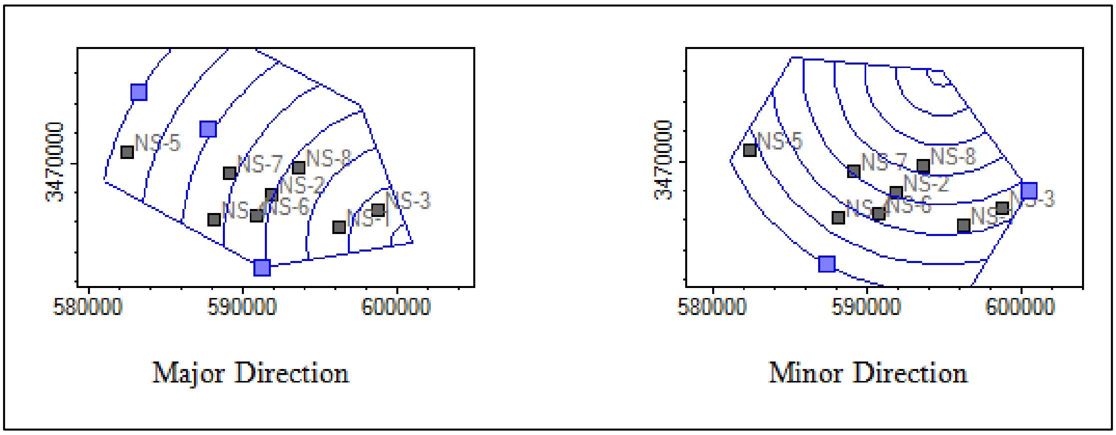


Fig.7, Major and Minor Direction Based on 2D Variogram Map

Table 3, Search Cone Parameters

Direction	Azimuth	No.of Lags	Lag Distance	Search Radius	Bandwidth	Tolerance Angle
Major	300	8	2561	20488	6375	40
Minor	210	8	1894	15152	8975	65

Porosity Variography

Exponential variogram model is applied for the behavior of the experimental variogram in the normalized porosity of unit MB1. The exponential behavior of this model makes a rapid variation at shorter distances (small lags) and it reaches the sill at asymptotic approach as shown in Fig. (8).

Water saturation Variography

Spherical model is used to represent the experimental variogram for the normalized water saturation of unit MB1. A linear behavior with a sharp transition to a flat sill are characterized in this model behavior as shown in Fig. (9).

Permeability Variography

The behavior of the experimental variogram for the normalized permeability is similar to that in porosity so that the exponential model is chosen as shown in Fig.(10).Variogram computation for the petrophysical properties for unit MB1 are resulted from the analysis of search cone parameters that reflect the shape of variogram analysis as given in table (4).

Property Modelling

It is the process of filling grid cell with discrete and continuous properties in which the layer geometry in the grid follows the geological layering in the model area. The purpose of property modeling is to make it possible to distribute different properties among the wells after performing data analysis. Sequential Gaussian Simulation (SGS) modeled all the continuous properties of porosity, water saturation & permeability and as shown in Fig. (11), 12) & (13), respectively. The distribution was done by Depending on variogram analysis parameters and as given before in table (3).

Table 4, Summary of the variogram parameters for the petrophysical properties of unit MB1

Property	Sill	Nugget	Major Range (m)	Minor Range (m)	Vertical Range (m)
PHIE	0.964	0	8596.4	5000	13
Sw	0.96	0	2559	1892	4
K	0.96	0	8158	5040	16.2

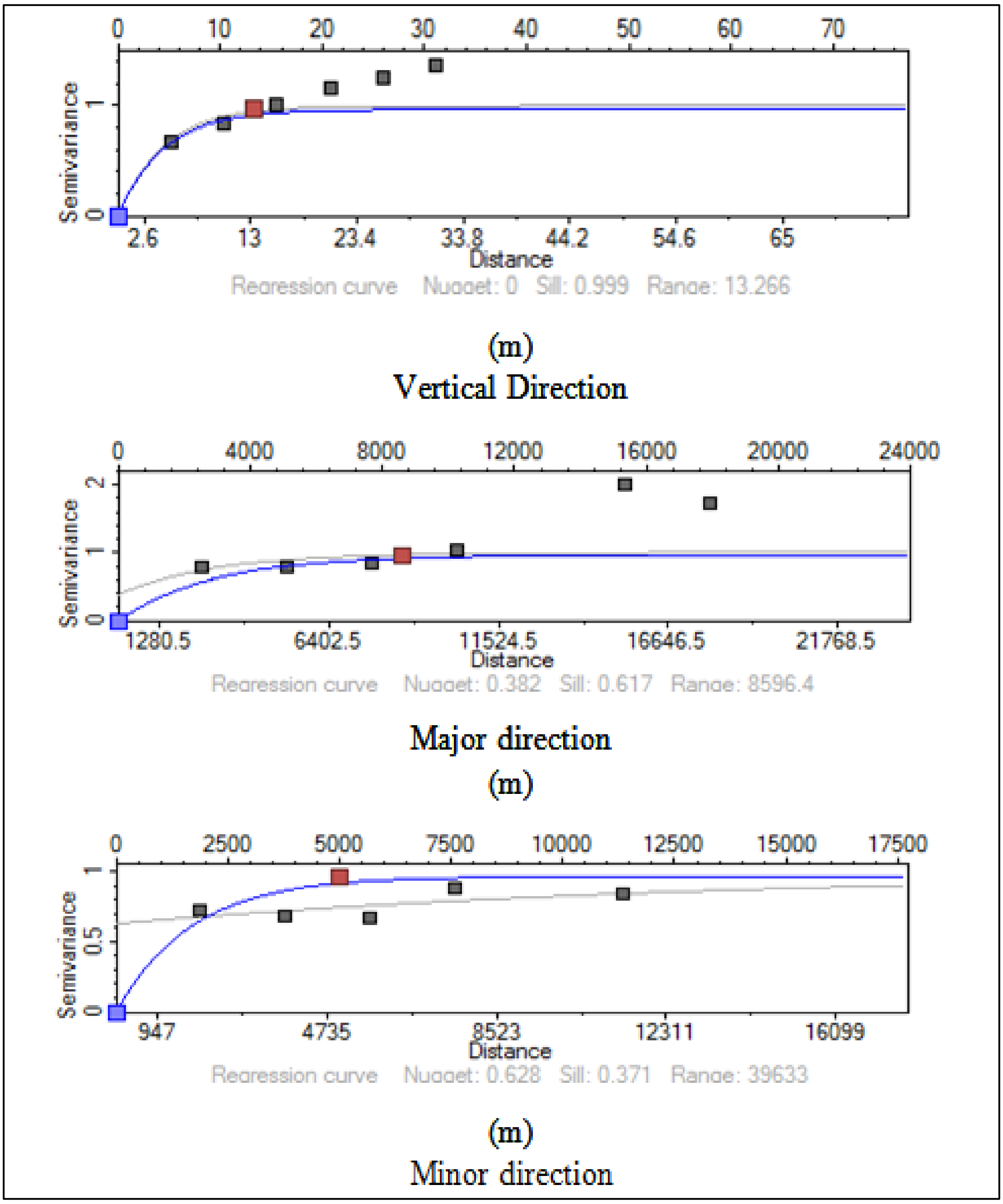


Fig.8, exponential variogram for porosity in unit MB1

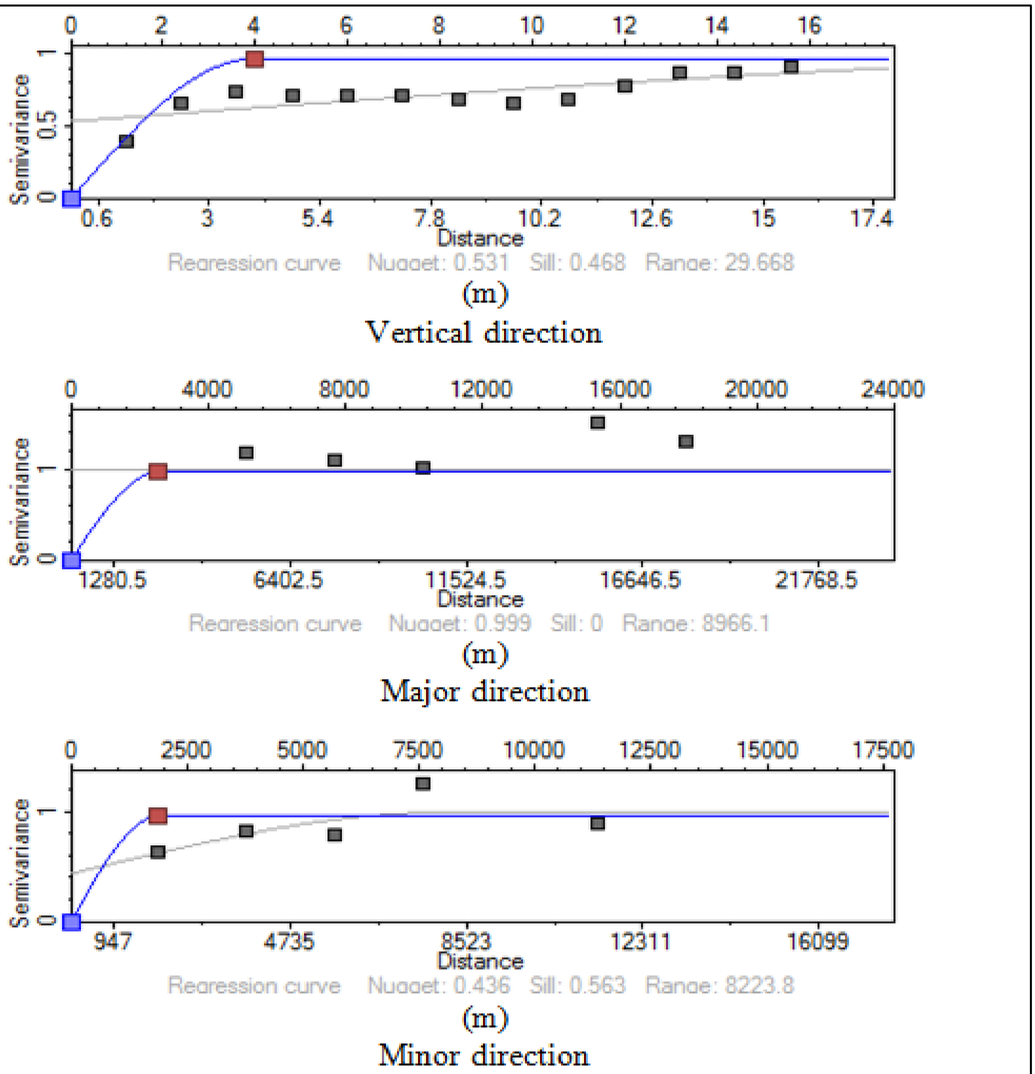


Fig.9, exponential variogram for water saturation in Unit MB1

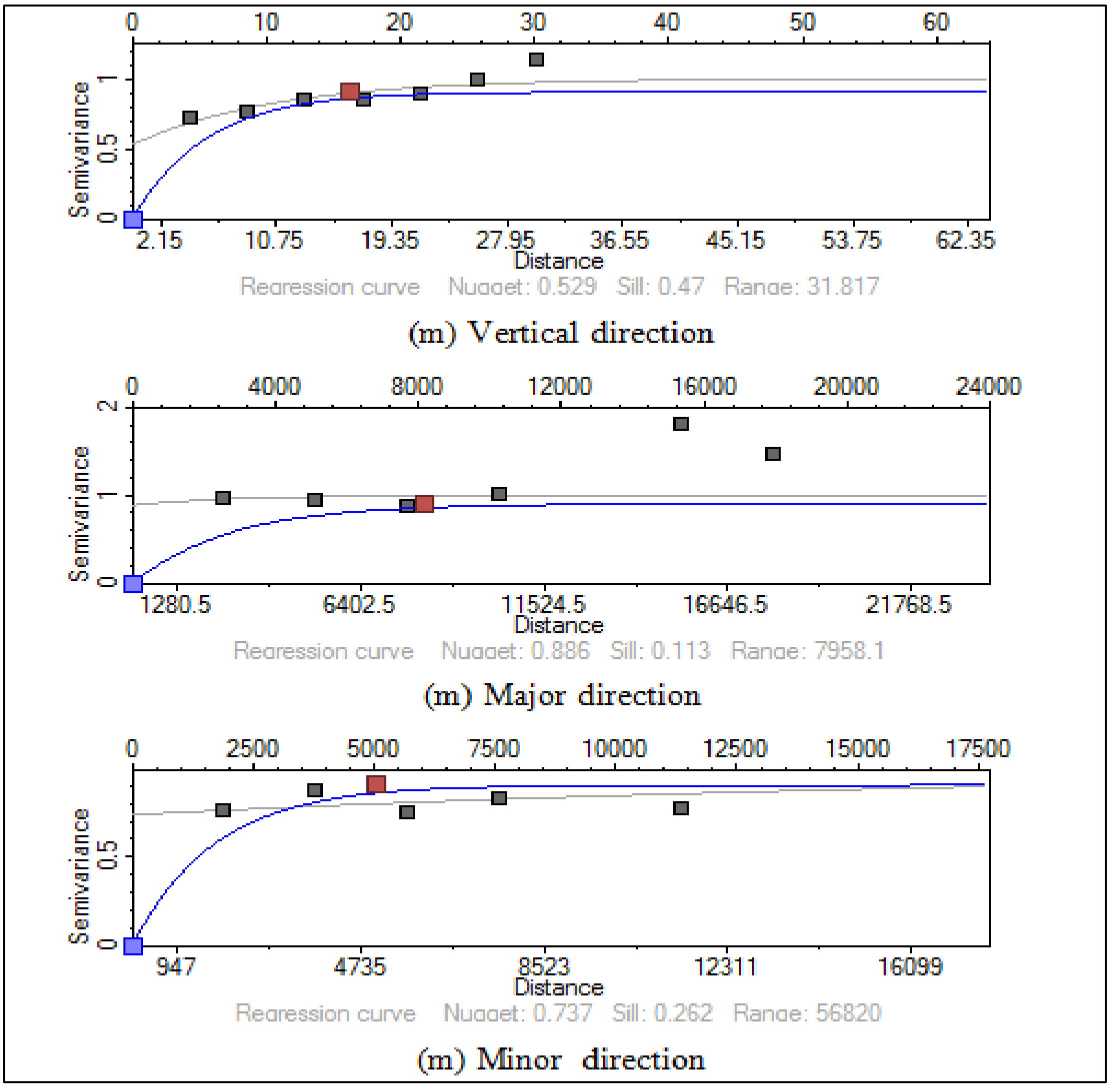


Fig.10, exponential variogram for permeability in Unit MB1

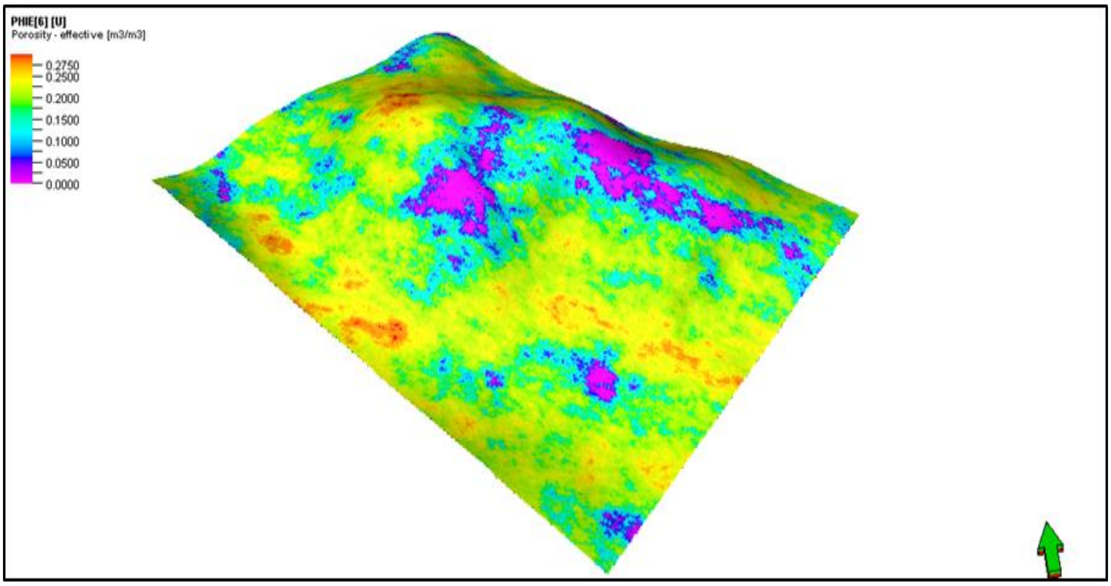


Fig.11, porosity distribution with variogram analysis dependent in unit MB1

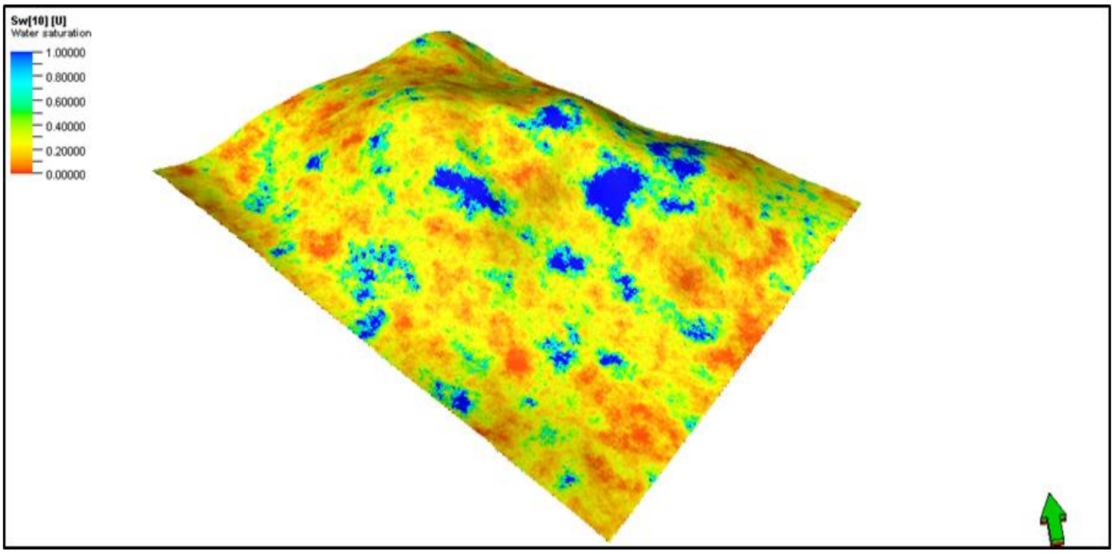


Fig.12, water saturation distribution with variogram analysis dependent in unit MB1

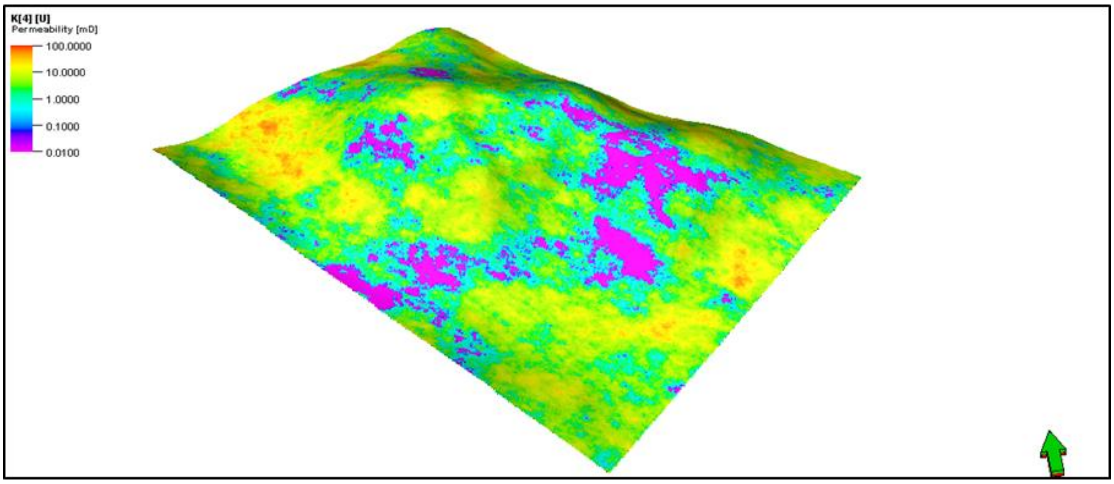


Fig.13, permeability distribution with variogram analysis dependent in unit MB1

Conclusion

It can be concluded from applying spatial data analysis in Mishrif Formation, Nasiriya Oil Field that the nature and quantitative summary of data can be visualized and so it would be easy to remove the skewness and improve the normality of the petrophysical properties for suitable distribution by the available algorithms.

The statistical average values of porosity (0.182), water saturation (0.285) and permeability (7.36 md) in unit MB1 of Mishrif Fromation reflect the the high quality of reservoir properties. Also, The distribution of porosity, water saturation and permeability as shown in fig.11,12 & 13, respectively support this conclusion.

References

1- Geoff Bohling, 2007 “Introduction to Geostatistics in Hydro geophysics: Theory, Methods, and Modeling”, Boise State University, Boise, Idaho.

2- Schlumberger, 2013 “Petrel technical Manual”,.

3- Holdaway, K.R.”Exploratory Data Analysis in Reservoir Characterization Projects”, SPE 125368,200.

4- Hameed, A.T,2016. "Geostatistical Approach of Petrophysical

Properties Distribution for Mishrif Formation in Nasiriya Oil Field" M.Sc. thesis, Petroleum technology , University of Technology,

5- Handhel, A.M. , 2006 " Reservoir Properties Study for Mishrif Formation in Nasiriya Oil File & their relation with Oil Production", thesis, Department of Geology, university of Basrah. (in Arabic).

6- Atiaa & Amnah M. Handhel “A fuzzy Logic approach in infer reservoir permeability from depth and porosity measurements for Mishrif limestone Formation at Nasiriya Oil Field, south of Iraq”, college of science, university of Basrah,ISSN:1991-8941.

7- Jreou, G. , 2013” A preliminary Study to Evaluate Mishrif Carbonate Reservoir of Nasiriya Oil Field", college of engineering, university of Kufa, 136305-0808-IJENS.