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PROVIDING A SUBSURFACE RESERVOIR QUALITY MAPS IN OIL FIELDS BY GEOSTATISTICAL METHODS

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Abstract. Under study reservoir oilfield is located south-west of Iran. This field is comprised of naturally fractured Asmari and Bangestan formation. Reservoir management and characteristic evaluation of this field requires good knowledge of reservoir rock and fluid properties. One of main methods to get such information is using known parameter and estimates this property in unknown area of reservoir by geostatistics and kriging method. In this research used the porosity parameter data from 36 oil wells that taken by well logging to estimate porosity parameter in unknown part of reservoir by geostatistics and kriging method. The porosity parameter had normal distribution. After surveyed the distribution of data varioghraphy was done and strength of structure was proved and kriging parameters including characteristic of search ellipse determined for estimation. Then porosity parameter was estimated with the use of geostatistical method in reservoir.

Keywords: porosity, reservoir evaluation, geostatistics, variogram, kriging.

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Introduction

Porosity, permeability and oil saturation are three effective parameters in formation evaluation. Porosity is one of the most principal issues in evaluating petroleum reserves. Accurate estimation of porosity is very important because the slight change in porosity estimation can result in an appreciable change in total reserves. Permeability is one of the most significant characteristics of hydrocarbon bearing reservoirs in which almost petroleum engineers and geologist are highly interested. It is essential to have accurate permeability values to give engineers and geologists the ability to design and manage the efficient processes in the development of oil and gas fields. Oil saturation estimation is one of the primary characteristics in evaluation of reserves and production. Accurate estimation of oil saturation is meaningful for evaluating the oil in place and the economics of the oil field. Porosity estimation using different logging tools is still underestimation due to lower tool resolution.

1. Lithology and porosity

The lithology kind is one of important parameters in cognition of hydrocarbonic reservoirs manner. The lithology can be assessed by petrophysical datas (Doveton 1994).

During sedimentation and diagenesis, some of primary developed pore spaces separated from other pore spaces by different diageny processes of cementation and aggregation. So most of pores have internal relation while the others are totally separated, this can cause the formation of two different sets of porosity, called absolute and effective. The absolute porosities are the proportion of total empty space of sample to the volume of total mass, without attending if they have internal relation or not. One rock may have extraordinary absolute porosity while because of none being internal pores connections; it does not have the capability of fluid transferring.

For recovering the gas and the oil from hydrocarbonic reservoirs, hundreds of foots must be flowing from pore channels in rock before it received to the

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productive well. If oil occupies the nonconnective empty spaces, it cannot be produced. Therefore, the effective porosity is a quantity that can be used in all reservoir engineering calculates.

Porosity logs

The porosity of one zone can be quantified from the log of solo porosity (acoustic, density and neutron) or the mixture of porosity logs. In this study, for assessing the porosity, the logs of density and neutron is used. The porosity base on density log measurement is calculated from mass balance relation:

$$\rho_b = \phi . \rho_f + (1-\phi)\rho_{ma}. \tag{1}$$

The porosity base on neutron log measurement is explained by following relation:

$$N = a - b\log\phi. \tag{2}$$

The high amount of neutron indicates low porosity and the low amount of neutron indicates high porosity. The combination of neutron logs and density is used as a device for measuring the porosity, which significantly the lithology is ineffective in it:

$$\phi = \sqrt{\frac{\phi_n^2 + \phi_d^2}{2}}. \tag{3}$$

2. Methods of geostatistical analysis

Geostatistical estimation of porosity data consists of two stages: the first stage deals with identification and modeling of spatial structure of data of under examination porosity data. In this stage, spatial structure of data is examined by means of variogram. The second stage has focus on the geostatistical estimation of data of porosity by means of kriging method. This stage is dependent on the features of variogram model selected in the first stage (Cressie, Hawkins 1980). If any mistake is made in selection of variogram model, all the subsequent stages will be affected as well. Compared to other statistical tools, the most important feature of variogram is simplification of variability. That is why there is extensive application of variograms in the entire disciplines relevant to oil industry.

Kriging is a geostatistical estimation method which can be considered as the best unbiased estimator. This estimator not only owns the least estimation variance but also assures unbiased of estimations, provided that data is normally distributed (Cressie 1990). One capability of kriging method is that it can provide both point estimation and block estimation. In case of block estimation, a block is simulated by means of a large number of points and then calculation of their integrals. Since data of porosity have been obtained along the well's depth in oil field, geostatistical estimation will be tow-dimensional. Additionally, considering that block kriging focuses on the relation between under estimation block and sampling points (data), so eventually block kriging attributed to the points (data) is applied (Dimitrakopoulos, Desbarats 1997).

In Studies and calculations of geostatistics, it is better that distribution of data is normal. Normal or Gaussian distribution is one of the most used statistical distributions, and most statistical methods accept the hypothesis of normal distribution of data.

Graph of the normal distribution is in the form of a completely symmetrical bell-shaped curve which was shown with the mean statistical parameters and variance and which indicates the amount of data distribution and thus the extent of normal distribution curve. And the common method for studying normal distribution of data is qualitative one. To do this, it is enough that the histogram of data is close to normal and that data's skewness and kurtosis are close to zero and 3, respectively.

3. Discussions and results

First is characterized Lambert coordinates system wells. This includes east and North coordinates well with the wells porosity parameter number 36 is given. Then deleted data, such as unacceptable negative productivity index from the list. Figure 1 shows the location of the wells that are having porosity.

In Studies and calculations of geostatistics, it is better that distribution of data is normal. To convert non-normal to normal distribution, methods as such logarithmic conversion can be used (Fig. 2).

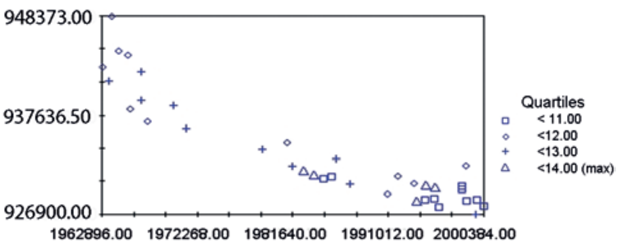

Fig. 1. Well location

3.1. Best variogram model

Empirical variogram not only is a useful method in examination and identification of feature of regional varying structure and indicates the manner of its variations but also it plays role in data purification. Rang and ratio so-called Relative Nugget Effect are two criteria of the strength of spatial structure which are determined by variogram. A variogram is therefore considered as more appropriate which owns a larger rang smaller nugget effect and also a shorter sill. It is achieved through a correct selection of lags. In this paper, considering ratio (indicating values of both sill and nugget effect) provided the said ratio approaching to 1, large rang and the least value of sill, the best selection of variogram has been achieved. It is notable that none of these parameters can solely be the decisive evidence indicative of appropriateness of model selected, so these three parameters should all be taken into account. For porosity data in this oil field, we suggest spherical variogram model which have more strength compared to the other spatial structure (Fig. 3 and Table 1).

3.2. Estimation by kriging method

For geostatistical estimation, it is needed to determine estimation parameters according to data distribution, spatial structure and estimation strategy. Estimation under strong spatial structural conditions with a large rang is different from that of under weak spatial structural conditions with a small rang. The more distance between points (data) gets the more spatial structure weakens and eventually it fades away. Therefore those points that their distances are greater than rang, have practically no effect on estimation point and there is no need to take account of them in the estimation process (Isaaks, Srivastava 1988). Number of points involved in the estimation process is a criterion to judge validity of the intended estimation. Because a large number of data with different positions are involved in the estimated value and affected it. So, whatever numbers of point are less, probability of random fluctuations effect will be more on the estimated value.

Since distribution of porosity data have great importance in geostatistical estimation, the uppermost factor affecting data distribution i.e. lithology of the reservoir should be examined as well. It is evident that the factors relevant to lithology of the reservoir play important role here. Geostatistical estimate the final outcome data, and distribution of error in the desired field shown in Figures 4 and 5.

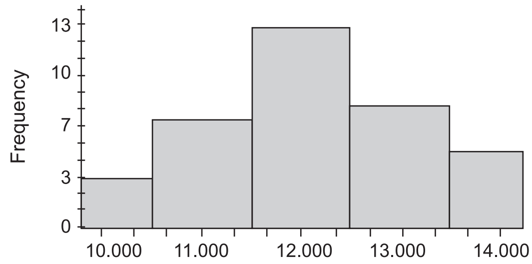

Fig. 2. Normal distribution of data

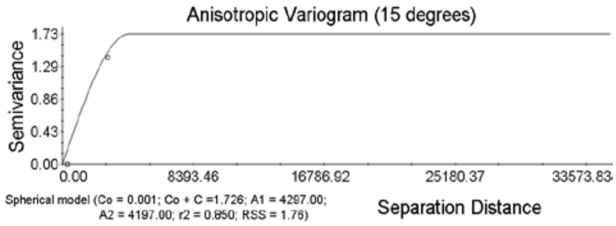

Fig. 3. Best variogram models for estimations in semivariance analysis

Table 1. Parameters of best variogram for porosity data

n	angle (deg)	tol (deg)	model	nugget	sill	sill / (sill + nugget)
1	0	75	spherical	0.001	1.76	0.999
2	15	75	spherical	0.001	1.75	0.999
3	15	90	spherical	0.001	1.621	0.999
4	30	45	spherical	0.001	1.65	0.999
5	30	75	spherical	0.001	1.65	0.999
6	45	75	spherical	0.001	1.76	0.999
7	45	90	spherical	0.001	1.62	0.999
8	60	60	spherical	0.001	1.78	0.999
9	60	75	spherical	0.001	1.72	0.999
10	75	30	spherical	0.001	1.65	0.999
11	75	75	spherical	0.001	1.65	0.999
12	90	45	spherical	0.001	3.4	0.999
13	90	75	spherical	0.001	3.6	0.999
14	120	30	spherical	0.001	1.65	0.999
15	120	90	spherical	0.001	1.62	0.999
16	135	75	spherical	0.001	1.76	0.999
17	150	60	spherical	0.001	1.78	0.999
18	150	75	spherical	0.001	1.72	0.999
19	175	30	spherical	0.001	1.77	0.999
20	175	75	spherical	0.001	1.71	0.999

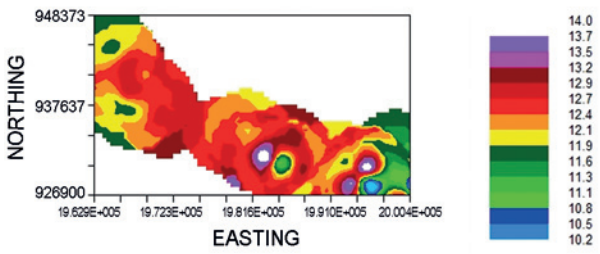

Fig. 4. Estimation of kriging method for porosity data

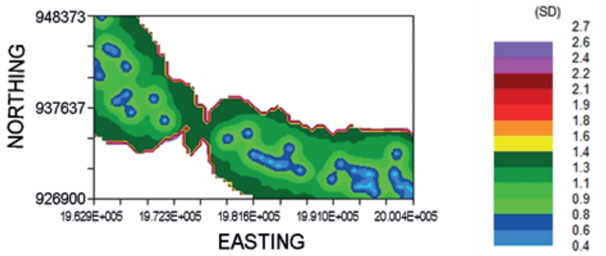

Fig. 5. Distribution of error for porosity estimation

Conclusions

– The porosity distribution is not a large dispersion and has a normal distribution so there is no need to use the normalization methods.
– Varioghraphy results show that this variable has a spatial structure and strength is strong.
– The new wells will be selected in sectors with higher porosity.

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Research interest: petroleum geology, geostatical modelling, petrophysics, rock mechanics, engineering geology.