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Possibilities of the Statistical Methods Utilization for the Geological Characteristics Variability Analysis in order to Improve the Efficiency of the Geological Surveys

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Abstract

This paper exposes the opportunity of the geological characteristics variability use for the oil reservoirs modelling. It presents the analysing mode of a case that has a normal and homogeneous variable repartition.

Key words: *geological characteristics variability, global variability, spatial variability, variability diagram, χ^2 Test*

Introduction

The *variability analysis* of the geological characteristics has as a purpose the percolation of all collected data from the preliminary exploration network, in order to prepare the adequate instruments to obtain the reservoir map.

Data consist in the spatial coordinates of the observation points, the hydrocarbon contents, the age or the physical parameters of the samples.

This step represents the beginning of the data processing and it is finalized by the *distance functions* obtaining.

The extraordinary *variability* of the geological characteristics is expressed by two aspects: *the global aspect*, which is expressed by the distribution of the characteristic values around a central value (the mean or the median), and the *spatial aspect*, expressed by the variation of the characteristic values (v_i) depending on the setting in the geometrical space of the process (usually, the position is expressed by the spatial coordinates x_i, y_i, z_i, *which for i* represents the observation point indices).

The Global Variability Analysis

The *global variability* analysis of the geological characteristics focuses on the insurance of *the representative* evaluation and it can be realised by the *distribution mode*, the heterogeneity and *the extreme values* analysis of the data selections.

The statistical evaluation methodology of a geological characteristic is elaborated for its normal distribution and that is why the nonconformities between the processed values distribution and the normal distribution generate the overestimations or underestimations proportionally with the asymmetry degree of this distribution. Thereby, the distribution mode of geological characteristic values around the mean or median generates influences on the statistical processing results. The histogram form depends on the sizes of the intervals that are used for the observations distribute. The intervals sizes depend on the number and the accuracy of the available observations. The mean of a number of observations depends on the distribution intervals sizes. If a big number of small size intervals is available, then the histogram can be replaced by a continuous frequency curve, without great errors.

The analyses of the distribution mode of the values frequency can go on unto two results:

- the values repartition is normal and, as a consequence, their processing by means of the statistical methods offers outcomes that are correctly interpretable;
- the values repartition is anomalous and in this case their transformation (normalization) is necessary, in order to eliminate the errors due to the overestimating or underestimating.

The selection heterogeneity analysis of the available data, that is usually realised by the multifactor variance analysis, has as a purpose the separation of the data selection by the values differentiate dispersion, that is determined by the physical and chemical factors which have divergent actions. The result of the data selection heterogeneity analysis can offer two ways for the continuation of the estimating:

- the data selection is homogeneous and in this case the statistical estimations must be realised on the whole data set by using one model for the spatial variability;
- the data selection is heterogeneous and in this case the data selection must be separated in homogenous groups, in which case it is necessary to find distinct models of spatial variability for each group.

The extreme values of the data selections assure the correct estimation of the confidence interval of the statistical parameters by correcting the exaggerate values of the dispersion. Including the extreme values in data processing generates important modifications of the selection dispersion and this determines the artificial growth of the uncertainty degree of the evaluations. The extreme values analyses can go on within two distinct situations:

- the extreme values are eliminated because they are not numerous and there are not statistically representative for the characteristic of the survey (they are derived from the measurement errors or from instantaneous variations that are not definite for the spatial variability of the characteristic of the survey);
- the extreme values are not eliminated because they are not numerous enough in order to form a data selection for which specifical processing methods can be applied.

The Normal and Homogenous Repartition Analysis

The repartition mode establishment there is realised in two steps:

- *the graphic analysis of the distribution model;*
- *the analytical testing of the concordance with the identified repartition model.*

The graphic analysis of the distribution model is based on the probability histogram (fig.1.a) *and diagram* (fig.1.b) *of the analysed variables.*

For example there is a presentation of the thickness evaluation for a reservoir being studied by 124 wells.

Table 1 presents the distribution mode establishment for the thicknesses of the reservoirs on X Structure.

Table 1. Thicknesses of the reservoir from the X Structure

Crt. no.	*Thickness g[m]*	*Crt. no.*	*Thickness g[m]*	*Crt. no.*	*Thickness g[m]*	*Crt. no.*	*Thickness g[m]*
1	602,47	32	555,46	63	551,54	94	244,11
2	607,20	33	406,81	64	539,97	95	83,55
3	927,18	34	750,22	65	622,09	96	192,70
4	450,37	35	649,77	66	638,18	97	21,03
5	662,22	36	528,71	67	383,54	98	23,44
6	737,94	37	627,29	68	559,45	99	36,14
7	799,48	38	496,16	69	588,81	100	50,28
8	617,00	39	536,19	70	575,85	101	41,55
9	391,45	40	780,16	71	612,05	102	31,32
10	499,71	41	453,90	72	571,67	103	543 ,78
11	532,44	42	492,62	73	683,04	104	485,56
12	675,76	43	325,98	74	824,11	105	478,52
13	859,18	44	726,91	75	643,87	106	330,93
14	584,43	45	698,84	76	428,93	107	259,91
15	371,32	46	707,51	77	354,17	108	15,27
16	395,34	47	632,66	78	521,33	109	547,64
17	482,04	48	517,69	79	580,10	110	315,68
18	928,00	49	506,85	80	525,01	111	425,30
19	716,81	50	432,54	81	690,71	112	510,45
20	563,46	51	471,50	82	439,71	113	399,20
21	567,54	52	475,00	83	178,82	114	274,13
22	597,83	53	446,83	84	414,27	115	320,89
23	514,06	54	421,65	85	443,27	116	299,09
24	358,55	55	304,80	86	464,47	117	293,21
25	340,51	56	162,71	87	436,13	118	387,51
26	457,43	57	403,02	88	349,70	119	345,15
27	118,71	58	467,99	89	362,88	120	252,24
28	379,52	59	460,95	90	267,21	121	22,13
29	764,08	60	417,98	91	204,98	122	143,42
30	668,83	61	489,08	92	280,74	123	335,78
31	593,28	62	655,88	93	287,09	124	375,44

The histogram analysis leads to the next observations:

- the histogram has only one module – that is a clear indication of the homogenous character (from a statistical point of view) of the selection; the consequence of this observation is that statistically, all factors that determine the reservoir's thickness distribution had a convergent action;
- the symmetric character of the histogram (the asymmetry coefficient $\beta = 0.01$) suggests a normal distribution of the values; the rightness of this hypothesis demands an analytical test).

The *probability diagram* analysis, for a normal repartition, enables the following observations:

- points that represent the thickness values are *collinear*, which indicates a certain *normal* *distribution* of them;

- at the extremes of the graphic there are 4 extreme values (two at the inferior limit and two at the superior limit); it is necessary to test their membership on the selection, using an analytical test.

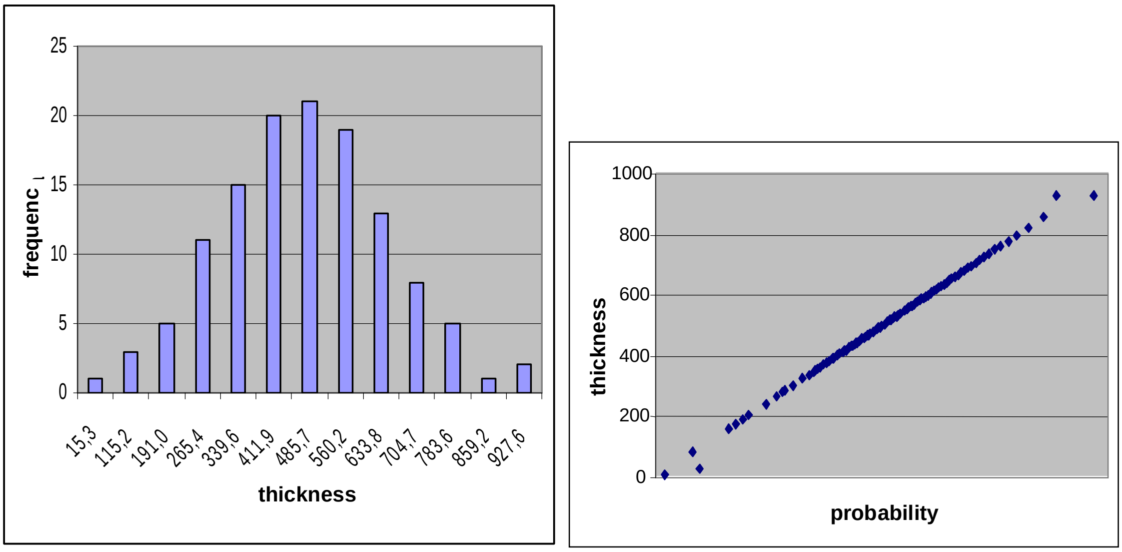

Fig. 1. The histogram (a) and the probability diagram (b) of the reservoir deposit thickness

The analytical testing of the values repartition concordance with the model of the normal repartition it can be realised by using χ^2 test.

The application of the χ^2 test is based on the histogram of the n = 124 thickness values; this histogram has been realised by data distribute on k = 13 *intervals*, which of them having the amplitude of A = 75 m.

The well-balanced average of the 124 values is m= 475,16 m, the standard deviation is s = 176,24 m, and the central values of the distribute intervals (x_{cj}) and the absolute experimental frequencies (n_i) there are distributed in table 2.

The data that are necessary for the χ^2 test there are: the statistically elementary parameters and the values from the columns 1-4 of the table 2.

The theoretically frequencies computation *(np_i)*, corresponding of the normal repartition (the 5th. column from the tab. 2), an of the statistic χ^2_{exp} it is effectuated by using the next formula:

$$np_i = \frac{A*n}{s*\sqrt{2*\pi}} * Exp\left[-0,5*\left(\frac{x_{ci}-m}{s}\right)^2\right] \quad (1)$$

$$\chi^2_{exp} = \sum_{i=1}^{k} \frac{(n_i - np_i)^2}{np_i} \quad (2)$$

By eliminating the extreme distribute intervals, which has absolute frequencies less then 2, it is obtained this value:

χ^2_{exp} = 0.46

For a risk of the I sort error, α = *1 %*, and for 7 liberty degrees $\nu = 7$ (after the three extreme distribute intervals elimination), from the χ^2 function table, result:

$\chi^2(0{,}99; 7) = 1{,}23$

In conformity with the concordance test χ^2 criteria, because: (χ^2_{exp} = 0.46) < (χ^2(0.99; 7) =1,23), result that from a statistically point of view, with an admissible error α = 1%, the deposits thicknesses distribution there is in conformity with the normal repartition model.

Table 2. The computation associated with the χ^2 test

Interval no.	*Inf. lim. of the. interval*	*Sup. lim. of the interval interval*	x_{cj}	n_i	np_i	$\frac{(n_i - np_i)^2}{np_i}$
1	0	75	15,3	1	0,70	0,13
2	75	150	115,2	3	2,62	0,06
3	150	225	191,0	5	5,74	0,10
4	225	300	265,4	11	10,37	0,04
5	300	375	339,6	15	15,66	0,03
6	375	450	411,9	20	19,74	0,00
7	450	525	485,7	21	21,02	0,00
8	525	600	560,2	19	18,74	0,00
9	600	675	633,8	13	14,04	0,08
10	675	750	704,7	8	9,01	0,11
11	750	825	783,6	5	4,55	0,04
12	825	900	859,2	1	1,96	0,47
13	900	975	927,6	2	0,78	1,91
						$\chi^2_{exp} = 0{,}46$

Conclusion

The reservoir deposits thicknesses that evaluated for the 124 wells have a normal repartition.

The result assures that the estimations being made by using the deposit thicknesses, by statistical methods (average thicknesses, the thicknesses sectoring, transport directions etc.), will be not affected by the overestimating or underestimating.

Every computation effort is less expensive than the obtaining of the data for the processing.

The limits associated with this conclusion

These are determined by using representative available data and it is necessary to pay attention to at least two questions regarding them:

- if the 124 available thicknesses, that are determined on the 124 wells, are enough to describe the global variability of the reservoir deposits from the survey area;
- if the reservoir deposits thicknesses have a normal distribution on this structure or only the 124 processed values are according to this condition.

The statistical methodology, aright applied, ensures representative results obtaining, but not necessarily representative utilized data.

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Posibilități privind utilizarea metodelor statistice în analiza variabilității caracteristicilor geologice în vederea îmbunătățirii eficienței economice a explorărilor geologice

Rezumat

Acest articol expune oportunitatea utilizării analizei variabilității caracteristicilor geologice în modelarea zăcămintelor de hidrocarburi. Concret, se prezintă modul de analiză a unui caz în care repartiția valorilor este normală şi omogenă.