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Geology

Relation of Mathematical Expectation Error of the Contact of Useful Component Calculated by the Method of Arithmetic Mean to the Variation of the Distribution of Mineralization

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ABSTRACT. The quantitative data of geological investigations belongs to 'badly organized systems' and accordingly the conclusions made on their basis are more or less prognostic. The main parameter of ore deposits economic evaluation– quantity of useful components - is also prognostic. Determination of the quantity of the metallic component in ore body is achieved by processing data obtained from discretely located observation points. In cases with extremely irregular mineralization, using the method of arithmetic mean gives unacceptable error that significantly decreases the reliability of estimation and increases the costs of mining.

We have performed calculation on data for more that 2000 samples from 26 locations that clearly shows the strong correlative link between quantitative values of the variation of mineralization distribution (variation factor) and the relative error. This interrelation gives an opportunity to correct the amount of content of the component calculated by the method of arithmetic mean with the regression equation using the variation factor. *©2011 Bull. Georg. Natl. Acad. Sci.*

Key words: *deposit, mineral resource.*

At the beginning of the new millennium it became clear that the degree of economic and political independence of a country is proportional to its supply with its own resources. As a newly created independent country, Georgia should pay greatest attention to the question of improving the given parameter determining the country's independence.

Mineral raw material or minerals is an important constituent part of the natural resources. The strictly centralized geological service of the Soviet Union, oriented to gigantic scales, paid little attention to small ore deposits, which consequently remained unstudied or undeveloped. This fact for its part proved favorable for Georgia. Many dozens of already identified mineralized territories have remained intact. The Geological Office of the country should make their inventory and study them by modern methods and techniques. The evaluation of the ore deposits brought to light should be carried out on modern scale and in accordance with the prospective demands of present-day Georgia. The mean value of the content of useful component (mathematical expectation) is one of the most important parameters of the reserves of minerals, being one of the principal evaluation criteria for mineralization. This is the value calculated by means of the data gained through selected and proved testing of the mineralized body. The total mass of samples taken from discretely located observation points "at best" is only one-hundred thousandth of the whole mineralized body. The distribution of the mineralization in the volume to be assessed is frequently quite and extremely uneven an area with low or acceptably average content is rarely, but still alternated by individual samples with uncommonly high content. In such a case, the problem of so called 'vortical pattern" takes place, as calculation of the average content by the method of arithmetic mean produces great error [4,5]. In the past, we studied one of the gold deposits in Algeria. Mathematical modeling demonstrated that the distribution of useful mineralization in the ore-bearing body was extremely uneven – the coefficient of variation V=161.6%. Grouping of 250 data of sampling in nineteen classes of the same rank demonstrated a strong inversely proportional relation between the gold content (C) and the frequency of classes (W_i) ($r_{c,v}$ = -0.71). This indicates that the influence of individual classes on the mathematical value of the mean content is directly proportional to its frequency and the calculation of mathematical expectation in relation to the frequency of the appropriate class of data should be made by the formula:

$$\overline{C}_R = \Sigma C_i W_i / \Sigma k_i W_i, \qquad (1)$$

where $\overline{C}_R$ is the mean value weighted to frequency, C_i is the sum of data included in individual classes, k_i - the population of individual classes.

The relative error between the values calculated by this rule and the method of arithmetical mean equaled 263.75%, which is absolutely unacceptable [2].

After reporting the data at international scientific conferences and publishing the work, we set ourselves the task of studying the regularities of the relation between the intensity of the data change and the above-mentioned error. To this end, we studied approximately two thousand data in 26 objects with the content of different components. By using a well-known mathematical model we obtained a result showing that three of them are characterized by quite an even distribution of mineralization (V≤20%), ten of them are characterized by even mineralization, seven have uneven mineralization, four have highly uneven mineralization and two of them are represented by extremely uneven mineralization (Table). The relative error between the contents weighted to the mean arithmetic value and frequency calculated for each object has demonstrated that the mathematical expectation should be calculated by means of arithmetic mean value, if the coefficient of variation V≤35%. This method is acceptable, if 35%<V≤55%; in the case of 55%<V≤100% the mean arithmetic value is to be necessarily corrected, and if V>100%, the error reaches inadmissible values and the use of mean arithmetic value is unacceptable. This is clearly seen in columns 2, 3, 4 and 5 of Table.

As the further calculations have demonstrated, there is a strong directly proportional relation between the coefficient of variation and relative error ($r_{v,\delta}$ = 0.91) [1].

In case of inadmissible value of the relative error, it becomes necessary to calculate the parameter under study by relating it to the frequency or by correcting the mean arithmetic value. The coefficient of correction (*K*) is calculated by formula:

$$K = \overline{C}_R / \overline{C}_A, \qquad (2)$$

where $\overline{C}_R$ is the mean content weighted to the frequency and $\overline{C}_A$ is the mean arithmetic value of the same parameter [3].

Comparison of the correction coefficients for all twenty-six objects calculated by formula (1) (Table 1, column 6) with the proper variation has proved the strongest inversely proportional correlation between these two values (r=-0.98). The high value of the correlation coefficient enables us to receive a formula by using a regression equation, which by inserting a new value of the variation coefficient (V_i) defines the value of the correction coefficient (*K*)

$$K=1.11 - 0.0049\ V_i. \qquad (3)$$

In order to examine the correctness of the expression, we carried out inverse action and by using formula (3), we once again calculated the correction coefficients for all twenty-six objects (Table, column 7). Then, by the regression correction coefficient, we corrected the arithmetic values calculated earlier (Table, column 8). Comparison of the results obtained with the ones calculated by frequency showed that the values calculated by regression correction coefficient give practically admissible results. Its application significantly reduces the error of mean arithmetic value even in the case of high value of distribution variation (Table, column 9).

We strongly believe that the studies carried out significantly increase the accuracy of the mean values of the data and reduce the number of operations necessary to calculate the mathematical expectation of the parameters under study.

Table

Calculation of parameters of relation between the variation of mineralization and error of mathematical expectation

No.	Variation coefficient, V (%)	Mean value weighted to frequency, CR	Mean arithmetic content, CA	Relative error, δ (%)	Correction coefficient, K	Regression correction coefficient, Kr	Regressive mean content, Cr	Error of mean regressive content, δr (%)
1	2	3	4	5	6	7	8	9
1	2.72	86.58	86.70	0.14	1.000	1.097	95.11	9.25
2	7.00	66.57	65.45	-1.68	1.017	1.076	70.40	5.75
3	7.22	67.21	66.47	-1.10	1.011	1.075	71.43	6.28
4	21.26	2.62	2.53	-3.44	1.036	1.006	2.54	-3.05
5	24.20	13.13	13.42	2.21	0.978	0.998	13.26	0.99
6	25.30	1.44	1.37	-4.86	1.051	0.986	1.34	-6.94
7	25.60	31.20	33.35	6.89	0.936	0.985	32.84	5.26
8	25.93	26.51	25.09	-5.36	1.057	0.983	24.66	-6.98
9	29.00	2.34	2.40	2.56	0.975	0.968	2.32	-0.85
10	34.11	16.75	16.34	-2.45	1.025	0.943	15.41	-8.00
11	37.18	1.53	1.55	1.31	0.987	0.928	1.44	-5.88
12	37.19	1.11	1.23	10.81	0.902	0.928	1.44	2.70
13	39.06	1.43	1.69	18.18	0.846	0.919	1.55	8.39
14	43.18	0.71	0.80	12.68	0.888	0.898	0.72	1.41
15	53.07	5.21	6.10	17.08	0.854	0.850	5.19	-2.38
16	58.80	2.01	2.77	37.81	0.726	0.822	2.28	13.43
17	64.28	0.60	0.74	23.33	0.811	0.795	0.59	1.67
18	68.95	2.17	2.79	28.57	0.778	0.772	2.15	-0.92
19	71.07	2.18	2.76	26.61	0.790	0.762	2.10	-3.67
20	91.74	0.99	1.20	30.43	0.767	0.660	0.79	-14.13
21	100.00	1.85	2.88	55.68	0.642	0.620	1.79	-3.24
22	118.05	4.5	10.70	137.78	0.421	0.532	5.69	26.44
23	138.00	5.94	16.60	179.46	0.358	0.434	7.20	21.21
24	144.47	11.03	44.23	301.00	0.249	0.402	17.78	61.20
25	161.60	5.75	20.88	263.16	0.275	0.318	6.64	15.48
26	206.42	4.46	24.14	441.26	0.185	0.099	2.39	46.41

გეოლოგია

სასარგებლო კომპონენტის არითმეტიკული საშუალოს მეთოდით გამოთვლილი მათემატიკური მოლოდინის ცდომილების კავშირი მინერალიზაციის განაწილების ვარიაციასთან

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გეოლოგიური კვლევების რაოდენობრივი მონაცემები მიეკუთვნება "ცუდად ორგანიზებულ სისტემას", და შესაბამისად, მათ ბაზაზე გაკეთებული დასკვნები ცოტად თუ ბევრად პროგნოზულია. ასევე პროგნოზულია საბადოს ეკონომიკური შეფასების ძირითადი პარამეტრი - სასარგებლო კომპონენტის რაოდენობა. მადნიან სხეულში მეტალური კომპონენტის განსაზღვრა ხდება დისკრეტულად განლაგებული დაკვირვების წერტილებიდან მიღებული მონაცემებით. უკიდურესად არათანაბარი მინერალიზაციის შემთხვევაში საშუალო არითმეტიკულის მეთოდის გამოყენება იძლევა მიუღებელ ცდომილებას, რაც ამცირებს გამოთვლების სანდოობის ხარისხს და ზრდის ხარჯებს.

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