DCGF© METHOD - A NEW METHOD FOR FORECASTING AND SEARCH FOR DEPOSITS OF DIAMONDS

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A method of distributed characteristics of the geochemical field (DCGF method) was developed by Russian geochemist A.A.Ivanov in the late 80s in the process of searching for relations between the arrangement of deposits of mineral resources and characteristics of the geochemical field at a significant distance from the deposits. Using an empirical approach, A.A.Ivanov revealed regularities governing a universal nature of the previously unknown geochemical phenomenon. Moreover, on the basis of these regularities, he developed an essentially new method for revealing deposits of mineral resources. The proposed technique is referred to as the DCGF method. In its essence, the DCGF method is a technique of remote geochemistry, which allows forecasting of the spatial location of deposits relying on the data of geochemical sampling carried out dozens and hundreds of kilometres away from these deposits. The DCGF method can be considered as a universal technique from several standpoints:

- calculation algorithms of the method weakly depend on the geologic structure and the landscape of the studied area;

- the method allows a construction of maps with various scales from 1:1,000,000 to 1:50,000 with various degrees of comprehensiveness of deposit specification (up to 0.5 km^2);

- one can forecast deposits of various types of mineral resources. (Up to now, the method has been elaborated only for forecasting of diamond-bearing kimberlites and copper-nickel ores).

The DCGF method is cheap, expeditious, environmentally safe, and allows one to make a prediction for large areas in short time. Furthermore, the method permits one to reveal deposits in not easily accessible and closed regions.

The Theoretical principles of Method. The DCGF method does not depend on concepts of forecasting used in conventional geochemical technologies. This method is based on the phenomenon of self-organization (low-entropy structuring of open dissipative and non-linear systems) of the field of microelements whose separate regions prove to be essentially interrelated and dependent on the location of the deposits. This interrelation is due to self-sustained wave processes, which ensure the information-energy exchange between various regions of the field. Self-organization of the field of microelements is a consequence of a complex of similar chemical reactions occurring in the distributed open system of the upper part of the Earth crust. A.M.Turing was one of the first scientists who considered the problem of description of self-sustained wave processes (or self-organization) in geology (Turing,1952). When studying a phenomenon of metasomatism, he used one of the basic models (so-called Brusselator) of the behaviour of open systems. In particular, this model describes the waves of metasomatism in a matter as a manifestation of self-organization in such systems. The DCGF method reveals another feature of open distributed systems, namely, appearance of spatially periodic and stable in time structures referred to as dissipative structures. Characteristics of the field of microelements of these structures (in particular, mean contents of microelements) unambiguously determine their distances from the deposits. From the mathematical point of view the calculation algorithms of the method reflect the general properties of non-linear systems and follow from the fractal analysis of geochemical field.

Methods of work. Implementation of DCGF method involves following stages:

1. Geochemical sampling of the area. Geochemical sampling should be performed in the areas, which are situated uniformly over the area under study. In each area a certain number of samples should be selected. Depending on degree of heterogeniousness of mineral composition of rocks under study a number of samples in one group may vary from 25 to 50. Linear dimensions of sampling for one group depend on the scale of the investigation and vary from 25 to 500 m. Sampling should be performed in bed rocks or in loose covering deposits. One must avoid sampling of rocks, which were expended to frequent motions or rocks, polluted through technogenious influence. Depending on the size of deposit under study, geological structure and scales of work, the general number of samples vary from 2000 to first tens of thousands.

2. Laboratory analysis of samples. The method is calibrated to utilize the spektral analysis data. In the analysis of the sample we are concerned of mean content in complete volume of the sample of the following chemical elements: Zr,V,Nb,Cr,Mo,W,Mn,Co,Ni,Cu,Zn,Sn,Pb,Sc,Y,La,Ga,Li. In general the content at least of 7 of these elements must be significant and mustn't be at the sensitivity threshold of the analysis.

3. Processing of the results of the analysis and construction of map for geochemical forecasting using algorithms of the DCGF method. Computers and a special software are used for processing of the sampling data. The study comprises the following: a)Preliminary processing of the sampling data; b)Definition of the deposit detection likelihood function; c)Construction of the forecasting map.

DCGF anomalies, that can be found on the geochemical forecasting map, are the areas of possible locations of deposits over the territory investigation.

Some results of the investigation. Up to now, regional and local forecast of deposits of diamonds, using the DCGF method was carried out in Yakutia diamond-bearing province, South of Kolskii peninsula and Northern Kazakhstan. The main volume of work was carried out in the South of Yakutia diamond-bearing province, where over the area of more than 400.000 km^2 were sampled more than 25.000 geochemical samples and construction of map using the DCGF method was performed in a large range of scales from 1:1.000.000 to 1:50.000. During the construction of the maps, successive approximations method was used: the large-scale maps of DCGF were constructed for anomalous areas, observed on small-scale forecasting maps of DCGF.

Regional survey using DCGF method was performed in Yakutia diamond-bearing province and based on the maps of scales 1:1000.000 and 1:500.000. This survey has the aim to determine efficiency of the method for forecasting of kimberlitic objects of different classes (from kimberlitic region to ensemble of kimberlitic bodies). Performed geological-metallogenic analysis of maps of DCGF anomalies resulted in following main regularities:

On the maps of a scale 1:1000.000 DCGF anomalies present large and medium kimberlitic fields, and at scale 1:500.000 they present small kimberlitic fields and ensembles of kimberlitic bodies. The area of anomalies doesn't exceed 5% of all area under study. At the same time the areas of kimberlitic fields and DCGF anomalies related to them, are commensurable, and all large deposits of diamonds are located within these anomalies. It must be mentioned that the same DCGF anomalies can be traced through maps of different scales (1:1000.000 and 1:500.000), using different initial data (different geochemical samples, different places of sampling). Trapp fields, which are widely spread over this territory, were not detected by the regional DCGF anomalies, therefore one can suppose high efficiency of using of the DCGF method for work in the areas, covered by trapp bodies.

Survey for investigation of the opportunities of using of the DCGF method for local forecasting of deposits of diamonds were performed at scales from 1:200.000 to 1:50.000 in six areas, which differed from each other by age and attachment of indications of kimberlitic magmatic activity, and also by geological structure of areas and genesis of potential diamond-bearing objects. Four of them are situated in Yakutia diamond-bearing province, the 5-th - on the South of Kolskii peninsula, where also are diamond-bearing kimberlites, and the 6-th - in Northern Kazakhstan, where the known diamond-bearing objects are connected with metamorphic rocks. In general, analysis of the results of surveys, performed in the kimberlitic deposits resulted in DCGF anomalies distribution:

DCGF anomalies show more than 60% of known kimberlitic bodies and the most large and diamond-bearing kimberlitic bodies are in accordance with the most intensive DCGF anomalies. Anomalies of scale 1:200.000 are related to groups and ensembles of kimberlitic bodies. The general area of anomalies vary from 3-5% of scale 1:200.000 to 1-2% of scales 1:100.000-1:50.000 from general area of the deposits. Kimberlitic dices at any of these three scales cannot be detected by the DCGF anomalies.

Some kimberlitic bodies, covered by sedimentary thickness and trapp covers, are displayed on DCGF maps, at the same time the DCGF anomalies don't detect trapp covers and it evidently proves the connection of DCGF anomalies with kimberlitic bodies, independently of presence of other rocks.

In comparison with kimberlitic deposits, the deposit in Northern Kazakhstan is complicated enough from the geological and structural-tectonic point of view. It is particularly interesting, because diamonds were found there in grafitic gneises and eclogiutes, guarts-tremolitic rocks and carbonatites, related to them. DCGF anomalies map of scale 1:100.000 was constructed, using geochemical sample analysis data, which were chosen from the core, obtained from reconnaissance wells. During the map construction, nearly 10 DCGF anomalies were detected. Four of them, which were the most intensive, detected six of eight diamond-bearing objects.

Conclusion. The DCGF method is under development. Unsolved problems exist in evaluation of theoretical principles and in technology. But in general the results of the performed surveys showed the high efficiency of the method in economical and geological search aspects. At stage of regional surveys, this method allows to guickly and easily obtain estimates of diamond-bearing of large areas. First of all it concerns not easily accessible and closed regions. It is appropriate to use the DCGF method for purposeful survey, what will give an opportunity to save money and to raise the efficiency of geophysical exploration and drilling.

At stage of local forecasting and search, this method will allow to localize prospective areas, especially those, where the search is complicated due to the presence of trapp covers and sedimentary rocks. This method is irreplaceable for search of non-magnetic kimberlitic bodies.

The method is very perspective and we hope, that its development and using will help to the development of sciences of Earth in general.

Turing A.M., Proc. Roy. Soc. B., 1952, V.237, P.37-71.