The main reliability problems of geological-prospecting works on diamonds

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The theory of geological prospecting systems reliability is based on the notion of **Failure** of the system itself or its element. The failure should be understood as any possible or real event resulting in missing at least one target on the area of investigations, with defined minimum meanings of commercial or indicator parameters. The potential ability not to miss such targets is supposed to mean the **Quality** of geological prospecting system. And the ability to preserve quality for a certain volume of works is supposed to mean **Reliability**. There are five types of failures in every elementary pair "target-method"

A. The failures of **material-indicated type** (bound up with instability of indicated properties of prospecting targets);

B. The failures of the **landscape-geological type** (bound up with the screening influence of the environment surroundings components)

C. The failures of **technical-metrological type** (bound up with insufficient density and accuracy of observations

D. The failures of **geological-interpretative type** (bound up with mistakes during geological interpretation and forecasting);

E. The failures of **evaluation type** (bound up with mistakes during the revealing of the prospecting targets).

The next stage of the reliability investigations of realised or projected forecasting-prospecting technologies is classification of revealed failures according to their frequency and the influence at effective prospecting. Then, for most essential of them there are specific quantitative or qualitative indexes. On the basis of the last one there was worked out a conventional special legend for mapping according to changing factors, which determine the prospecting reliability. These maps serve as a basis for evaluation of prospecting reliability and for a new high-quality technological scheme of prospecting. The main application results of the theory of geological prospecting system reliability in the practice of diamond prospecting investigations in Yakutian diamondiferous province are the following:

For the traditional regions of operating mining plants, in the way of the failures of material-indicated type investigations, there were precised minimum industrial and minimum commercial parameters of targets (kimberlite pipes) and were determined typomorphical indicated features of pipes for each kimberlite field. Methodical techniques in increasing prospecting complex reliability were recommended. By means of investigations of the failures of landscape-geological type and the failures of technical-metrological type special maps of zoning on factors defining methods reliability were made. The methods of reserving failures of this type were also worked out.

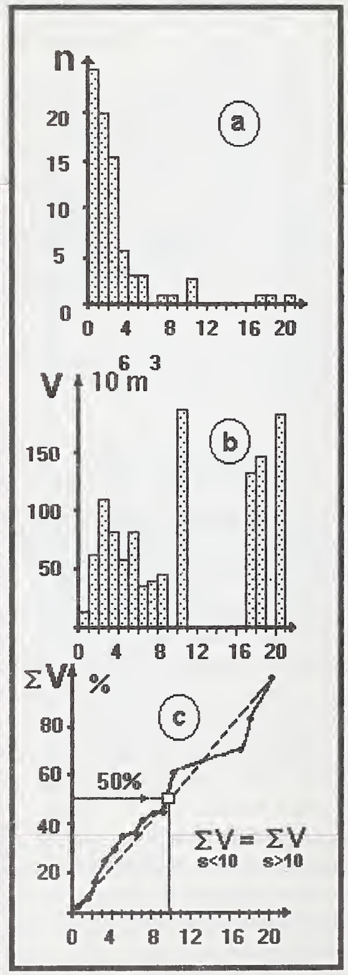

Fig. 1 Distribution of mining mass resources of kimberlite rocks in kimberlite pipes of different sizes (the model of general population).

However the main conclusion about reliability evaluation of diamond prospecting works in different regions of Yakutian diamondiferous province was the one about typical model of distribution of kimberlite rocks resources within the unified field of kimberlite magmatism occurrence (Fig.1). The materials of carried out investigations show that distribution of occurrence frequency of kimberlite bodies in size in a l l well prospected fields is distinctly described by exponential law of probability density distribution (Fig. 1a). Fig. 1b shows distribution of kimberlite rocks resources in each sized class of diatreme. Fig. 1c illustrates cumulative curve of resources distribution in kimberlite field attributed to 100%. From the last figure it is evident that general resources of kimberlite rocks in average and small kimberlite bodies are equal to their resources in pipes large in size.

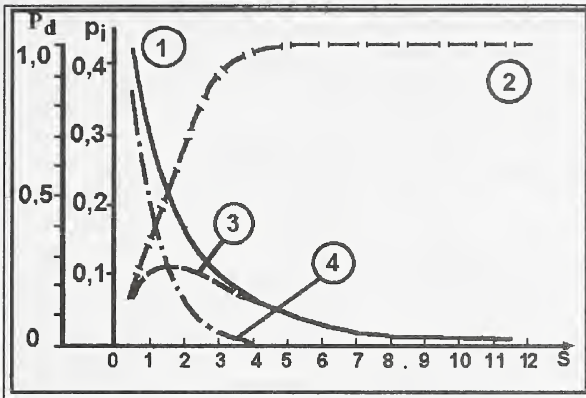

Fig. 2 Example of kimberlite rocks undiscovered resources evaluation within the known kimberlite field.

Fig. 2 shows an example of evaluation of residual resources of kimberlite rocks within the earlier prospected kimberlite field. Here the chart under index "3" shows distribution of known kimberlite pipes according to size. Chart "2" illustrates the dependence of pipes discovery probability by a complex of geological-geophysical methods from size. This chart is the result of carrying out reliability analysis of prospecting the field's territory. Then chart "1" - represents distribution of all diatremes (including not disco-vered) in the field according to the size - general population for the field, and, at last, chart "4" shows distribution according to the size of pipes which are not discovered so far. The above data and the data on changeability of other indicated parameters of dia-tremes within separate kimberlite fields, make it possible to come to an important practical conclusion.

It means that in a l l the investigated examples for the general population of diatremes in one field there is specific exponential distribution of sizes, magnetic susceptibility, content of indicator minerals (pyrope, picroilmenite and so on). As a consequence of this conclusion there is a claim that in all the situations when distribution of the mentioned parameters differs from exponential distribution towards logarithmic-normal we deal with not sufficiently prospected territory. And the more significant is this difference, the more undiscovered resources there are in the investigated territory.

In Fig. 3 you can see the data about the relationship of kimberlite bodies sizes and their diamondiferous property. In the upper part of the picture there is a clear view of positive correlation between the discussed parameters. In the lower part of the picture you can definitely see that there is no such relationship. Hence for the first field the problem of revealing residual resources is of low actuality, as for the second one, it is hard to overestimate how actual it is.

. The conducted investigations in evaluating reliability of geological exploration on diamonds in some regions of our country, analysis of publications concerning other regions, made it possible to formulate two radically different conceptual models of geologic-exploration works, which in each region replace each other in time. These are the model of geological prospecting (exploration) in a new region and the model of exploration in a region of a functioning mining enterprise.

For the model of **geologic-exploration works in a new region** the basic geologic-economic task is to detect a single or single deposits of diamonds, sufficient in the quantity for substantiation to build a profitable for a long period mining enterprise. Accordingly, the targets of geologic-exploration works in such regions are deposits large in size, contrast in indicated features and occurring in favourable geologic-exploration environment. Usually such are discovered by comparatively cheap expressive prospecting methods. The leading role in detecting deposits here usually belongs to the methods directed at revealing prospecting features, while exploration premises for a certain region are worked out not in a sufficient way. Unlike the stage scheme of geologic-exploration process here is rather often used a shortened scheme of prospecting. The last one, under favourable conditions, makes it possible to find deposits, new mineragenic taxons (fields, clusters of pipes and others) escaping whole stages of investigations. An important feature of works in a new region is a sufficient efficiency of using in practice typical, close to average models of targets and hosting them landscape-geological environment, which, in its turn, presupposes as possible to use traditional probability-statistical algorithms in evaluation.

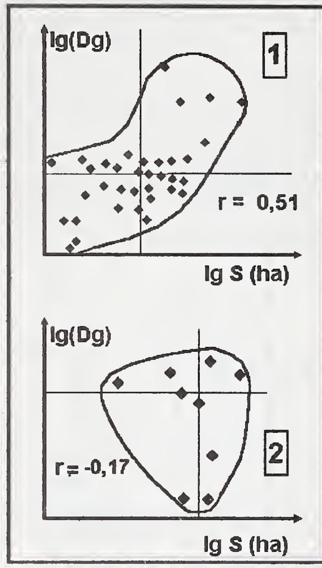

Fig. 3 Relationship "size-diamondiferous property" for different kimberlite fields.

For the model of **geologic-exploration works in the regions of operating mining enterprises** the main geologic-economic task is to provide the operating enterprise by additional resources for prolonging the term of profitable existence. The volume and structure of expenses for the development of the deposits here, in comparison with a new region, sufficiently differ, and accordingly differ the demands of industry to the minimum parameters of deposits. On the other hand, the data on diamond deposits make it possible to consider that summarised resources of diamonds, distributed in a large quantity of small and average deposits of one region, rather often can be equal to the resources concentrated in this same region in single large deposits. From these positions the deposits smaller in size, in comparison with the discovered deposits, become the targets of prospecting works in the regions of operating mining enterprises. And due to the methods specific features of carrying out exploration at the first stage they include large deposits as well, but either low-contrast in indicator parameters, or occurring in unfavourable prospecting situations. As the experience of works shows such targets are usually found when applying rather complicated combinations of prospecting methods and carrying out significant volumes of mining-bore works. While doing it the part of methods directed at detecting a target only by prospecting indications decreases and the part of forecasting with application of the revealed local and narrow-local prospecting premises increases. Accordingly the reduced (shortened) scheme of exploration at the second stage becomes low-effective and the effectiveness of works depends either on the details of working out and the degree of practical application of investigation scheme by stages or on substantial increase and concentration of the volumes of mining-bore works. Here, unlike a typical model of a target, the application in practice of indicator parameters is rather limited, those parameters which characterise in average the deposits discovered earlier. Each target on each prospecting area should be considered as a not typical, but rather individual phenomenon. If at the first stage of works the solution of geologic-economic task was achieved by discovery of some quantity of targets from their rather large availability in nature, then, at the second stage, in order to satisfactorily solve the geologic-economic task all or practically all minimum industrial deposits must be discovered. Prospecting of such deposits is usually carried out on local perspective areas. It fundamentally changes the axiomatic probability model of geologic-prospecting works efficiency evaluation; instead of a model of detecting many targets out of the many, which can be realised on large areas, it is necessary to use the models of detecting single, not typical targets, out of the single ones on local areas (plots).