WHITE-PAPER

Introduction

Placers play an important role as sources of many types of mineral raw materials, including: minerals of titanium, zirconium, tantalum, niobium, tungsten, tin; gold, platinoids (platinum, iridium, rhodium, palladium, osmium, ruthenium), amber, diamonds.

The high interest of the mining industry in placer deposits is due to a relatively low level of costs in obtaining high-quality concentrates of valuable minerals.

At the same time, a significant part of the placer deposits for various reasons is not attractive to the investor.

This is due primarily to the fact that large, rich and shallow-lying placers are now exhausted. Placers remained:

- if intact, then in remote areas, poor, at considerable depths and watered;
- if partially exhausted, then devaluated by selective excavation of rich sections.

In connection with the exhaustion of the fund of "readily discovered" deposits, pre-project forecasting assumes great importance in the general cycle of geological exploration.

This project purpose - to create a tool for large-scale forecasting of placer objects.

As a result of the project implementation, a software system will be created that:

- provides a physically grounded identification of areas promising for a accumulation of useful components with the necessary detail for largescale forecasting (scale of reporting materials 1:50000-1: 25000);
- enables us to obtain quantitative estimates of the forecast resources of category P2-P3 (GKZ*) ~ exploration target (JORC Code) — Hypothetical Resources (Circular 831 USGS 1980);
- is characterized by a high degree of automation 4 minimizes the effect of the subjective factor.

*GKZ - Russian State Commission for Reserves (*Gosudarstvennaya Komissia po Zapasam*)

The products received as a result of the project implementation are the geological forecast.

Consumers of the geological forecast are mining and junior geological companies that produce prospecting geological prospecting.

Technology features

The scientific novelty of the solutions proposed in the innovative project is:

- in the application of the modern apparatus of mathematical physics to describe the transfer of a useful component (placer-forming minerals) - anomalous diffusion (sub-diffusion) on the fractal structure is the best approximation of the real process of transfer of the useful component, in comparison with the prevalent models of the diffusion type;
- in account the effect on the transfer and accumulation of a useful component (at the diffusion coefficient level) of the fractal nature of the erosional relief;
- in the use of methods for solving inverse problems of mathematical physics in the approximation of nominal geological variables.

Methods and technique for solving the problems

Physically grounded identification of areas promising for a accumulation of useful components.
The search strategy for new mineral deposits is based on a purposeful and effective selection of objects for further geological research.
Accurate and reliable geological forecast sharply increases the effectiveness of searches.

Nevertheless, at the present time, the strategy of prospecting for objects of both primary and placer gold is built according to the standard scheme:

- The allocation of potentially promising areas in the rank of ore regions, nodes, fields and deposits is made using empirical forecasting and search models of metallogenic and morphogenetic taxa of different levels;
- perform geological prospecting.

Considering that:

- forecasting and prospecting models are compiled from well-studied geologicalgeomorphological taxa, but are applied in areas of the previous level with a lower level of study, where the most important typomorphic features have not yet been found;
- the use of medium-scale geological maps (scale 1: 200 000), with weak exposure, often do not reflect the true geological structure;
- forecasting and prospecting models are subjective, depend on the metallogenic concepts accepted by the authors, replacing each other as the Earth sciences develop;

in order to increase the efficiency of prospecting for placer deposits, it seems necessary to supplement the existing approach in the construction of a placer forecast, fundamentally different, based on physical concepts of the mechanism of transport and accumulation of a useful component.

In the project method for forecasting placer deposits of minerals, by creating a digital terrain model (DEM) of the research area and calculating the morphometricdifferential characteristics of the relief, within the drainage area, promising areas for the presence of accumulation of useful components are identified.

For the research area, predictive signs are used calculated estimate of the right-hand side of

the transport equation in a non-linear diffusion approximation of fractal derivative for a fractal substrate, which is an estimate of the divergence (taken with the opposite sign) of the hypothetical flow of a useful component, as well as its differential characteristics.

The calculations use the diffusion coefficient, which characterizes the transfer rate of a useful component as a result of the action of gravitational and water processes, which (the diffusion coefficient) is a function of coordinates, depends on the relief of the earth's surface within the drainage area of the point with the current coordinates, its (relief) of differential and fractal characteristics, as well as the area of the fractal surface of the drainage area.

The detail necessary for large-scale forecasting (scale of reporting materials 1: 50000-1: 25000); The rejection of the traditional model of smooth approximation of the relief in favor of fractal, as the most justified, allows using the results of stereoscopic optical and interferometric radiolocation space surveys-global digital elevation models (GDEM) with sufficient resolution for research purposes (up to 1" ~ 30 m in the plan) without preliminary generalization or smoothing.

From the fractal model of the relief, for its approximation, the application of the apparatus of a two-dimensional discrete Fourier transform follows naturally, the calculation of fractal derivative is carried out in the sense of Weyl, and the differential transformations of the calculated divergence estimate are performed in the frequency domain, followed by the Fourier transform, which together with preliminary interference suppression errors in the initial GDEM) with the help of locally-daptive filtering provides the required detail of the forecast.

High degree of automation, minimizing the influence of subjective factors.

The calculated estimation of the divergence of the flow of a useful component has a simple physical meaning - it characterizes a small neighborhood of the point under consideration for the presence of sources or sinks (accumulation place), the areas promising for the presence of placer objects are distinguished by the values of the divergence and its differential characteristics.

When determining model parameters (fractal powers of derivatives and others), a criterial approach is used. The evaluation is performed in accordance with the maximum value of the binary classification quality criterion under conditions of strong class imbalance.

Support for the adoption of management decisions to conduct prospecting (verification) geological exploration to assess the forecast resources.

It is ensured by the transparency of the result of the forecast, which is an estimate of the probability of the presence of a placer object within the area of the research area corresponding to the DEM element, provided that the transfer of the useful component is realized.

Problems solved by the project

Pospecting and exploration of mineral deposits are classified as high-risk areas of economic activity, especially in the early stages of geological research.

It is sufficient to indicate an approximate interval that determines the number of spontaneously initiated projects brought to the stage of mining (from 1 in 10,000 to 1 in 100,000).

In order to reduce geological risks, pre-project works are carried out, the task of which is to select areas for geological prospecting , the choice is based on the predictive estimates of their (areas) prospects for the availability of minerals.

Nevertheless, according to VP Orlov (Geological Forecasting - M Nedra 1991), the confirmability of geological forecasts in many cases does not exceed 3-10%; for the non-ferrous metals deposits, only 4% of the forecast resources of category P3 (GKZ) ~Hypothetical Resources (Circular 831 USGS 1980) reach the category of stocks C2 (GKZ) ~ Inferred Mineral (JORC Code). At the same time, this share is, for iron ore -35%, for oil about 50%.

It should be noted that 4% confirmation of the geological forecast for non-ferrous metals largely discredits both the idea itself and the apparatus used in constructing the forecast.

Other purpose of this project is to increase the confirmation of the forecast to 25-30%

Business model

Processes that create value

The value is created as a result of the creation and processing of digital terrain models, other geological and geophysical data, interpretation of the results obtained.

The value is a large-scale forecast of alluviality with a scale of 1: 50000-1: 25000 reporting materials, which gives the opportunity to obtain quantitative estimates of the forecast resources of category P2-P3 (GKZ) ~ exploration target (JORC Code) - Hypothetical Resources (Circular 831 USGS 1980) ;

Resources that create value

- Prognostic software is already created and developed in the process of project implementation;
- Computing power - It is supposed to use several super-mini computer systems based on NVIDIA server solutions (CUDA technology using Tesla P100 graphics accelerators) with a peak processing power of at least 16 Teraflops in calculations with double precision;
- System software - is not weaker than Windows Server 2008 R2 Enterprise Edition x64 with support for up to 2 TB of RAM;
- Application software - compilers modula2, C, C ++, Lua generating 64 bit executable code. C and Fortran compilers PGI CUDA;
- Database management systems - will be used sufficiently low-level database managers that

support the key-value access mechanism, for example, UNQLite;

- Geological and geophysical data - global digital terrain models and other geological and geophysical information.

Customers

As consumers of the results of the forecast of placers, mineral developer and junior geological companies.

Volume and capacity of the product market

The product offered to the market is a forecast of placer content of the territory determined by the customer, presented in the form of forecast maps on a solid or electronic carrier in the coordinate system and map projection required by the customer.

The forecast area - is the whole surface of the globe uncovered by glaciers, since, to date, 100% coverage of the earth's surface by highprecision global digital terrain models (WorldDEM and ALOS World 3D Topographic Data) has been achieved.

Thus, the capacity of the world market is determined by the number of geological (including junior) and mining-geological companies engaged in prospecting for placer deposits or planning such operations.

According to the minimum estimates, the number of such companies is several hundred (500), which at a price of 10-50 $ km2, the forecast of placer content and the minimum order volume of 1000 km2 per year is 5-25 million USD per year.

A pessimistic estimate of the market volume is 0.5 to 2.5 million USD per year, respectively.

Current status of the project and development plans

At present, the invention is registered 2017129479/28 (051186) "Method of forecasting placer deposits"

In the short term (within a year and a half), it is planned to create an integrated software system, obtain pilot forecasts, at the end of a two-year period, sales are expected (with a pessimistic estimate of market capacity and a wholesale price of 10USD / km2) of the volume of the first millions of USD per year.

In the medium-long term (within 5 years), it is planned to enter the market as a junior geological company, within 8 years acquiring the status of an extractive mining and geological company.