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Research Article

THE USE OF MATHEMATICAL STATISTICS METHODS IN THE FORECASTING OF PLACERS ON THE EXAMPLE OF ANGREN DEPRESSION (CHATKAL-KURAMA REGION, MIDDLE TIEN SHAN)

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ABSTRACT
The article discusses the method of statistical metallogenic analysis and its use for gold ore objects forecasting. The result of the study was the selection of five promising areas for gold deposits within Angren-Almalyk mining region.

Keywords: *Statistical analysis, Relief, Geomorphology, Gold-ore deposits, Angren depression, Placers*

INTRODUCTION

Theoretical basis and methodology of statistical metallogenic analysis, used in this work, was developed by the academician F.A. Usmanov (Usmanov, 1997, 2003). Initially, it was an information technology that includes the “Geoanalysis” computer program and were compiled in the Mapbasic language in GIS Mapinfo. They are designed so that from them it is possible to form various options for solving the problems of statistical metallogenic analysis and quantitative forecasting of ore deposits. The technological scheme for solving a separate problem includes several interconnected system programs used in a certain sequence. Depending on the initial data and the tasks solved, the technology can be applied for regional, local and detailed forecasting. To date, more than 20 programs have been developed to solve the problems of statistical metallogenic analysis and forecasting ores of territories (Usmanov, 1997; Sadikova *et al.*, 2014).

MATERIALS AND METHODS

In this work, the “Density” program of this system was used, and it was adapted to use the tools of the ArcGIS system.

The methodology of the "Density" program is to determine the regularities of the spatial distribution of ore objects. For software implementation, the sliding window method is used, similar to the field averaging method widely used in geophysics. The data analysis algorithm was as follows: the entire territory where Paleozoic formations are exposed is covered with a square mesh with a step of 0.5 km. In each mesh node, a circle with a center was held in a given node with a diameter of 4.5 km (this diameter value was chosen as optimal as a result of a series of experiments). For a circle with the center at point (i, j), the area of the Paleozoic rocks outcrop S_{ij}, the number of ore objects falling into the circle N_{ij}; the density of the placement of objects $P_{ij} = N_{ij} / S_{ij}$ are calculated within the circle. Then the center of the circle moved to the next point. The result was a continuous field of density of placement of ore objects. The resulting numerical field is approximated by the continuous surface by the triangulation method, as a result, the density of the placement of ore objects is obtained.

Functional categories, i.e. tools of the additional Spatial Analyst module are as follows: conditional instruments allow you to control the output values based on conditions applied to the input values. Conditions that can be applied to two types are either attributive requests or a condition based on a conditional proposal in the list. Density. Using density tools (Density group), you can calculate the density of the input objects in the vicinity around each output cell of raster.

To identify quantitative factors of localization and forecasting of ore objects, the module of the "Geoanalysis" computer system (Density) and ArcGIS (Spatial Analysis, ArctoolBox) were used. According to statistics, within the limits of the Angren depression, about 300 golden objects are known, of which there are more than 25 deposits (Akturpak, Bichanzor, Kauldy, Kochbulak, Kyzat, Kairagach, Kyzylalmasai, Katrangy and others) and about 270 ore occurrences (Sadikova *et al.*, 2023; Kustarnikova *et al.*, 2012; "Ore deposits of Uzbekistan, 2001).

In the analysis of the statistical regularities of the spatial placement of golden objects, the Spatial Analyst module of Arcgis Pro program was used. On the given below scheme (Figure 1), the zones with the maximum density of golden objects: I - Almalyk, II - Kyzyllmasai, III - Kochbulak, IV - Aderekly, V- Revashty, were clearly designated.

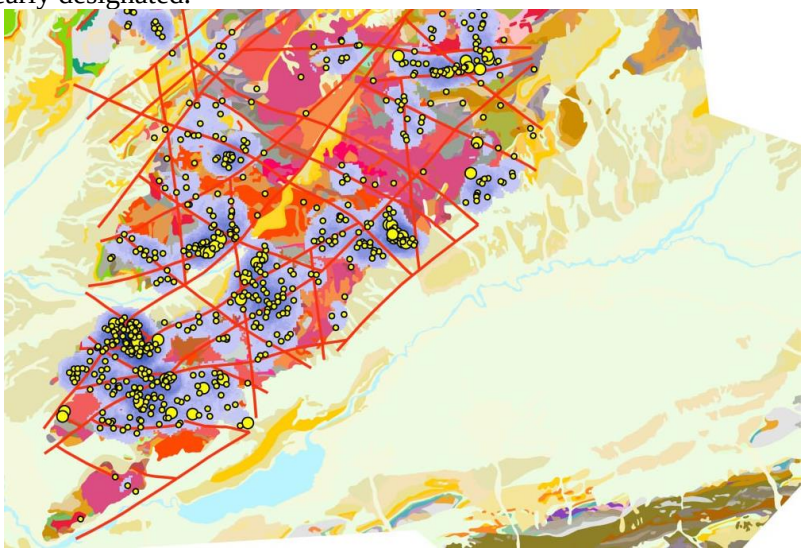

Figure 1: Computer zoning of golden objects by placement density

Relation of placer gold with original supply sources.

In many gold ore regions of the world, placer gold is the main mineral resourse and contains the main reserves of the metal. In industrial significance, the first place is occupied by placers of quarter age. The preservation of ancient placers is determined by the geological and geomorphological features of the area (Shilo, 2000; Vinogradova, 2006).

Among the placers, the following genetic types were highlighted: eluvial, deluvial and solifluction, alluvial, proluvial, mixed. So, the morphological types of these placers are also diverse: bench and etc. (Razumikhin, 1982; Popenko, 1982).

The Angren Valley is a tectonic inter-mountain depression of the synclinal structure, composed mainly by Mesozoic and Cenozoic sediments resting on the Paleozoic foundation. The rocks of the Paleozoic foundation appear on the sides of depression and compose the massifs of the SW of the Chatkal and Kurama ridges surrounding it. The sharp difference between the complex tectonic structure of the Paleozoic foundation, structure of which is consisted by strongly displaced Paleozoic strata and erupted rocks, and simpler tectonics of Mesosoic and Cenozoic deposits is characteristic. In the Mesozoic era, the Angren valley mainly accumulated sediments, firstly in wet and warm climatic conditions. Jurassic deposits are represented by clay with a thick layer of coal and coal shales, covered from above with kaolin clays. In the Cretaceous period, the Angren depression experienced a slight lowering motion; red-colored desert-continental and coastal sediments (red-colored conglomerates, sandstones, clays, marls) were deposited.

Cretaceous deposits are covered with lower Tertiary marine deposits (pebble conglomerates, sandstones and limestones). These deposits are distributed almost to the top of Angren and, in places, on the watershed of the Kurama ridge.

Marine paleogene deposits underlie a thick stratum of brick-red clays, marls, sandstones and conglomerates, which indicates the rising of this area, which coincided with the alpine mountain folding. Quaternary deposits - pebbles, loess, alluvial fans of lateral inflows, glacial and landfill deposits near the foot of the mountains (Sadikova *et al.*, 2014).

The geomorphological structure of the Almalyk-Angren district has all the features of the epiplatform orogenic region and is characterized by the presence of various categories, types and forms of relief that make up the valley of the Akhangaran river and its mountain surroundings (Figure 2**)**.

Mountain surroundings are mainly characterized by denudation-tectonic relief. Depending on the uplift degree, in the mountain surroundings, the high-, medium- and low-mountain areas are distinguished.

The high-mountain region occupies the northern part of the territory (the upper reaches of the Akhangaran River). A feature of the region is the presence of peneplanation planes, which are part of the large Angren upland.

The medium-mountain region occupies the main part of the mountain surroundings of the Akhangaran river. The relief of the medium-mountain is stepped due to changes in the angles of the slopes. In the Chatkal range, the angles of the slopes change from steep to gentle, in Kurama range – from medium to gentle (in the direction of Akhangaran River). River valleys that cut through the steeply-slope medium-mountain are occured in the instratal phase of development and are characterized by predominantly narrow, sharpened channels, the absence of meanders and accumulative terraces. In the areas of the medium-mountain region with a low- and medium-slope relief, the slopes covered by eluvial and deluvial deposits are typical. The profile of the river valleys is flatten out, the bottoms of the valleys are expanded, relatively extended erosion-accumulative and accumulative terraces appear. In the medium-mountain region, as in the high-mountain region, landslide processes are widely developed. Within the medium-mountain region, there are golden objects of the Kyzylalmasay and Kochbulak ore fields.

Below the zone, that makes up the medium-mountain, is a low-mountain region, gradually sticking together with the foothill plains. This part of the territory is characterized by gentle slopes with soft outlines and varying degrees of degree roughness. Sometimes the slopes break off to the Akhangaran river valley with steep erosion and tectonic ledges, due to which some of the streamlets is overhung relative to the bottom of the valley. The lowlands are characterized by a very wide development of slope processes that led to the accumulation of a powerful case of small -ground material, often completely overlapping indigenous rocks. The low-mountain region is characterized by a very wide development of slope processes that led to the accumulation of a thick cover of fine-grained material, often completely overlapping indigenous rocks. Further flattening of the profile of the river valleys and their expansion due to accumulative terraces, which are most common here, occurs. Within the low-mountain region, there are gold deposits and occurences of the Almalyk ore field.

Accumulative processes and, accordingly, the emergence of accumulative types and forms of relief, which are of greatest interest as placer-bearing deposits, are associated with the erosion-accumulative activity of the Akhangaran river and its inflows. The result of such activities was the accumulative valley of the Akhangaran river in the lower part, which responds in plan to the depression of the same name, terraces of lateral inflows, alluvial fans (Kurbanova, 2023).

The placers of the alluvial genetic type are located in the middle of the medium-mountain region, dedicated to the pebbles of the Golocene and, to a lesser extent, the Upper Pleistocene. Placers have striate character, they are very non-uniform by different parameters (length, width, content), over-bedrock, with small gold resources in the Gushsay and Kyzylalmasay placers. The other placer points and occurences (Yakarcha, Karabau, Kandyrsai and Abjazsai) have the same genetic and morphological type.

In addition to alluvial placer gold occurences, deluvial-proluvial (Akcheku) and deluvial-technogenic (Akturpak) genetic types are highlighted.

During the forecasting of placers using the developed “Density” program, the intersection of previously selected zones (I-Almalyk, II-Kyzylalmasai, III- Kochbulak, IV-Adjerekly, V-Revashty) with certain morphostructures and hydrosystems in Angren depression was carried out (Figure 3).

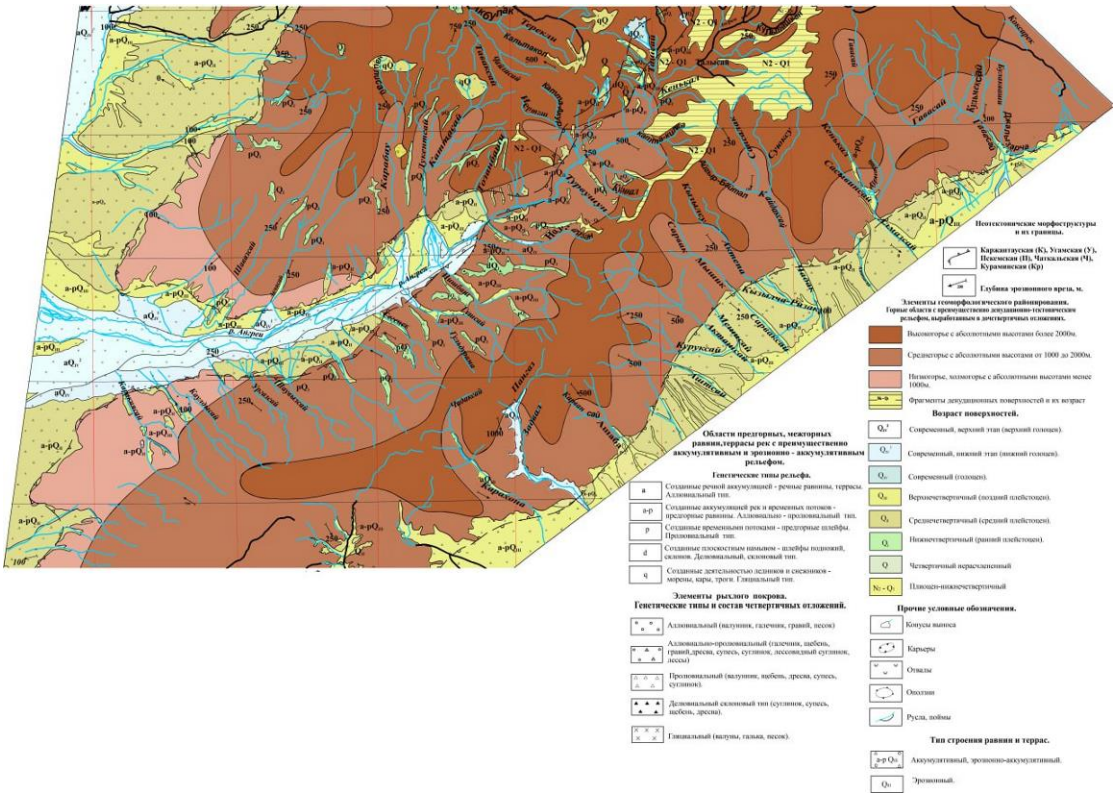

Figure 2: Geomorphological map of the Angren-Almalyk district. Scale 1: 100,000 (Yu.A. Skvortsov, with authors' additions).

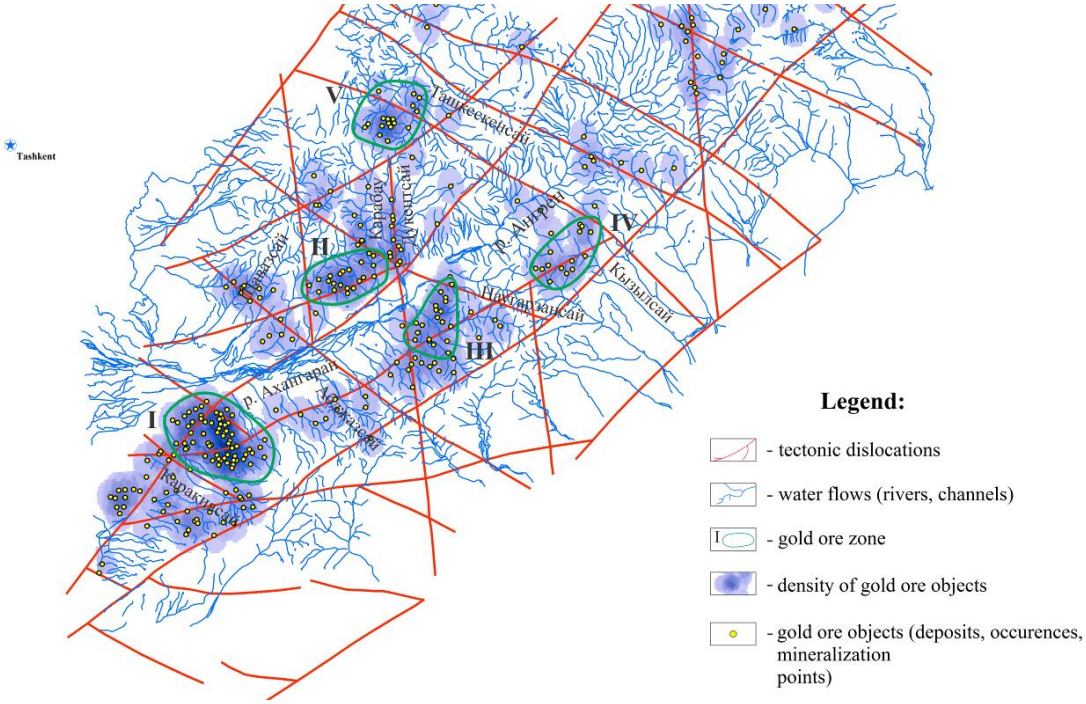

Figure 3: Map of the gold zones of the Akhangaran river basin and adjacent territories, scale 1: 200,000. Zones: I-Almalyk, II-Kyzylalmasai, III- Kochbulak, IV-Adjerekly, V-Revashty.

CONCLUSION

1. As a result of the statistical metallogenic analysis, five zones (areas) (Almalyk, Kyzylalmasai, Kochbulak, Adjerekly, Revashty) with high density of golden objects and crossing with certain morphostructures and hydrosystems in Angren depression were selected.
2. Angren depression can be attributed to the promising, since a significant number of golden deposits and occurences facing the surface are concentrated here.
3. The described relief is characterized by differentiating tectonic activity in the neotectonic stage, when all the Quarternary cycles and processes of sedimentation in equilibrium conditions were replaced by activation, which led to the formation of erosion-accumulative terraces of different ages. The alluvial-proluvial boulder-pebble deposits of the Tashkent and Hungry-steppe complex can be the placer-bearing formations.

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