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Research Article

REGIONAL METALLOGENIC ANALYSIS USING MATHEMATICAL STATISTICS METHOD (NURATA REGION, UZBEKISTAN)

***Lola Sadikova[1], Shahzodahon Kasimova[2], Saodat Maripova[3] and Aziz Abduazimkhodjaev[4]**
[1] Institute of Geology and Geophysics, Academy of Science of the Republic Uzbekistan, 100041, Tashkent, Olimlar 49, Uzbekistan
[2]State Committee of Republic Uzbekistan on Geology and Mineral Resources, 100060, Tashkent, Shevchenko 11, Uzbekistan
[3]Scientific Research Institute of Mineral Resources, State Enterprise, 100060, Tashkent, Shevchenko 11[a], Uzbekistan
[4]Institute of Hydrogeology and Engineering Geology, State Enterprise, 100041, Tashkent, Olimlar 64, Uzbekistan
**Author for Correspondence*

ABSTRACT
Method of statistical metallogenic analysis of ore deposits has been developed. Proposed method increases the accuracy of the prediction area for the potential ore fields detection. Applying the method we are estimated metallogenic potential of the Nurata mountains for the selected perspective objects and provided recommendations for future exploration.

Keywords: *The Density of the Ore Facilities, Statistics, Metallogenic Potential, Diagnostic Criteria, Quantitative Evaluation*

INTRODUCTION
Metallogeny is the study of patterns of formation and distribution of mineral deposits in the area and is the link between fundamental and applied geological research and has practical orientation. It examines the relationship between ore deposits and other geological objects. The number of such objects in the study of regional metallogeny, usually are equal to hundreds or thousands, so usually is presented as a statistical ensemble, and therefore, the relation should be probabilistic.
Metallogenic analysis by the mathematical statistics approach includes a set of statistical and probabilistic methods, and collection of statistical laws.

Study Area
Nurata Mountain mining region includes Northern, Southern Nurata and intermountain basin. The region is characterized by a complex double-level structure - folded basement and weakly dislocated Mesozoic-Cenozoic cover. The structure of the first is combined by sedimentary, igneous and metamorphic rocks of Precambrian and Paleozoic age, the total thickness of which up to 5-10 km. Mesozoic-Cenozoic sedimentary cover correspond to the platform stage of the region development.
Formation of the region took place in the Caledonian, Hercynian and Alpine tectonic cycles. According to tectonic zoning schemes of Nurata mountains in the western part of the zone of the South Tien Shan orogenic belt, "... formed as a result of the subduction of the oceanic crust of the Turkestan paleoocean under the Kazakhstan-Kyrgyz continent and its subsequent collision with the Karakum - Tarim continent" (Yakubchuk *et al.*, 2005; Goldfarb *et al.*, 2013; Seltmann *et al.*, 2011).
During the Ordovician - Early Silurian (more ancient history is not reliable) within the territory under consideration there is single large basin with oceanic crust - Paleoturkestanian ocean (Mossakovsky *et al.*, 1993).
The region went through complex and multi-stage history of geological development, and as the result there was formed infolded-cover-construction. The complexity, heterogeneity and multi-stage formation of the structure led to different ideas about the laws of geotectonic development of the region and geodynamic regimes operating within it. It was considered the block (a block-fold) mechanism of vertical

movement mechanism (Belousov *et al.*, 1984; Rezvoy, 1956; Makarov, 1990) and the mechanism of the general horizontal compression and significant horizontal displacements of crustal blocks (Leonov, 1996). It is allowed combined effect of total compression, mantle processes and the transformation of compression stresses in the block-folded structure (Kolodyazhniy *et al.*, 1991). Pre-Alpine structure and history of the region are described in numerous articles and monographs (Leonov, 2008).

According to modern concepts, the structure of the Paleozoic Southern Tien-Shan is formed by lateral contraction and horizontal submeridional compression, complicated by the existence of independent geodynamic stages: gravitational and bending deflection instability of geologically stratified lithosphere. These mechanisms are created specific structural assemblies, which greatly influenced the morphostructural development of the region in the Mesozoic and Cenozoic, in the beginning of which in the place of Turkestan paleoocean was formed complex and heterogeneous fold-thrust structure.

The high ore potential of the region is determined by location in its territory large commercial deposits of precious (Zarmitan, Sarmich, Pistali and others), Rare (Koytash and others) metals, polymetals (Uchkulach and others). Despite the detailed studies of the region by geophysical, geological and geochemical methods, the majority of geologists which have studied this region believe in the prospects of significant increase of mineral resource potential of Uzbekistan in gold, tungsten, lead, zinc, uranium and other metals, Paleozoic oil.

MATERIALS AND METHODS

Research Methodology

Methods of statistical metallogenic analysis consisted of three main stages: creation of electronic maps database for Nurata region (geological, structural, space geological, ore minerals, structural-formational, geophysical, geochemical, and others); computer database analysis and identification of the factors of localization of ore deposits of Nurata region (lithological and stratigraphical, structural-tectonic, and others); interpretation of the computer analysis results.

Data base of map information is prepared in Arc GIS format. A set of regional cartographic materials included in the electronic database is selected in such a way as to reflect the geology of the Nurata region from different sides - ore potential, stratigraphy, lithology, tectonics, geodynamic conditions, magmatism, metamorphism, etc. Totally our database includes 14 different maps of the scale 1: 100,000 - 1: 200,000.

For example, for the map of Nurata region mineral resources, scale 1: 200,000 it was created electronic catalog of ore objects. It consists of 475 objects of precious (Au), rare (W), non-ferrous (Pb, Zn), ferrous (Fe and radioactive metals (U) of various sizes (deposits, field occurrences, mineralization points).

The study of relationships between signs of different geological formations and ore content of Nurata region are carried out using ArcGis (Spatial Analyst modules and Tool Box).

The technique we used is as follows. The whole exposed pre-Mesozoic basement, was covered with a square grid with spacing 0.5 km. From each node of the network is carried out a circle with the center in this node with a diameter of 4.5 km (such diameter value is selected as an optimal result in a series of experiments).

For the circle center at (i, j) it is calculated area Sij of Paleozoic rocks within the circle; the number of gold objects Nij, falling into the circle; density of objects Pij = Nij / Sij. Then, the center of the circle is moved to the next point. As a result we obtain continuous field-density of ore objects. The resulting numeric field is approximated by a continuous surface by triangulation method, and as the result we have diagram of ore objects density distribution. These areas represent metallogenic anomalies corresponding to the size and shape of isometric ore concentrations (Usmanov and Maripova, 2006).

Further we have calculated links of mineralization with various factors, which are reflected in the respective maps. To measure this relation we used the coefficient of spatial relations. The favorable lithological and stratigraphical, structural-tectonical, geochemical, geophysical and other factors are superimposed on the map of densities of a particular type of ore objects (in this case the map of density of precious metals of the Nurata region). The resulting forecast-metallogenic map - is the imposition of various combinations of favorable factors, which allow us to identify new promising areas for the discovery of new gold deposits.

RESULTS AND DISCUSSION

Results of Statistical Metallogenic Analysis

As a result of the statistical metallogenic analysis of Nurata region we obtained the following results:

1. Statistics of the distribution of Nurata region ore objects demonstrate that from 475 deposits there are 377 of gold ore; 50 of tungsten; 38 of nonferrous metals, 5 of uranium and 5 of ferrows. Statistics of distribution shows that metallogenic specialization of Nurata region is mainly for precious and rare metals.
2. The scheme of placement density of gold objects of the region under study has been compiled. Within the Nurata region in average there are 2 objects in 100 km^2, which is defined by us as a regional background. The areas presented in the scheme as white, where the density of objects of gold is equal to, or below of the regional background. The areas where the density of gold objects above of regional background marked in colors (blue, red, orange and yellow) and represent metallogenic anomalies corresponding to the size and of isometric shape of gold ore (Figure 2). The areas of concentration of gold objects, expressed in colors: blue - areas of high density of gold mineralization - more than 10 sites per 100 km^2, red - from 9 am to 7 projects per 100 km^2, orange - from 6 to 4, the object is 100 km^2 yellow - 3 to 1 object 100 km^2.
3. In the diagram of frequency of occurrence of ore objects by age in the host rocks in Nurata region (Figure 4) it is obvious that the majority of ore deposits are concentrated in the Upper Ordovician-Lower - Silurian age. Therefore, deposits of this age are the most favorable for mineralization.
4. Most favorable for the localization of mineralization are ruptural structures of the north-west direction (Figure 4).

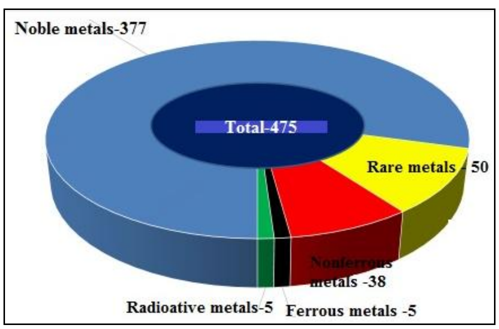

Figure 1: **Chart of Distribution of Metallogenic Potential for the Nurata Region**

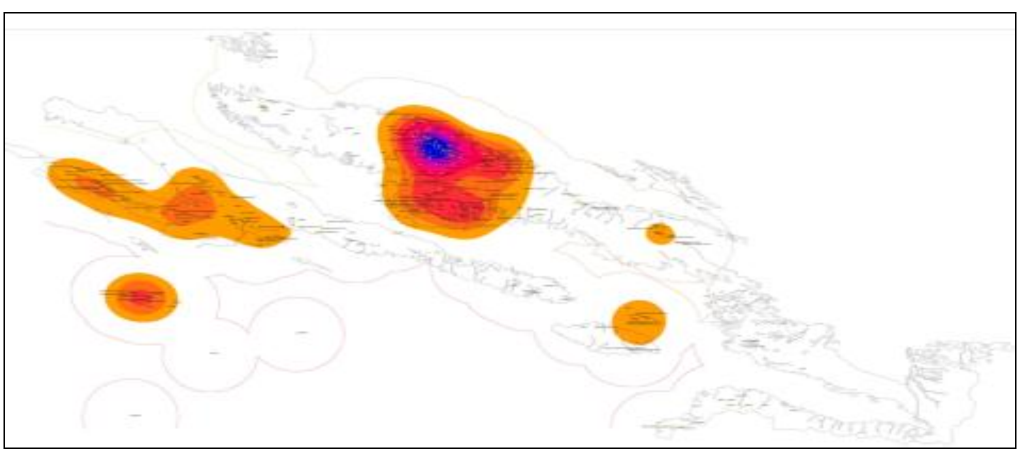

Figure 2: Scheme of Density of Precious Metals for Nurata District

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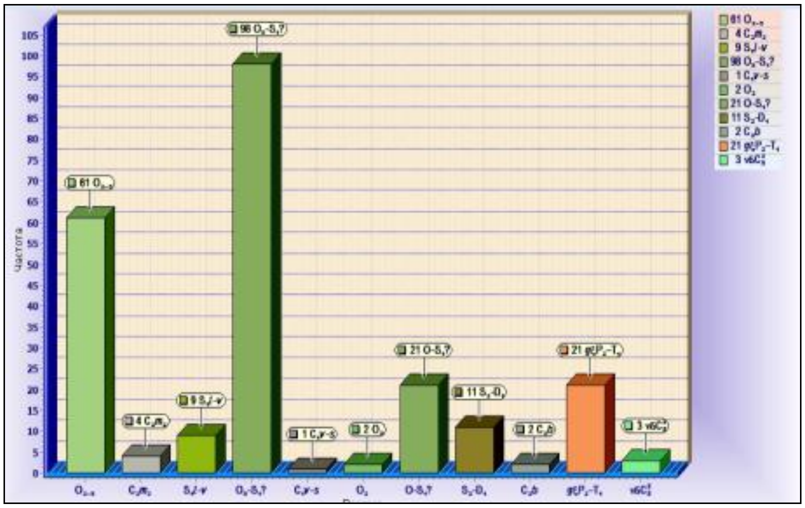

Figure 3: The Frequency of Occurrence of Gold Deposits in Geological Formations

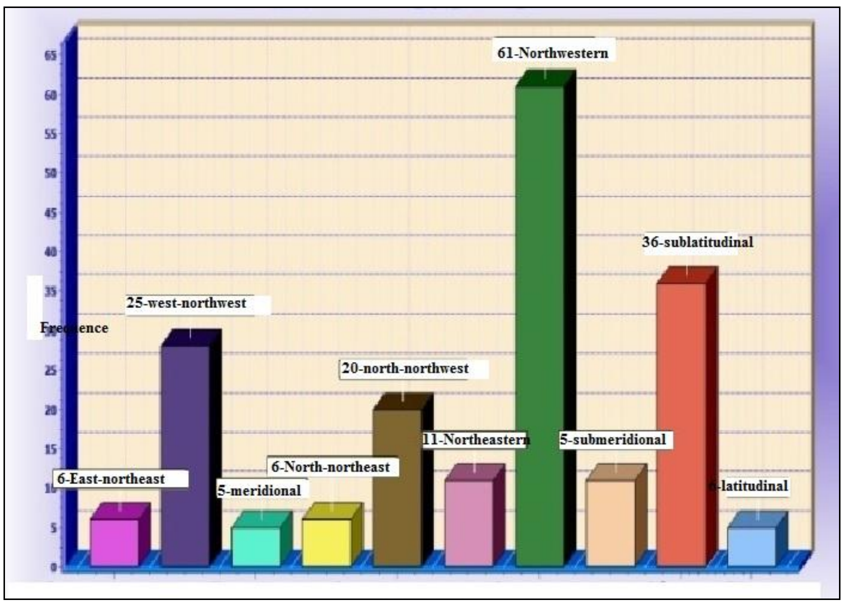

Figure 4: Chart of Distribution of Nurata Region Objects Relatively Ruptural Structures - Significant Thrusts

Conclusion

1. Developed statistical method for predicting ore deposits by range of geological, geophysical and geochemical maps of the territory is intended for cases where the relation between the informative indications on the different maps are missing or so weak that do not affect the final results and can be ignored. It is based on a calculation of the integrated information content of individual cells, into which we are parceling all the territory.
2. Computer analysis of the data and identification of lithological and structural factors of localization of the Nurata region ore deposits are provided.
3. The ore-controlling structure - large sub latitudinal zone or W-NW faults; ore conducting structure - east north-east direction; ore objects are formed in the foliation systems along the zone of thrusts and the shear fractures, associated with axial and marginal zones of geosuture; at the junction of the north-western (sub concordant) and northeast (intersecting) structures it is possible delineation of ore columns of high contrast.

4. The main lithological differences of ore-bearing formations are inequigranular sandstones, siltstones and shales, metamorphosed at sericite-chlorite green schist's subfacies. They are the matrix for lenticular tectonic and sheet-like carbonate bodies, flints, quartzites, metabasite and metavolcanites. The most favorable environment for the accumulation of mineralization is shale and silty-shale deposits rich in carbon. The next are limestone-shale formations and tectonized and coalified contact zones of carbonate and clastic rocks.
5. On the basis of quantitative evaluation of factors by computer integration it is produced electronic maps of Nurata Mountains with sites prospective for gold, tungsten, lead, zinc, iron. Totally are distinguished 22 areas of different rank.

The estimation of metallogenic potential of the selected perspective objects of Nurata Mountains is provided and recommendations for future exploration are given.

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