

Evaluation of the Presence of Rare Metals in Katpar and Akshatau Deposits, Central Kazakhstan Using Geological and Geophysical Tools and Development of Geophysical Criteria for Forecasting Rare Metal Deposits

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ABSTRACT: The basis of forecasting rare metal deposits in Central Kazakhstan is the system of geological, geochemical and geophysical criteria and indicators used to define the most likely areas of localization of rare metal mineralization, its size and quality, by which to measure the uniqueness of rare metal deposits. To large and unique the deposits with very large reserves of rare metal materials suitable for the economic development on technological properties of ores and their conditions of occurrence.

KEYWORDS: large-scale prospecting rare metal deposits, geological and geophysical models, ore fields

I. INTRODUCTION

In Kazakhstan, at this stage, there are several dozens of large and unique endogenous deposits of rare metals. The important in a practical are skarn-type greisen deposits Katpar, with complex molybdenum - tungsten ores and related bismuth, copper, lead and zinc. Akshatau field presents classical standard quartz veins - greisen and rare metal formation group which consider an object of scientific knowledge. Completeness of petrophysical, geological and geophysical data on the deposit produces various models to develop the scientific basis of criteria forecasting. Therefore, we considered geophysical information to construct a geological-geophysical model of the field

II. MATERIALS AND METHODS

Central Kazakhstan deposits and occurrences of rare metals were first discovered by the visual method in the 20-30 years of the last century, during the route studies or the study of certain areas M.P.Rusakovym, R.A.Borukaevym, V.F.Bespalovym, AS .Osipovym et al. Systematic search for new deposits of rare metals have been launched in the postwar years and the most extensive development of searches obtained after the start of systematic geochemical and geophysical studies in Central Kazakhstan, performed by Agadyr geophysical expedition.

There are several stages of the research:

First phase, from 1917 to 1930, during this period carried out episodic route studies, mainly in order to clarify the geological structure, which allowed simultaneously identifying ore of tungsten, molybdenum and tin.

Second stage - 1931 -1936, geological establishments have set up special detachments and expeditions, which had to search for deposits of rare metals. These studies led to the discovery of a number of industrial fields in various parts of the region.

Third stage - from 1937 to 1970, during this period carried out a detailed case-study of the geology, petrography, and mineralogy fields, to identify common patterns of distribution of rare metal mineralization. This period is the most intense on the results and the rising volume of research.

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Fourth stage, from the end of 1970, started a new stage in the study of rare metal deposits in Central Kazakhstan. The development of science and technology are allowed to explore the subsurface analytical and quantitative methods, which resulted in the models of typical fields.

Methods of complex of search works can be briefly showed as following:

- 1 Regional studies of scale 1: 500 000 - 1: 200 000.
- 2 Areal and detailed survey and assessment of scale of 1:50 000.
- 3 Magnetic explorations.
- 4 Gravitational explorations.
- 5 Geoelectrical explorations.

Methods of interpretation of geophysical data are magnetic field and gravity field interpretation.

III. GEOLOGICAL-GEOPHYSICAL MODEL OF KATPAR ORE FIELD

Two gravity lows within 0.4 mGal correspond to the domed structures of granite massifs of the Lower Carboniferous (biotite granites) and Upper Permian (leucocratic granites), they are the low-density rocks of the ore zone ($2,55 - 2,57 \text{ g/cm}^3$). Gravity lows within 0.6 mGal corresponding to a yield of Permian granites on the surface. Alternation of gravity of positive anomalies associated alternation of rocks of different densities of Devonian age, as well as dome structures intrusive formations, leading to an increase in capacity of the overlying rocks.

As seen, all the rocks of the Devonian with a density of $2,65 - 2,70 \text{ g/cm}^3$ give a positive gravity anomaly within 0,2-0,4mGal.

In addition, it should be noted that the Carboniferous carbonate rocks in the contact zone with the Permian recrystallized granites, which are formed as a result of marbles with a density of 2.70 g/cm^3 . Therefore, in the northern part of the field Katpar gravitational field has a positive sign of the intensity of 0.4 mGal. The deposit area Katpar dedicated to the dome structure Permian granites; there is a negative gravitational minimum of 0.4 mGal.

In this section all the Devonian rocks have low magnetic susceptibility in the range $12-120 * 10^{-6}$ except hornfelsed rocks of the Middle Devonian ($940 * 10^{-6}$). On the northern border zone created magnetic field gradients, and the border itself is allocated positive magnetic anomaly intensity 100 nT, it is associated with Carboniferous granites. The southern boundary allocated magnetic field with intensity decays to 0 nT.

Negative magnetic anomalies intensity up 100 nT mapped areas deep drawdown. The deposit area Katpar enclosed in Middle Carboniferous is allocated positive magnetic anomalies intensity 50 nT, reason is the low magnetic susceptibility of Middle Carboniferous, the value of which less than $12 * 10^{-6}$. As seen from the geophysical section boundaries of Middle Carboniferous allocated clearly in the magnetic field.

Skarn carbonate rocks and intrusive rocks of Permian age are distinguished by positive magnetic anomalies intensity of 100 nT. Therefore in Akmaya-Katpar ore field, Katpar is allocated negative gravity and positive magnetic anomalies intensity, respectively 0,4mGal 50 nT and skarn Carboniferous rocks in the contact zone with the Permian granites are distinguished by positive gravity and magnetic anomalies intensity respectively 0.2 mGal and 100 nT.

A distinctive feature in this geophysical section is the attenuation of negative magnetic anomaly intensity from north to south. In addition, it is possible make the following conclusions:

Stable positive magnetic anomalies mapped granitoids (calm negative values of the magnetic field - sedimentary formations, regardless of age; sharp alternating magnetic fields - areas of volcanic and pyroclastic formations (liparites, Lipari-dacite, andesite-dacite), positive values of the magnetic field - zone skarn rocks.

Figure 1 shows Akmaya - Katpar ore zone dedicated to the southern board of Akmaya massif, in the geophysical section along profile AB gives the local gravitational and magnetic anomalies associated with the geological structure and petrophysical properties of rocks of the section [1,2,3,4, 5].

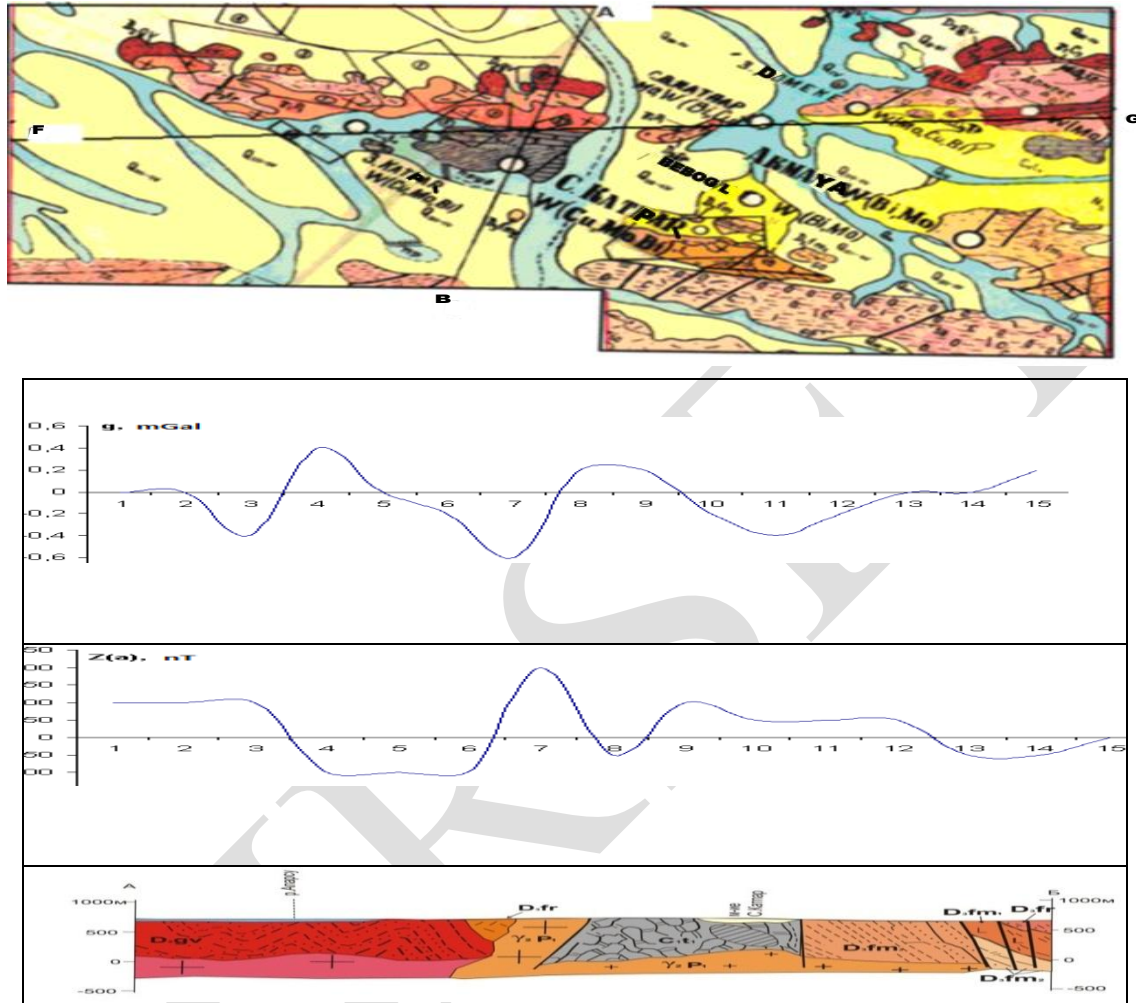
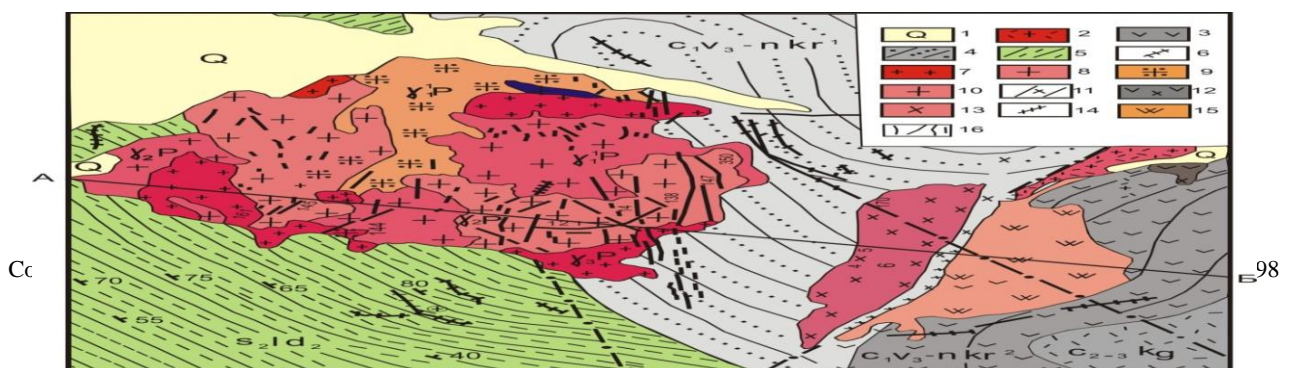


Figure1 Geological – Geophysical model of Katpar ore field

V.GEOLOGICAL-GEOPHYSICAL MODEL OF AKSHATAU ORE FIELD

Figure 2 shows the interpretative section (AB) akshatau granites complex bearing rare metal mineralization is characterized by a density of 2.60 g/cm^3 and are accompanied by negative gravitational anomalies to -7 mGal. It is associated with an excess density within 0.14 g/cm^3 between the granites and Silurian rocks hornfelsed (Figure 2).



Within the ore area, the intensity of the gravitational field up to -15 mGal [1, 3, 6, 7].

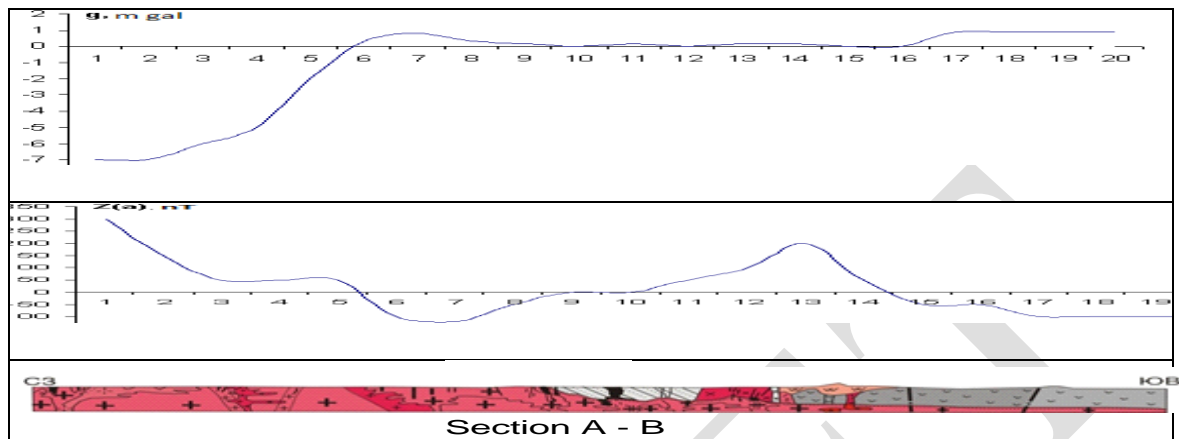


Figure2. Geological- Geophysical model of Akshatau field

According to the gravity survey in Akshatau ore district, zone greisenization showed relatively negative gravity anomalies intensity 0.3-0.8 mGal.

Greisen-vein bodies form a steeply dipping zone with a capacity of up to 30 m, and a depth of up to 300m spread. Their excess density in granite is 0.02 g/cm^3 , in sandstones 0.12 g/cm^3 . Anomalous effects from such bodies by interpretive section reach to 0.2 mGal. Therefore, these ore bodies in the granites and sandstones are marked by local positive gravity anomalies

Positive gravity anomaly in south-eastern part of the ore field associated with Carboniferous effusive rocks, namely rhyolite-dacite Upper Visean-Namurian. In the interpretative section of low-density rocks, sandstones and secondary quartzites give near normal anomaly.

Magnetic field is mapped under the Silurian formations in granite intrusion of the Permian age. This interpretative section shows that Akshatau intrusion in the north-western part has observed intensity of 300 nT. This magnetic anomaly is associated with the contact zone of hornfelsed granite rocks of Silurian, where a part of hornfelsed rocks encountered magnetite. Next in the field area Akshatau observed quiet low magnetic field up to 50 nT. Positive low-intensity magnetic field associated with the distribution of fine-grained and medium-grained granites of akshatau complex. Negative magnetic anomaly with intensity of 120 nT mapped topaz -quartz greisens and greisen body in granites with abundant inclusions of pyrite, the content of which is up to 15%.

Magnetic field of Carboniferous sedimentary rocks characterized by reduced anomalies. High negative magnetic anomaly in the south-eastern part of the ore field intensity up to 200 nT gives granodiorites complex. Tectonic faults in this area give negative magnetic anomaly intensity up to 50 nT.

This interpretative section of the magnetic field is a gradient; it is associated with the spread of greisen-ore bodies' hornfelsed rocks, tectonic disturbances.

IV.GEOPHYSICAL CRITERIA FOR FORECASTING

As is known, in small-scale forecasting mineral deposits, including rare metals, most large role are ore formation analysis. It allows you to identify the main factors on which fundamentally solve the problem of ore potential of a territory of Kazakhstan. In this case, the prognostic assessment of resources is the more reliable than the more favourable rare metal mineralization factors laid its foundation [7, 8, 9, and 10].

Except large-scale search for rare metal deposits criteria are needed for large-scale prediction and assessment detectable mineralization that have scientific justification. Such criteria are developed based on a systematic analysis of geophysical and geochemical fields already identified and studied ore occurrences and deposits. In this case, the objects of forecasting are not such large units as provinces, zones and nodes.

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Consequently, changing and complex search features of deposit ore fields, sometimes ore bodies of rare metal deposits, employees starting point of forecasting. The degree of reliability of forecasting is guaranteed only when it is possible to establish patterns of ore genetic system development.

It follows that for the most objective conclusion about the geological structure for considered deposits, required combined analysis of geological and geophysical information, as well as the introduction of such a representation of the analysis, in order to fully display aspects of the objects under study.

These requirements satisfy petrophysical model of modified zones and geological-geophysical model of deposits and ore fields. These models accumulate all the information stored in various stages of exploration and prospecting until stock assessment and development of the field. They therefore constitute the scientific basis of geophysical criteria for forecasting.

As known, under the forecast-search of geophysical criteria, characteristics refer to geophysical fields anomalous and their populations, with a certain probability indicating structurally real environment favorable for finding geological objects.

Forecasting objects in this case are geological units within which contains large intrusions with associated rare metals deposits in Central Kazakhstan. It should be noted that this will lead to the definition the specificity of forecasting, which determined by: their peculiar structural position; multistage formation reflected in their zoning; species composition and content of accessory minerals; Due to the presence of these specific size and shape of the magnetic, gravitational, and geochemical radioanomaly halos, and other features.

Large and unique deposits of rare metals in Central Kazakhstan represented by the following geological-genetic types: quartz -greisen (Akshatau); greisen -quartz veins- stockwork- (Karaoba, Upper Kairakty); skarn-greisen (Katpar). In addition, the above rare metal deposits in Central Kazakhstan have a high content of rare elements in the ore minerals. In general, they are rare elements, such as lithium, beryllium, tantalum, niobium, rhenium, germanium, scandium, gallium, selenium, tellurium, and rare earth elements (REE) - yttrium and fifteen chemically similar elements [lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), lutetium (Lu)]. This provision increases the practical value of these deposits.

It should be noted that the distinguishing feature for forecasting of such large and at the same time unique rare metals deposits of different geological-genetic types is that they tend to forecast-specific local search features. They are similar to the characteristic of small and medium reserves objects of the same type. This facilitates the task of establishing predictive-search criteria in the fields of rare metals.

In such cases, the criteria are developed for forecasting based on the analysis and synthesis of the search features in the fields of different scale. The only difference is - the nature of the manifestation of these symptoms. In large and unique deposits the intensity, area and their display becomes larger.

Based on the building petrophysical, geological and geophysical models of rare metal deposits in Central Kazakhstan revealed the following geological and geophysical criteria:

Based on density characteristic of rock on rare metals deposits in Central Kazakhstan are divided into three groups: denser rocks with a density of 2.70 g/cm^3 to 2.84 g/cm^3 are metamorphic rocks (hornfels, schists) and volcanic rocks of basic and intermediate composition (andesite porphyry); basic volcanic rocks and felsic Devonian sediments have an average density in the range of 2.65 g/cm^3 ; less dense rocks are intrusive rocks of all complexes. Except topar (akchatau, kaldyrm) with a minimum density to 2.54 g/cm^3 and hydrothermally altered rocks (silicified and sericitized - with a density of 2.40 g/cm^3), ore Stockworks have an average density in the range 2.72, skarn-greisen ore body - 3.00 g/cm^3 . Excess density which causes gravitational anomaly does not exceed 0.3 g/cm^3 ;

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In gravity fields domed structure intrusive masses with which is spatially and genetically related rare metal deposits, allocated negative gravitational minimum ranging from 0.2-0.3 to 4.5 - 7 m. Gal;

Based on the magnetic properties, rocks are divided into three groups: non-magnetic - this limestone; low-magnetic - all intrusions complexes; moderately magnetic - hornfelsdiabase and andesitic porphyry, the value of their magnetic susceptibility reaches from 500 to 2500 * 10⁻⁶;

Regional plan, a regular confinement of rare metal mineralization to the rear area of the Upper Paleozoic continental-margin volcanic-plutonic belt;

Local structural-tectonic forecasting features of rare metal deposits based on their confinement to local (tens, sometimes up to a few hundred square kilometers) ring structures. Rocks ring structures are the host rocks for deposits of rare metals. This field localized within the ring structures (Karaoba) and along the periphery;

Volcanic and sedimentary rocks, mainly Devonian age are the ore-hosting. The physical fields of volcanic-sedimentary formations have a calm nature;

Development of multiphase granitoid massifs, as rare metal mineralization in Central Kazakhstan spatially genetically related to multiphase leucocratic granite massifs akshatau complex Permian;

Ore-bearing granitoids, parent for such ore deposits formation, characterized by negative, skarns and Greisen weakness (an average of 2.8 m. Gal) positive gravity anomalies. Moreover over the granite gravitational field is smooth and over greisens and skarns - strongly differentiated;

Based on density characteristics, rare metal body (stockworks, skarns, greisen body) and volcanogenic-sedimentary rocks do not constitute anomalies, but relatively mineralized granites of this regularity is broken;

The similarity of mineralogical composition of ores and ore body morphology at all rare metals deposits expressed in the similar nature of the physical fields, namely the zone of negative minimum gravitational fields and areas of positive magnetic anomalies are a sign of rare metal ore content;

On the surface there are halos of ore elements (W, Mo, Bi), creating geochemical anomalies. In large rare metal deposits geochemical halos - areal, combined, almost beyond the ore bodies. Placer and halos characterized by considerable contents of ore and associated minerals. Each element of the small and medium scale deposits forming narrow low-intensity halos isolated or only partially aligned, and halos content placer of stable conditions supergene ore and accessory minerals miserable.

IIV SUMMARY AND CONCLUSION

In physical fields, ore enclosing volcanic-sedimentary formations of Central Kazakhstan has a calm nature;

Ore-bearing granitoids, parent for such ore deposits formation, characterized by negative, skarns and Greisen weakness (an average of 2.8 m. Gal) positive gravity anomalies. Moreover over the granite gravitational field is smooth and over greisens and skarns - strongly differentiated;

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Gravity negative anomalies of mapped granite massifs, bearing rare metal mineralization, Intensity of negative gravity anomalies depends on the size, depth and density of intrusions as well as the density and the vertical thickness of the enclosing rocks. In general, the intensity of negative gravity anomalies for the above mentioned fields are 5-7 m. Gal except Katpar field where the intensity of the gravity anomaly detected 0.2-0.3 m Gal.

In Katpar deposit area is allocated reduced positive magnetic anomalies with the intensity of 50 nT. Skarn deposits of carbonate rocks, developed near the contact with the intrusive bodies, noted the positive magnetic anomalies at 100 nT.

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