ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Scientific Basis of Prospecting Rare Metals and Construction of Petrophysical, Geological and Geophysical Model in Akshatau Field, Central Kazakhstan.

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ABSTRACT

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.
Keywords: Petrophysical characteristics, magnetic susceptibility, Gravitational Field, Geophysical section, greisen-vein body.

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INTRODUCTION

Petrophysical characteristics of the rock and ore deposits of this peculiar field, relate the spatial arrangement of the field, it covers the south-eastern part of the anticlinal folded sandstones and shales of the Upper Silurian, in the place where it passes into Tokrausky Syncline. Therefore, the eastern part of the deposit is composed of volcanics of the Lower Carboniferous. Silurian Species collected in steep folds NW-trending, and carbon deposits adjacent to the east.

Petrophysical model of the deposit

Density

Hornfelsed Silurian rocks consisting of sandstones, shales and siltstones, have densities in the range of 2.74 $g/см^3$ and they occupy the western half of the ore field while unaltered Silurian rocks have densities in the range of 2.65 $g/см^3$ [1-4,]. Devonian rocks consisting of diorite porphyry, have approximately the same density limit of 2.92 $g/см^3$, they are developed in the northern part of the ore field in the form of fractured intrusion.

Carboniferous deposits in this ore field compose the eastern part, and are mostly volcanic rocks. In addition there are a number of subvolcanic and extrusive formations related to Keregetasskoy formation. The density of Carboniferous species in the section of the field varies between 2.59 -2.77 $g/см^3$. Less dense are liparites and liparite-dacites, ie volcanic rocks of acid and mixing formulations 2.59 $g/см^3$. The highest density is in the range of 2.77 $g/см^3$ are andesite porphyry. In Carboniferous section, the observed decrease in the density of altered rocks shows secondary quartzites with a density of 2.57 $g/см^3$.

Permian multiphase leucocratic granites, with associated rare metal mineralization in this ore field, have a low density in the range 2.60 $g/см^3$. Note that intrusions and effusive rocks of acid composition in this ore field have approximately the same density in the range 2,59 –2,60 $g/см^3$. The Permian quartz - muscovite greisens have a high density within the range of 2,70 - 2,71 $g/см^3$.

As seen, in the field area, high density appears in Upper Silurian hornfels (2.74 $g/см^3$), Devonian diorite porphyry (2.92 $g/см^3$) and andesites of the Lower Carboniferous (2.77 $g/см^3$).

Increasing in the density depends on the increasing of heavy mafic minerals in the composition of the rocks, increasing the content of the ore minerals, sedimentary rocks and the degree of metamorphism [6, 7], (Fig.1,2).

Magnetic susceptibility

Magnetic susceptibility for virtually non-magnetic rocks, are Silurian sedimentary deposit (12 * 10^{-6}) and quartz-muscovite greisens (7 * 10^{-6}). Hornfelsed sandstones, shales and siltstones of the Upper Silurian rocks are magnetic, their magnetic susceptibility is defined within 550 * 10^{-6}.

Devonian diorite porphyry have a magnetic susceptibility within 850 * 10^{-6}. The reason is their mineralogical composition, where the content of magnetite, together with other ore minerals up to 5%.

The magnetic susceptibility of Carboniferous rocks varies widely from7 - 2440 *10^{-6}. This suggests that the magnetic susceptibility of rocks compared to spread of their strata generally increases significantly, andesite porphyry with magnetic susceptibility 1100 * 10^{-6} and adamellites - 2440 * 10^{-6}, which developed in the eastern part of the ore field with mineralogical composition represented by magnetite, pyrite and hematite.

Secondary quartzites and liparites and felsite porphyry in this section are non-magnetic rocks, their magnetic susceptibility varies from 7 - 20 * 10^{-6}.

Permian granites, especially equigranular are moderate magnetic rocks, as their magnetic susceptibility has a value in the range 162 * 10^{-6} (Figure 1).

Polarizability of the intrusive rocks and secondary quartzites in this ore field varies within 2.5-3.5%, ie merges with the usual normal background

Electrical resistance

This field have been studied by various methods and logging operations. Species of the deposit area is well differentiated by electrical resistance. The lowest electrical resistance have been observed in solid sulfide ores (1-50 Ohm. m), loose - clay (10-70 Ohm. m) and the greatest resistance have been observed in Silurian sandstones (50-150 ohm. m).

In akshatau complex, Granit and Adamellites are characterized by electrical resistivity in the range 540-1500 ohm.m, changed due to their difference, while in namely granites and granodiorites - pyrite observed reduced electrical resistance, in the range 50-200 Ohm.m. High electrical resistance are unaltered effusives, in the range 500-2500 Ohm.m.

As seen, the change in resistivity affects the hydrothermally altered rocks (silicification) results in an increase in resistivity, chloritization, sericitization, pyritization - to a decrease in resistivity. This opportunity allows selecting electrical zones of sulphide mineralization, tracing contacts of rocks, faults, and identifying areas of hydrothermally altered rocks by the electrical resistivity.

Gravitational field

In gravitational field, hornfelsed rocks and diorite porphyry of Silurian Devonian age displaying local positive gravity anomalies. Akshatau granitic complex, keregetassky Formation effusives rocks appear in the gravitational field of the negative anomalies. Species with average density - subvolcanic granodiorite-porphyry, dacite lava keregetassky Formation, granodiorites complex anomalies observed near normal.

Diorite complex, hornfels Upper Silurian, quartz - muscovite greisens Permian, kalkanemelsky Formation volcanics are characterized by local positive gravity anomalies.

Magnetometric field

In the magnetic field, sedimentary rocks and greisens characterized by reduced anomalies; akshatau granites, subvolcanic granodiorite porphyries are characterized by calm fields with minor positive gradients while hornfels, diorite and granodiorite intrusions appear in the intense magnetic field anomalies with high gradients.

Geological-geophysical model of Akshatau ore field

In the interpretative section (AB) akshatau granites complex bearing rare metal mineralization is characterized by a density of 2.60 $g/см^3$ and are accompanied by negative gravitational anomalies to -7 mGal. It is associated with an excess density within 0.14 $g/см^3$ between the granites and Silurian rocks hornfelsed (Figure 3). Within the ore area, the intensity of the gravitational field up to -15 mGal [1, 6, 8, 9].

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, in sandstones 0.12. Anomalous effects from such bodies

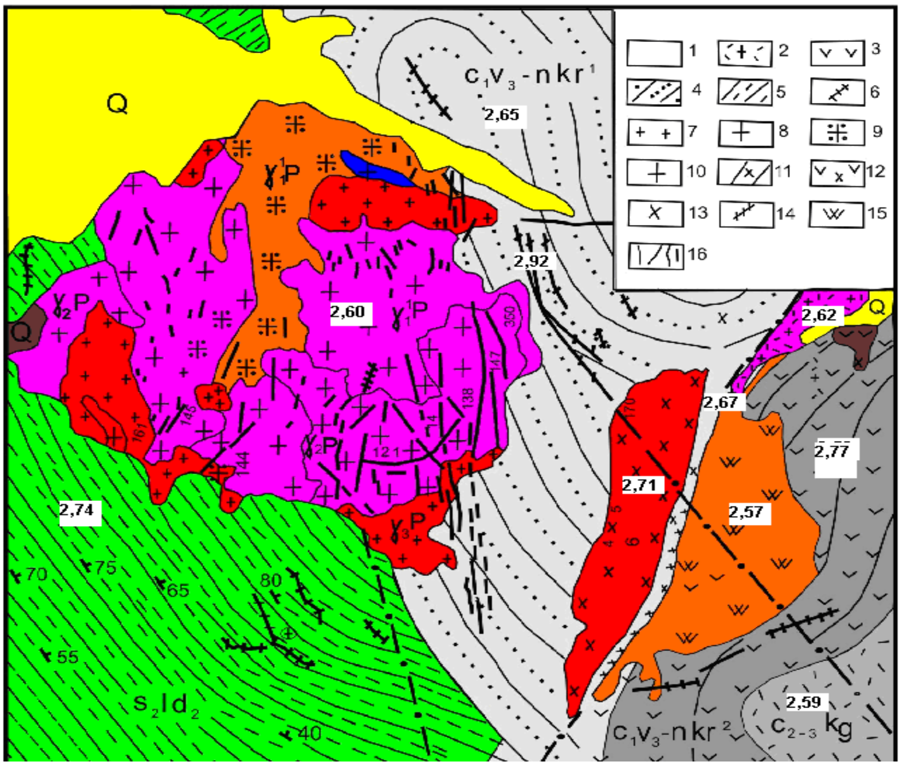
ISSN: 0975-8585

by interpretive section reach to 0.2 mGal. Therefore, these ore bodies in the granites and sandstones are marked by local positive gravity anomalies.

system	Division	Strata. Index	Strata. column	Characteri-stics	density, $g/см^3$	magnetic susceptibility $\chi * 10^{-6}$	Polarizabilityь η,%	App.resist.. ρ, Ом*м
Permian	Lower	P_1		Granite	2,60	162	2,8	1500
Carboniferous	Middle Upper	C_{2-3}		Liparites and felsite porphyry	2,62	7	0,58	
		$C_{2-3}kg$		Granodiorite porphyry	2,67	413		540
		$C_{2-3}kg$		Liparites and dacites	2,59	350-500	3,5	800
		C_2		Adamellites	2,71	2440	2,5	1500
		C_2		Secondary Quartz	2,57	20		
	Middle	C_{1-2}		Andesite	2,77	1100		2500
	Lower	$C_1v_3 - nkr^1$		Sandstones, Shales, Siltstones	2,65			
Devonian	Upper	D		Diorite porphyry	2,92	850		1500
Silurian	Middle	S_2ld_2		Hornfelsed Sandstones, Shales, Siltstones	2,74	550-847		50 -150

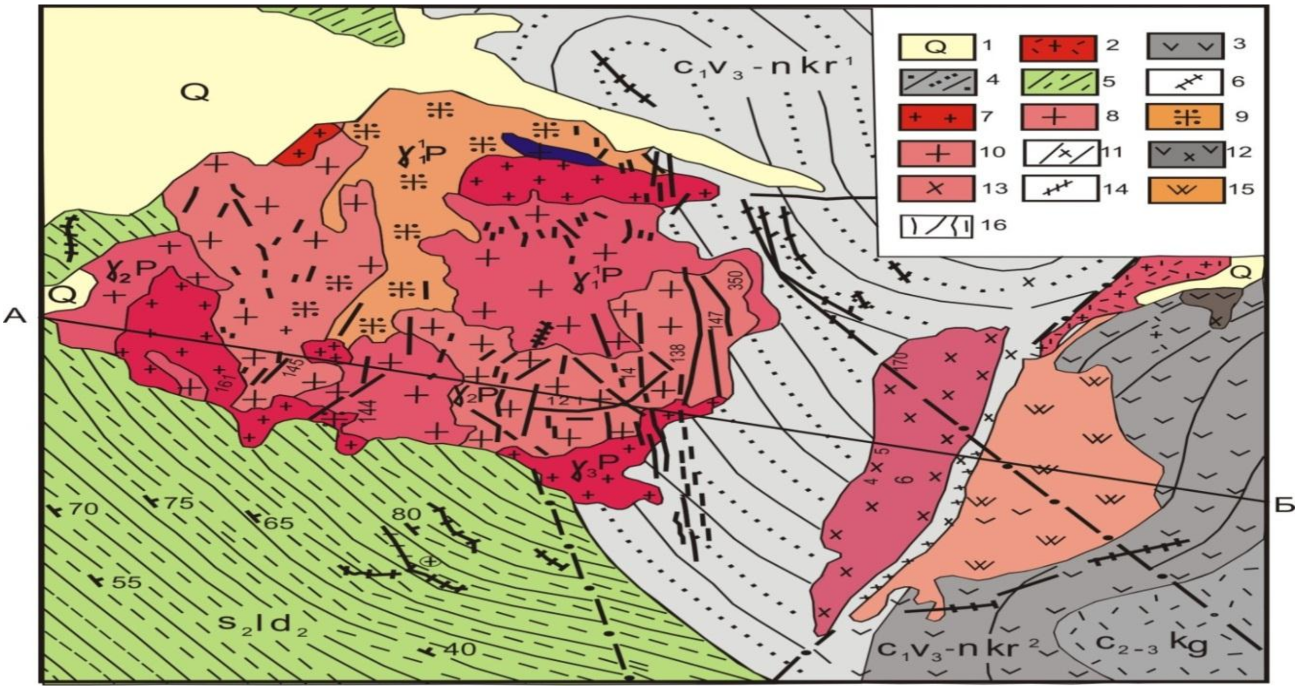
ISSN: 0975-8585

Figure 1: Petrophysical model of Akshatau field



1 - Quaternary deposits, 2- liparites and felsite porphyry (Middle-Upper Carboniferous), 3 - liparites-dacites
4 - sandstone, siltstone, shale, effusives , 5 - hornfelsed sandstones, siltstones, shales , 6 - diorite porphyry
7 - Permian granites, fine-grained, 8 - Permian granites, medium - grained, 9 - Permian granites, medium-coarse grained
10 - Permian granites, coarse grained, 11 - Carboniferous granodiorite porphyry, 12 – granosyenites
13 – adamellites, 14 - Aplite dikes of fine-grained granites, 15 - secondary quartzites, 16 - greisen ore, quartz greisen and quartz veins

Figure 2: Geological map of Akshatau field showing the Petrophysical characteristics of rocks.



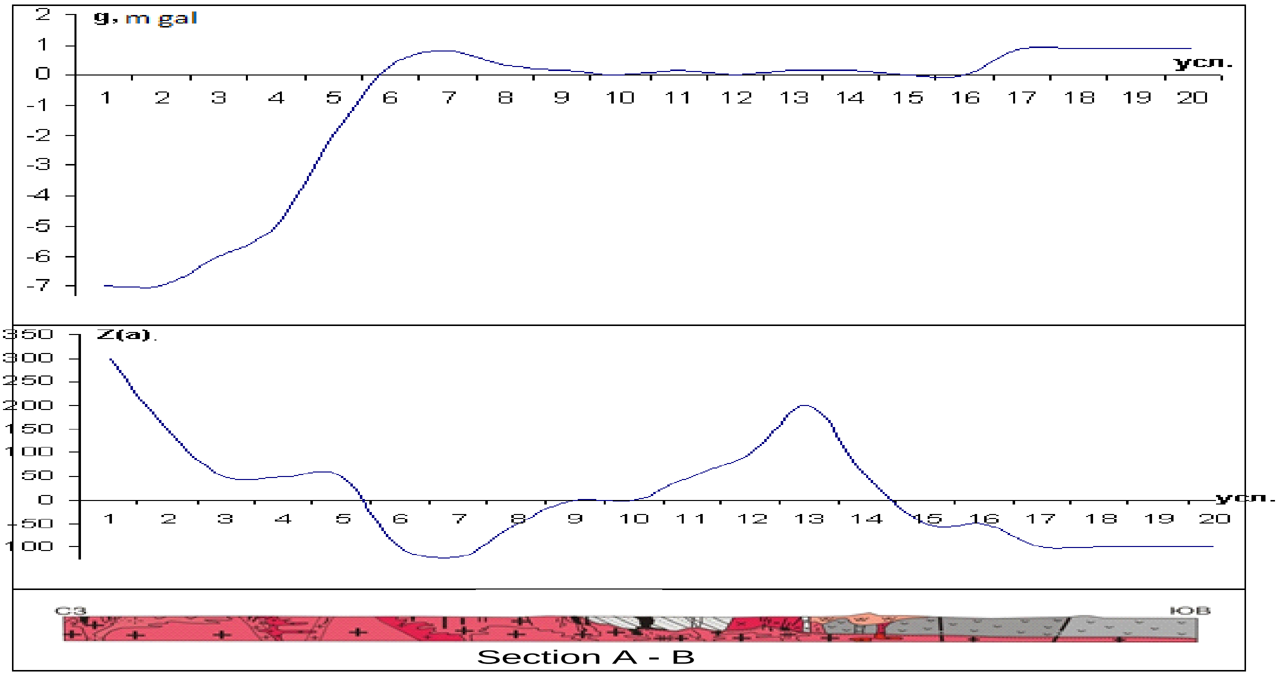


Figure 3: Geological- Geophysical model of Akshatau field

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. 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. 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 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 gives granodiorites complex. Tectonic faults in this area give negative magnetic anomaly intensity up to 50.

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

SUMMARY

Depending on density, rocks in this field divided into three groups

- Group 1, rocks with a low density, it is the intrusive (Permian granites), effusive rocks of acid composition (liparites) and altered rocks (secondary quartzites) with a density in the range 2,57 - 2,62 $g/см^3$.
- Group 2, rocks with an average density, it is the intrusive and sedimentary rocks of Carboniferous age (granodiorite porphyry, sandstone, shale, siltstone) with a density in the range 2.65 - 2.74 $g/см^3$.
- Group 3, rocks of higher density, it is Devonian diorite porphyry and Carboniferous andesites with a density in the range 2,77 - 2,92 $g/см^3$.
- Rocks in this field by magnetic properties are divided into three groups

- Group 1, the non-magnetic rocks represented in sandstone, limestone, siltstone of the Upper Silurian and Carboniferous secondary quartzites (1-50 * 10^{-6}).
- Group 2, weakly magnetic rocks represented in hornfelsed rocks of the Upper Silurian, Carboniferous liparites and dacites (50-550 * 10^{-6}).
- Group 3, strong magnetic rocks represented in diorite porphyry Devonian andesites and Carboniferous adamellites (550 - 2500 * 10^{-6}).
- Summarizing, we can conclude that the rocks of the region clearly differentiated by gravity and magnetic properties that shows successful application of magnetic prospecting for Geological Mapping

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