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ИЗВЕСТИЯ

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РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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STUDY OF THE GREATER KARATAU'S SOUTH-WEST BY RANGE OF GEOPHYSICAL SURVEYS IN SEARCH OF THE CRUST-KARST TYPE POLYMETALLIC MINERALISATION

Abstract. The Big Karatau is a recognised major mining region since the mid-XX century, with discoveries of not only lead and zinc deposits, but also those of gold, vanadium, granular phosphorites, barite and others. According to the Mineral Resources Development Programme, the Republic of Kazakhstan (RK) is one of the world's top ten countries in terms of ferrous and non-ferrous metal reserves. However, a significant part of the reserves seems to be uncompetitive for the fact that production volumes exceed the growth rate for almost all types of minerals. Considering that it takes at least 15 years from prospecting to development preparation, development of critical situation is expected in the RK copper, lead-zinc and gold-ore sectors in near future. On the other hand, the production decline has already led to socio-economic problems. Over the last ten years mining was halted at virtually all major deposits in South Kazakhstan: Mirgalimsai, Achisai, Bayzhansai. The Achpolymetal enterprise is the Kentau's city-forming enterprise, and the relevance of discovering new commercially significant ore objects in this area is indisputable.

The purpose of the work is to investigate the prospects of the southwest of the Greater Karatau ridge for polymetallic mineralization of crust-karst type within the limits of the Ayusai deposit.

The object of the study are lithological and stratigraphic irregularities of undivided deposits of the Jurassic and Triassic deposits of Ayusai. The article presents a short review of the results of prospecting and geological surveys and the analysis of the geological and mineralogical assumptions. The results of scientific research suggest the discovery of the crust-karst-type commercial objects with complex lead-zinc-iron-bauxite ores within the study area of highly aluminous deposits with increased lead and zinc content. The results of complex geophysical methods can provide a geophysical basis for further geological exploration of the area, 3D-modelling and calculation of reserves.

Key words: polymetallic mineralization of the crust-karst type, the Greater Karatau, magnetic survey, electrical survey, lead, zinc, undivided Jurassic-Triassic deposits, Paleozoic basement depressions.

Introduction. The Ayusai site is located in the Baidibek administrative district of the South Kazakhstan oblast. The first information on the geological structure of the Greater Karatau Ridge is contained in the works of I.L. Severtsev, D.M. Romanovsky and I.V. Mushketov. The works of R. Frese and A.P. Tatarnikov (1866-1877) resulted in a description of the geological structure of the Achisay and Turlan deposits [1,3].

In the early XX century, geological surveys were carried out in the Greater Karatau Mountains to search and explore polymetal deposits. Interest in the Karatau region increased sharply after the discovery of the Achisai deposit. In 1928 prospecting and exploration works were started in Biresek, Bayaldir and Djagalati areas. I.S. Komishin, I.I. Knyazev, N.A. Bryzgalov, E.A. Nemov, D.N. Rasha, A. Yakovlev and others took part in the works. As a result of these studies, the Mirgalimsai deposit and a large number of mineralisation points were discovered.

Systematic geological research in the Greater Karatau began in 1932, when N.V. Dorofeev, N.M. Salov, I.I. Mashkara, V.S. Malyavkin, T.A. Mordvilko and others carried out geological survey work, which resulted in a brief description of the geological structure of the Karatau Ridge and compilation of a geological map of scale 1:200 000.

In 1964, generalization of geological and geophysical materials based of results of large-scale (1:50 000) geological survey works (V.V. Galitsky, N.A. Nozdrev, A.S. Pirgo, I.I. Bok, E.A. Ankinovich, M.A. Senkevich

and others) allowed producing the State Geological Maps of 1:200 000 scale on sheets K-42-II (O.S. Grum-Grzhimaylo), K-42-III (L.V. Belyakov).

The 1970s are characterized by the introduction of geophysical methods in assessment of prospects of Paleozoic deposits in western regions of South Kazakhstan (O.A. Fedorenko et al.). During this period, the helicopter high-accuracy aeromagnetic survey (1:10,000) of the south-western foothills of the Greater Karatau was conducted by the South Kazakhstan Geological Expedition (Ignatyuk O.V., 1971; Krivorotenko A.N., 1973). Numerous positive anomalies of small size were identified, the drilling of which allowed detecting several ore occurrences and a small bauxite deposit Kutyrgan on the southwestern slopes of the Boroldai ridge.

The Ayusai ore field was discovered in 1987 in the process of gamma-gamma logging works ("GGK-50") by the "Yerubay PSP" of the "Karatau State District Exploration Expedition" under the supervision of E.T. Tursunkulov. Notably, at the time the Shaimerden deposit was not yet discovered, and increased contents of lead and zinc associated with bauxite and allite layer were of no interest.

The high prospects of the Ayusai site for the discovery of the Shaimerden type lead and zinc commercial mineralisation were identified in the course of additional site appraisal ("GDP-200" by the AGP "Geological Prospecting and Exploration Expedition"), after discovery within its boundaries of a bauxite object with estimated prognostic resources of commercial conditions. Each of the boreholes that penetrated the Triassic-Jurassic bauxite deposits had increased zinc and lead contents to the first percent values. Lignite layers up to 20 m thick were identified in the overlying Jurassic sediments. These factors justified further prospecting and appraisal work [4].

Most of the drilling and mining activity at that time was concentrated within the previously found depressions of the Paleozoic basement aiming to assess the revealed zinc-lead mineralisation. And eventually these areas were found to have lead and zinc of less than 80% of the total lead and zinc reserves of the Ayusai area. Practically all occurrences of lead and zinc are confined to aluminous rocks, therefore reserves of lead, zinc, aluminous rocks and iron extracted during processing of bauxite-allite deposits were calculated according to categories C2 and P1. Alumina and iron were calculated as by-products [4, 7].

Extensive geophysical surveys (magnetic surveying, VES, MGIP) and drilling works in search for new depressions in the Paleozoic basement arrived to no success. It was established that the level of lead-zinc mineralisation of Triassic-Jurassic bauxite-bearing sediments does not reach commercial contents, remaining within tenths of a percent, occasionally reaching 1.5-2.0% in some samples [10].

Thus, analysis of the earlier studies conducted within the Ayusai field and areas in vicinity indicated a rather low level of geological and geophysical knowledge. Geophysical works at the end of the XX century were carried out with equipment and machinery which cannot compete today. Modern equipment in terms of accuracy, precision, processing and interpretation technology can provide high quality geophysical research in the area.

The Ayusai ore field is located at the southern end of the Central Karatau synclinorium. The ore deposits lie in the core of the Ayusai syncline and are confined to the lower part of the Mesozoic-Cenozoic sediments, which unconformably lie on carbonate and terrigenous-carbonate rocks of Carboniferous age [12].

The geological section of the Central Karatau is represented by Devonian, Carboniferous and Mesozoic-Cenozoic sediments. The Paleozoic sediments belong to the Greater Karatau structural-formation zone. The Alpine structural layer is represented by sediments of the Syr-Darya structural-formation zone. Its northern boundary is controlled by rocks of the north-eastern end of the Leontiev graben [1, 3].

The lower part of the Paleozoic sediments is represented by red-coloured terrigenous rocks of continental mollasse of the Middle-Late Devonian period (Tulkubas suite). Further, there is continuous interbedded carbonate and terrigenous-carbonate lithofacies of marine genesis of the Late Devonian-Middle Carboniferous period (sediments of the Randysay-Aktas section type). According to V.M.Buvtyshkin's ideas, accumulation of the Late Devonian-Middle Carboniferous deposits took place inside the carbonate platform, which was formed at the place of development of red-coloured sandstones of Tulkubas suite under the influence of prolonged sea transgression on the passive continental margin (2008) [5, 9].

The lower part of the Randysai-Aktas sediments contains carbonate-terrigenous deposits of the Korpesh suite of the Frasnian age. In the Famennian sediments lie the lower unit of the Khantaga series, the Randysay series and the basal Turlan and Shilbyr suites. Rocks of the Late Famennian-Early Tournaisian age are represented by deposits of Aktasian complex and rocks of Aktasian reef complex. The Aksai, Orgailysai, and Ayusai suites and structures of the Ayusai Reef Complex date to the Early to Late Tournai. The Kazanbuzar suite (Early Visae) and the Zhartoba suite (Middle Visae-Bashkirian) occur upward in the section [4].

The Mesozoic-Cenozoic formations are represented by Triassic, Jurassic, Cretaceous, Paleogene and Neogene rocks. They comprise the upper part of the Syrdarya depression and the Leontiev graben.

In terms of morphology, the Paleozoic age foundation is a paleo-depression-type structure of 1.6x2.5 km, unclosed on the southern side of the deposit. The roof is dissected by numerous faults of small amplitudes. The faults extend to north-east and north-west. Drilling and electrical surveys indicated submeridional troughs of up to 1.6x350m within the depression. The depressions are separated by basement protrusions up to 90 m high, limited by sub-vertical faults. The relief of the Paleozoic basement is overlaid by the clastic cemented deposits of the Mesozoic-Cenozoic. Undivided Triassic-Early Jurassic and Jurassic sediments also fall out of the section. This indicates tectonic activity and permanent alteration of the basement relief during the Triassic and Jurassic periods. The basement roof sediments (up to 150 m thick) contain karsts shaped as cavities, caverns and cracks with serrated irregular walls. They are filled with iron oxides, fragments of host limestone and white calcite [2, 8].

Analysis of geological and tectonic features, sampling, coring and laboratory tests indicate that the undivided Triassic-Early Jurassic sediments at the Ayusai deposit are productive deposits with the identified lead-zinc-iron-bauxite ores [6].

Materials and methods. The presented materials allowed justifying a set of geophysical methods including magnetic and electrical exploration. Within the Ayusai deposit, the magnetic survey resulted in geological mapping, confirmation and detailing of the previously identified magnetic field anomalies and in discovering new ones. The survey was conducted on a 100m x 10m grid with 50m x 5m detailing. A ground station provided the recording of the magnetic field variations. Control measurements amounted to 7.3% with the RMS error of ±2.8 nTl. The achieved accuracy allowed compiling maps of the anomalous magnetic field with an isodynamic cross-section of 5 nT. The core capping was a merit of the work: it was carried out in the drilled boreholes with a field magnetic susceptimeter KP-01 for studies of the magnetic properties of rocks [1].

Results. Analysis of prior data showed that the study area is located predominantly in a negative magnetic field with a north-eastern direction of -4 to -5 nT per 1 km. The latest surveys in the field not only confirmed the previously identified anomalies, but also revealed a number of small size positive anomalies with intensities from +30 to +200 nT (Fig.1).

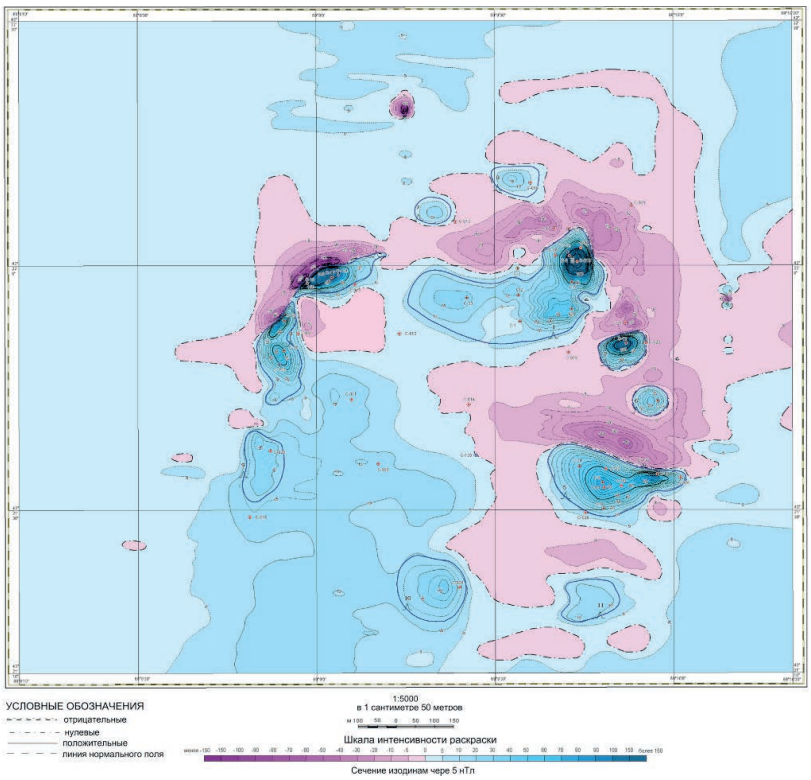

Fig. 1 - Map of the Ayusai deposit anomalous magnetic field ΔT [1]

Geologically, these anomalies allow mapping the ferruginous bauxite varieties of undissected Triassic-Early Jurassic deposits. The magnetic susceptibility of the light grey low-iron bauxites and allites was 90-400·10^{-6} CGS, in isolated cases reaching 1,100-2,200•10-6 CGS; in ferruginous varieties 4,000-7,000•10-6 CGS,

in single cases 70,000•10-6 CGS; in magnetite-bearing sandy-siltstone sediments of Jurassic carbonaceous sequence (rare cases) 2,000-3,590•10-6 CGS. In order to determine the lithology of magnetically active rocks, all magnetic anomalies were verified by drilling.

In order to identify and trace faults, to delineate ore bodies and to determine their occurrence parameters in the Ayusai deposit, electrical prospecting was carried out using the vertical electrical sounding (VES) and the induced polarizability in modification of the median gradient (MGIP) methods. The MGIP method was used to detail the detected anomalies within the observation system of AB=2,200 m, MN=100 m in a 200x100 m profile grid.

The VES survey was to clarify the topography of the Paleozoic crystalline basement and to detail the structure of possible ore objects. The VES work was planned as follows: AB up to 1,500 m, the 200 m step on profiles. Power was supplied with help of a 4.5 kW generator group, using a converter-rectifier (up to 1,000V) and a control device of supply and receiving lines. The MGIP supply line used 1.5m x 0.8m galvanised sheets buried 0.7m to 0.9m down and watered abundantly. The VES supply line used 1x0.2m galvanised sheets buried up to 0.5m down and flooded too.

Non-polarising ceramic electrodes with an intrinsic polarisation of no more than 2 mV were used in the receiving line of the electrical survey methods. Repeated measurements were conducted at the beginning, in the end and at every tenth measurement point along the profile. Mean relative errors under the VES and MGIP methods were 4.4% for polarizability and 2.3% for resistivity. [1]

The MGIP exploration method resulted in four zones of high apparent resistivity of up to 2,000 Ohm and five zones of increased polarizability of more than 3.5% (Table 1, Fig. 2).

Table 1. The MGIP exploration results

Zone no.	Location in the Ayusai site	Value ρk, Oh·m	Value ηk, %	Geological nature of resistance anomalies
1	**2**	**3**	**4**	**5**
I	The north-western part	10,000.	2	Reef outcrops of the Lower Carboniferous age
II	The north-eastern part	6,000.	4	To the north of the site, there are outcrops of reef formations of the Ayusai reef complex
III	The central part	3,500.	4,5	To the north of the site, there are outcrops of reef formations of the Ayusai reef complex, deposited at shallow depth (as per the drilling data) and overlain by loose sediments
IV	The south-eastern part	2,500.		

The high polarizability values in Zone II could be conditioned by highly waterlogged porous reef structures as the Ayusai Brook flows through this area.

The deposits of the Ayusai reef complex, to which anomaly III is confined (a bauxite-bearing sequence up to 60 m thick in places and located at this depth), are highly mineralised.

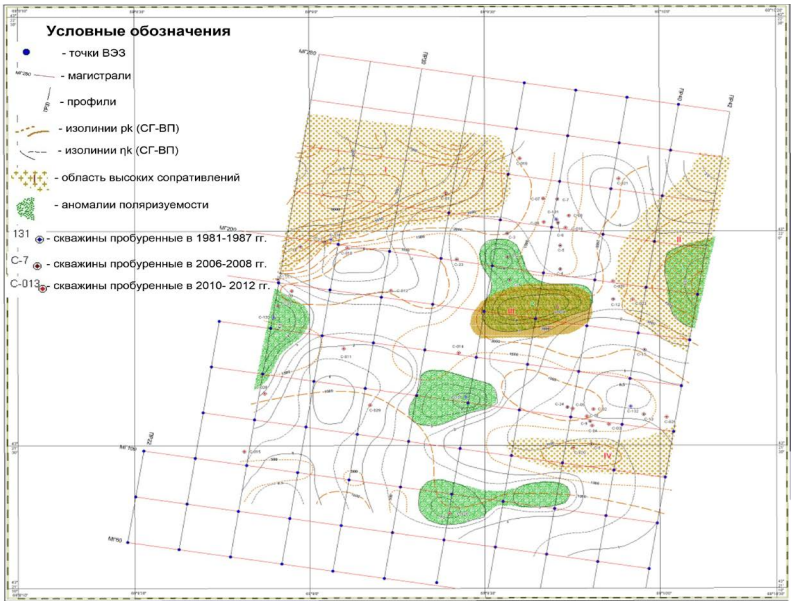

Fig.2 - The map of the Ayusai field VES exploration results [1]

Table 2. The VES exploration results

Anomaly's no.	Value ηk, %	Size, km	Geological nature of polarizability anomalies
1	**2**	**3**	**5**
1	5	Not delineated	waterlogged reef formations of the Lower Carboniferous Ayusaic complex (rfC_1as)
2	4.5	0,4*0,4	waterlogged reef formations of the Lower Carboniferous Ayusaic complex (rfC_1as)
3	4	Not delineated	waterlogged reef formations of the Lower Carboniferous Ayusaic complex (rfC_1as)
4	5	0,35*0,2	waterlogged reef formations of the Lower Carboniferous Ayusaic complex (rfC_1as)
5	4	0,6*0,2	waterlogged reef formations of the Lower Carboniferous Ayusaic complex (rfC_1as)

Discussion. The VES study of the upper part of the ore section allowed constructing the apparent resistivity (ρk) sections along profiles (Fig. 3). The use of VES data makes it possible to construct a map of iso-thicknesses of loose deposits and determine the depth and relief of the Paleozoic basement roof.

Thus, the study presented in the article shows that lead-zinc mineralization of the Shaimerden type is a new commercial type under conditions of the Greater Karatau. This type of mineralization is associated with destruction of Paleozoic sediments under active crusting processes occuing in the Mesozoic time. Stratimorphic polymetallic mineralisation dispersed in the basement sediments had eventually localised into ore formations within the terrigenous Mesozoic rocks.

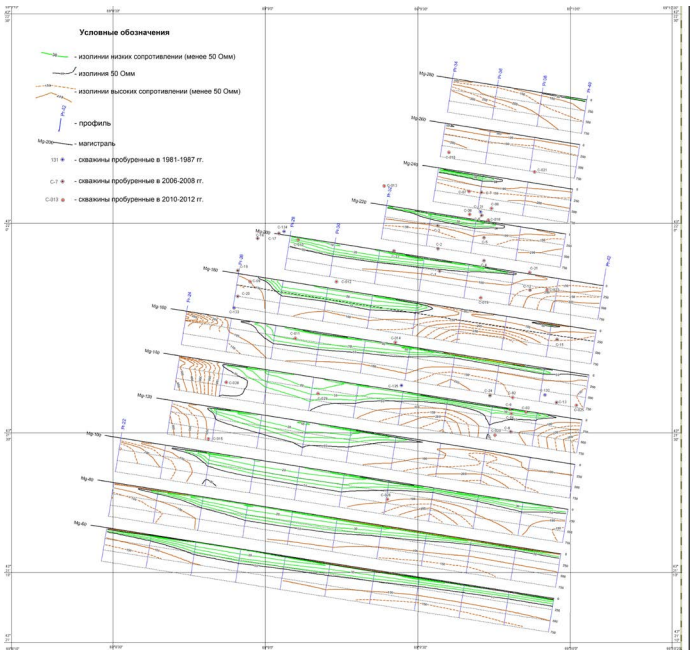

Fig.3 - The map of apparent resistivity sections as per VES exploration results [1]

Conclusion. The results of the prospecting works and of the geological and mineralogical assumptions on the area suggest discovery of crust-karst-type commercial objects here with complex lead-zinc-iron-bauxite ores. The implemented geophysical survey is the basis for further geological exploration of the area, including, development of criteria to calculate polymetallic ore reserves within the Ayusai deposit.

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ҚАБЫҚ-КАРСТ ТИПТІ ПОЛИМЕТАЛЛ КЕНДЕНУІН АНЫҚТАУ МАҚСАТЫНДА ҮЛКЕН ҚАРАТАУ ЖОТАСЫНЫҢ ОҢТҮСТІК-БАТЫС БЕТКЕЙІН ГЕОФИЗИКАЛЫҚ ӘДІСТЕР КЕШЕНІМЕН ЗЕРТТЕУ

Аннотация. Үлкен Қаратау XX ғасырдың ортасынан бастап танылған, ірі тау-кен өңірі болып табылады, онда қорғасын мен мырыш кенорындары ғана емес, сонымен қатар алтын, ванадий, түйіршікті фосфорит, барит және басқа да кенорындары ашылған. Қара және түсті металдар қорлары

бойынша минералдық-шикізат кешенін дамыту бағдарламасына сәйкес Қазақстан Республикасы (ҚР) әлемнің жетекші елдерінің ондығына кіреді. Алайда бұл қорлардың едәуір бөлігі бәсекеге қабілетсіз болып табылады. Себебі, пайдалы қазбалардың барлық түрлері бойынша өндіру көлемі олардың өсімінен асып түседі. Егер іздеу сатысынан бастап кенорнын игеруге дайындауға дейін кемінде 15 жыл талап етілетінін ескеретін болсақ, онда жақын арада ҚР мыс, қорғасын-мырыш және алтын кені салаларында дағдарыстық жағдайдың дамуын күтуге болады. Сонымен қатар, өндіру көлемінің төмендеуі қазірдің өзінде әлеуметтік-экономикалық проблемалардың дамуына алып келеді. Мысалы, соңғы он жылда Оңтүстік Қазақстанда барлық ірі, яғни Мырғалымсай, Ащысай, Байжансай кенорындарында өндіру тоқтатылды. Егер «Ачполиметалл» кәсіпорны Кентау қаласы үшін қала құраушы болып табылатынын ескеретін болсақ, онда осы ауданда жаңа өнеркәсіптік маңызы бар кен объектілерін табудың өзектілігі даусыз..

Жұмыстың мақсаты – Үлкен Қаратау жотасының оңтүстік-батысындағы Аюсай кенорны шегінде сиыр-карст типті полиметалл кенденуін анықтау перспективаларын зерттеу болып табылады.

Зерттеу нысаны – Аюсай кенорнының юра және триас шөгінділерінің литологиялық-стратиграфиялық әртектілігі.

Мақалада іздеу және геологиялық түсіру жұмыстарының нәтижелеріне қысқаша шолу, сондай-ақ геологиялық және минерагендік алғышарттарға талдау жасалды. Ғылыми зерттеулердің нәтижелері қорғасын мен мырыштың жоғары құрамы бар жоғары сазды шөгінділер таралған зерттеу аймағында күрделі қорғасын-мырыш-темір-боксит кендері бар қабатты-карст типіндегі өнеркәсіптік нысандарды табуды болжауға мүмкіндік береді. Кешенді геофизикалық әдістердің нәтижелері ауданды одан әрі геологиялық жете зерттеу, үш өлшемді модельдерді құру және қорларды есептеу үшін геофизикалық негіз бола алады.

Түйінді сөздер: қабатты-карст типтес полиметалл кендену, Үлкен Қаратау, магниттік барлау, электрлік барлау, қорғасын, мырыш, бөлінбеген Юра-триастық шөгінділер, палеозойлық іргетастың депрессиясы.

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ИЗУЧЕНИЕ ЮГО-ЗАПАДА БОЛЬШОГО КАРАТАУ КОМПЛЕКСОМ ГЕОФИЗИЧЕСКИХ ИССЛЕДОВАНИЙ С ЦЕЛЬЮ ОБНАРУЖЕНИЯ ПОЛИМЕТАЛЛИЧЕСКОГО ОРУДЕНЕНИЯ КОРОВО-КАРСТОВОГО ТИПА

Аннотация. Большой Каратау с середины XX века является признанным, крупным горнорудным регионом, в котором открыты не только месторождения свинца и цинка, но и месторождения золота, ванадия, зернистых фосфоритов, барита и других. В соответствии с Программой развития минерально-сырьевого комплекса по запасам черных и цветных металлов Республика Казахстан (РК) входит в десятку ведущих стран мира. Однако значительная часть этих запасов является неконкурентоспособной. Причина заключается в том, что практически по всем видам полезных ископаемых объемы добычи превышают их прирост. Если учесть, что, начиная от стадии поисков до подготовки месторождения к освоению требуется, как минимум, 15 лет, то уже в ближайшее время можно ждать развитие кризисной обстановки в медной, свинцово-цинковой и золоторудной отраслях РК. Вместе с тем, снижение объемов добычи уже сейчас ведет к развитию социально-экономических проблем. Например, за последние десять лет в Южном Казахстане прекращена добыча практически на всех крупных месторождениях: Миргалимсай, Ачисай, Байжансай. Если учитывать, что предприятие «Ачполиметалл» является градообразующим для города Кентау, то актуальность обнаружения новых промышленно значимых рудных объектов в этом районе является бесспорной.

Цель работы сводится к исследованию перспектив юго-запада хребта Большой Каратау на обнаружение полиметаллического оруденения корово-карстового типа в пределах месторождения Аюсай.

Объектом исследований являются литолого-стратиграфические неоднородности нерасчлененных отложений юры и триаса месторождения Аюсай.

В статье представлен короткий обзор результатов поисковых и геологосъемочных работ, а также проведен анализ геологических и минерагенических предпосылок. Результаты научных исследований дают возможность предполагать обнаружение промышленных объектов корово-карстового типа с комплексными свинцово-цинково-железо-бокситовыми рудами в пределах района исследований, где распространены высокоглиноземистые отложения с повышенными содержаниями свинца и цинка. Результаты комплексных геофизических методов могут стать геофизической основой для дальнейшего геологического доизучения площади, построения трехмерных моделей и подсчета запасов.

Ключевые слова: полиметаллическое оруденение корово-карстового типа, Большой Каратау, магниторазведка, электроразведка, свинец, цинк, нерасчлененные юрско-триасовые отложения, депрессии палеозойского фундамента.

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