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ГЕОЛОГИЯ ЖӘНЕ ТЕХНИКАЛЫҚ ҒЫЛЫМДАР СЕРИЯСЫ



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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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LEAD-ZINC KARSTS OF SHAIMERDEN TYPE

Abstract. On the example of exokarst deposits of lead and zinc of the world and Kazakhstan, the prospects of non-traditional for the Republic of industrial type deposits of lead-zinc ores are shown. In world practice karst lead-zinc deposits occupy one of the leading places in the reserves and exploration of rich ores. By the content of metals, they surpass all other industrial-genetic types. Exocarstic deposits of lead and zinc are one of the industrial sources of metal mining. Prospects for this type of mineralization in Kazakhstan where carbonate rocks and stratified lead-zinc mineralization are widely developed are not defined and require a comprehensive evaluation.

Key words: karst, lead-zinc mineralization, prospects, carbonate deposits.

In world practice karst lead-zinc deposits occupy one of the leading places on reserves and exploration of rich ores [2, 3]. According to the content of metals, they exceed all other industrial-genetic types (table 1).

For Kazakhstan, exokarst deposits are a new industrial type [1, 3]. The exploration of objects of this type were produced earlier, for example: in 1936 Badambai deposit (KaraTau) produced 200 tons of cerussite ore with lead content of 20-22%; another example is the rich lead ore deposits Sastube.

The world practice shows the exploration of the rich oxidized ores from exokarst in the United States (Franklin field), Australia (Beltana, Haruna), Algeria (Arsenic) and other countries.

In the past, hypergenic deposits of lead and zinc were major suppliers of metals. In ancient times, first of all, explored oxidized ores (Nerchinsko-Zavodskaya group (Russia), Tintic (USA), Santa Eulalia (Mexico), Kyzyl-espe, Toksabay, Achisay (Kazakhstan), etc.). But such deposits represented in most cases as small objects or oxidized sulfide ores.

The problem of exokarst mineralization was studied by A. P. Niyazov, S. M. Iskuzhina, T. M. Ottelbekov, Nigay, L. A. and others [13-15]. The investigations were directed to the identification of contact karst weathering crusts with copper and lead mineralization in the Turgai and Ulytauskoe regions. Karst cavities are made of sandy-argillaceous material, quartz-kaolinite composition with hydromica. The lead content in them reaches 3%, zinc 2%. Sources of metals - horizons of organogenic dolomites with stratified ore mineralization.

Since the 90s in connection, due to the discovery of the Shaimerden deposit, Venkov D.A., Ivlev A.I., Puchkov U.I., Ishchenko A.M., Deineka V.K., Buvtyshkin V.M., Zorin A.E., Zorin E.S. have been engaged in the problem of exokarst.

Exocarstic deposits of lead and zinc can become one of the industrial sources of metal mining. Prospects for this type of mineralization in Kazakhstan, where carbonate rocks and stratified lead-zinc mineralization are widely developed are not defined and require a comprehensive assessment. Confirmation to this is the discovery of the Shaimerden deposit in Torgay, where the hypergenically important zinc ore is associated with the underlying deposits of bauxite clays of the Mesozoic age. Similar objects should be met in Karatau, where small deposits such as Shashtyube and Visejskoye are known.

With the discovery of Beltana, Aruna (Australia) and Shaimerden in Kazakhstan, the hypergenic deposits of lead and zinc have attracted the attention of oremining geologists. The change in priorities in

Table 1 – The content and reserves of lead and zinc in deposits of different genetic types

Deposits	Host rocks	Average content, %	Reserves
Exokarst			
Shaimerden (Kazakhstan)	Limestone of Vize	Zn – 27 Pb – 0,5	878,4 thous.t. of zinc
Beltana (Australia)	Limestones of the Cambrian	Zn – 35,3-38,2 Pb – 2,3-2	863 thous.t. of Ore
Arana (Australia)	Limestones of the Cambrian	Zn – 34,4 Pb – 1,6	150 thous.t. of Ore
Franklin (USA)	Precambrian Limestones	Zn около 15	9 mln.t. of ore
Endokarst			
Achisay (Kazakhstan)	Dolomites, limestones of Famena and Tourne	Sulphide ores: Zn – 13 Pb – 15 Oxidized ores: Zn – 12 Pb – 8	–
Smena (Kazakhstan)	Dolomites, limestones of the Tourne	Zn – 5,6 Pb – 1,4	132 thous.t. of zinc
Tsumeb (Namibia)	Dolomites	Pb+Zn+Cu – until 60	1,8 mln. t. amount of metals
Tree - State (USA)	Limestones of the Lower Carbonian	Zn – 2,07 Pb – 0,42	Zinc – 4,5 mln.t Lead – mln.t
Pain-point (Canada)	Dolomites of the Upper Devonian	Zn – 6 Pb – 2,5	43, mln.t of ore
Other genetic types			
Shalkiya (Kazakhstan) hydrothermal-sedimentary	Dolomites, Famennian limestones	Zn – 3,32 Pb – 0,89	–
Mirgalimsky (Kazakhstan) hydrothermal-sedimentary	Famennian limestones	Pb – 1,8	–
Zyryanovskoye (Kazakhstan) pyrite	Volcanogenic-terrigenous rocks of the Middle Devonian	Zn – 1,41 Pb – 0,79	–
Mount Isa (Australia) metamorphogenic	Dolomites and calcareous shales	Zn – 6,3 Pb – 6,9	56,6 mln.t of ore
Sullivan (Canada) hydrothermal- metasomatic	argillites, Precambrian siltstones	Zn – 6,5 Pb – 8,3	3454 thous.t. of lead 2743 thous.t. of zinc

the direction of prospecting and exploration works is affected by the tendency of the exhaustion of reserves of hypogene ore, lying in the near-surface conditions and, as a consequence, the cost of production of the mine. Therefore, geologists and miners increasingly turn to hypergenic (exokarst) surface deposits as the most profitable in terms of economics. These deposits lie at shallow depths and are distinguished by high lead and zinc levels reaching 50-60% in total.

The Bullman deposit (Australia) is localized in limestones of the Lower Proterozoic [21]. Ores mostly oxidized (hydrozincite, smithsonite and willemite), in a small amount relic galena is present. Ore bodies are wedged out at a shallow depth (figure 1). Contacts of ores with host rocks are sharp. Stratified dispersed sulfide mineralization is present in the host rocks (limestones and siliceous schists). The content of zinc in ores averages about 20%, lead - 3%.

There are two points of view on the genesis of the deposit. The first - considers ore deposits as oxidized sulfide bodies, the second - assumes their formation due to redeposition of ore components of stratified mineralization into the exokarstic cavity during karst formation.

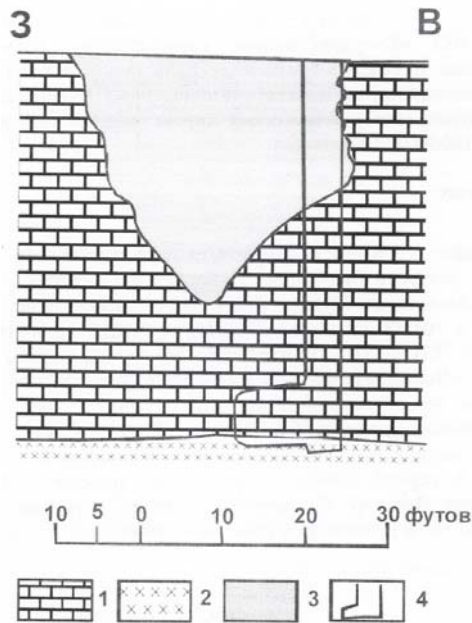


Figure 1 – Geological section of the Bullman deposit [24]:
1 – Siliceous shales and limestones; 2 – dolerites; 3 – ore body; 4 – mine workings

The Beltan-Aruna ore field (Australia) is confined to limestones of the Lower Cambrian [20]. Of the three ore bodies located along the overthrust, the main ore body on the surface of the view of the crest of a triangular shape, holds approximately 85% of the industrial zinc reserves in all ore field.

With depth, the shape of the ore body becomes more and more lenticular and wedges out at a depth of 90 m. The ore body of the northern flank has a saucer-like shape and extends to a depth of 18 m. The blind ore body of the southern flank almost flat falls to the east at an angle of 700 to a depth of about 100 m.

The ores of the whole field are mineralogically the same. More than half of them consist of willemite with hematite, calcite, dolomite, coronadite, heterolite, gedifan, smithsonite.

According to Australian geologists, the source of metals is a layer of black shale, lying at a depth of 350 m, containing a rare impregnation of pyrite, galena and sphalerite.

The Bawdwin deposit (Birma) is an irregularly shaped vein in the suite of sandy shales, marls and limestones [11]. The vein was made unevenly with the mineralized clay material. The largest reservoir has a width of 20-25 m, to a depth of up to 210 m. The main ore mineral is galena. The content of lead in ores is on average 7%, silver is 0.3-2.1 kg/t.

The deposit of **Ouarsenis** (Algeria) is confined to Layas limestone. The mineralization is localized in the clay mass, which forms a columnar-shaped body. Ore minerals - smithsonite and calamine, rarely galena. The content in zinc ores is 18.33%, silver - 300 g/t.

The Franklin-Sterling area (USA) includes a number of deposits of spent zinc ores consisting of willemite, zincite and franklinite localized in marbled Precambrian limestones [4, 17]. The content of zinc is 29.3%.

Shaimerden (Kazakhstan) deposit is located on the area of the Krasnooktyabrsky bauxite deposit, covered by a loose cover of Mesozoic Cenozoic formations with thickness of 63 m [5.8]. The deposit is confined to karststone limestone formations of the Sokolov suite (figure 2.3). Ores form almost a single reservoir with branches and apophyses. The main ore body performs a deep narrow karst basin in limestone with a length of 270 m, a width of 80-100 m. In the latitudinal section the ore body has a cup-shaped form with a maximum thickness (up to 120 m) in the center.

Mineralization is represented by essentially zinc carbonate - siliceous ores. In the total mass there are: clay-crushed, siliceous, carbonate, sulfide ores and ore-bearing limestones. The mineral composition of all types of ores is close to each other and differs only in the quantitative ratio of ore minerals [5]. The main minerals of zinc are calamine and smithsonite. There are sphalerite, sokonite, less often zincite, heterolite and willemite in small quantities. Lead in ores is almost everywhere, but in small quantities it's in the

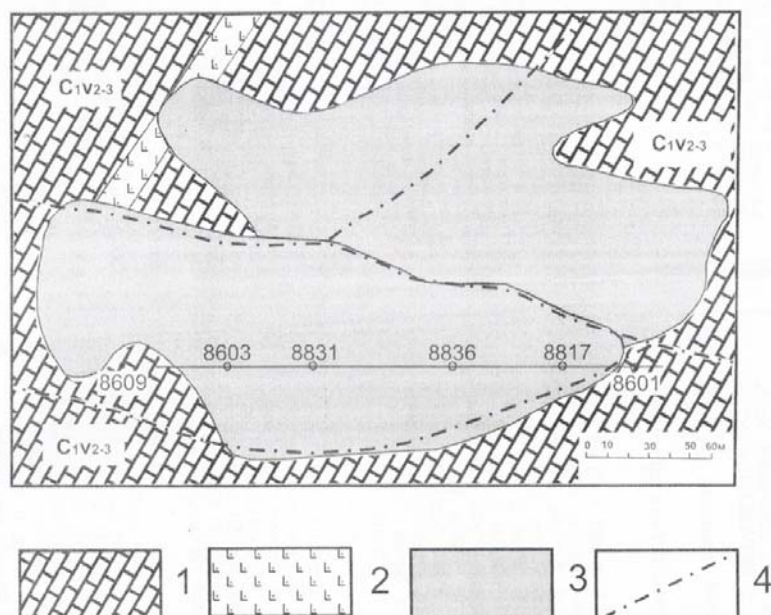


Figure 2 – Schematic geological map of the Shaimerden field (based on the materials of "Shaimerden"com., A. I. Ivlev):
 1 – limestones of the Sokolov suite ($C_{1V2-3SK}$); 2 – interlayers of volcanogenic rocks (andesites, andesite basalts, their tuffs);
 3 – smithsonite-calamine ores; 4 – discontinuous violations

form of cerussite and galena, rarely plumbogawsonite, mimetite, anglesite, wulfenite and vanadite. Almost everywhere in the ores there are oxides and hydroxides of iron and manganese (0.5% -5%). In small quantities, there are arsenopyrite, pyrite, chalcopyrite, native silver, molybdenite. The bulk of nonmetallic minerals is represented by the minerals of the montmorillonite group. The deposit divides into 2 groups - rich (zinc is more than 5%) and poor ore. The first are characterized by a stable high content of zinc, sometimes exceeding 40%. The average content of zinc in rich ores is 27%. Petrified limestones contain, on average, 3.5% zinc. Poor ores with a zinc content of 2-5% are usually found in the roof of the rich.

The karstic cavity tends to the body of aluminosilicate rocks (figure 2). This spatial arrangement is favorable for the formation of exokarst (contact karsted rocks with non-karsted). In this case, the aluminosilicate rocks are suppliers of aggressive components to the aqueous solution (including silicic acid) [7, 9, 10], which ultimately led to the formation of calamine (zinc silicate).

According to A. I. Ivlev et al. the Shaimerden deposit has a secondary accumulation of zinc brought by groundwater from the oxidized portion of the sulphide lead-zinc deposit located somewhere a short distance from Shaimerden. The source of silicic acid in solutions was also the aluminosilicate rocks developed on the deposit. Deineka V. K. [9] believes that the formation of Shaimerden type karst deposits is associated with the demolition of underground mineral ore from the slopes of karst depressions. Shaimerden field, according to Ischenko A. M. [11], is confined to the volcanic vent and the origin of zinc ores is associated with a vent device.

Shaimerden deposit belongs to exokarstic objects. The ore-bearing basin is a karst crater formed in the Mesozoic during the formation of the weathering crust in the Paleozoic rocks. In the open cavity, a detrital clay-ore material of collapsing mineralized rocks collapsed into a karst crater, which subsequently became the enclosing medium for zinc ore. Their contribution to the formation of ore mineralization was made by groundwater, which in the way of its movement leached zinc from carbonate rocks and transferred it to a karstic funnel. As is known, zinc in hypogene conditions is one of the most mobile elements and is carried out primarily from lead-zinc ores. An example of such a separation is the Achishai deposit, where oxidized zinc ores contain independent deposits located hypsometrically below oxidized lead. Sphalerite is one of the most easily oxidized sulphides. It is especially rapidly oxidized and dissolves when in contact with other sulfides [18]. The processing of ore material by the carriers of CO_2 and SiO_2 leads to the development of calamine ores. Calamine is formed from zinc carbonates and is deposited from solutions, so it is not often possible to observe the replacement of smithsonite with calamine.

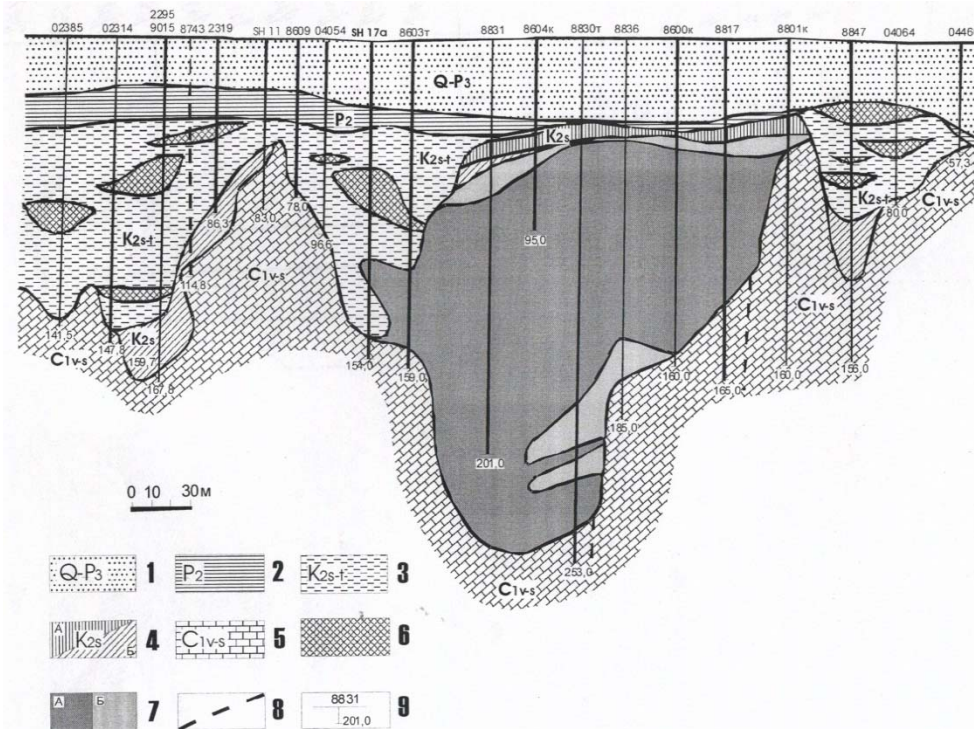


Figure 3 – Geological section of the exploration line 21450 (based on JV "Shaimerden", with changes):

- 1 – Oligocene - Quaternary deposits. Loams, sandy loams, clays, sands are heterogeneous;
- 2 – Eocene deposits. Laminated clays with powder and lenses of glauconite-quartz sands;
- 3 – Senoman-Turonian deposits. Colored and lignite clays, bauxites are stony and friable;
- 4 – Cenomanian formation. A – deluvial-proluvial variegated clays with detrital texture, B – kaolinite-montmorillonite clays;
- 5 – Viseisk-Serpukhov formation. Sokolov suite. Limestones are gray, pink-gray, organogenic-detrital, massive, clayey, karstic;
- 6 – bauxite deposits;
- 7 – Ore bodies of smithsonite -calamine ores: A – rich ores (ore body 1), B – poor ores (ore body 3);
- 8 – faults;
- 9 – exploratory wells, their number and depth

The karstic cavity tends to the body of aluminosilicate rocks (figure 2). This spatial arrangement is favorable for the formation of exokarst (contact karst *vuyuschih* rocks with non-karsted). In this case, the aluminosilicate rocks are suppliers of aggressive components to the aqueous solution (including silicic acid) [8, 12, 13], which ultimately led to the formation of calamine (zinc silicate).

Bauxite deposits located above the zinc ores are also spoken about exokarst genesis (figure 2). The signs of zinc-karst mineralization in the area of the Krasnooktyabrsky bauxite deposit were met before, but they were not given serious significance. By now it is known that such zinc mineralization is widely developed in the underlying bauxite rocks and traced for many kilometers, which places the Valerianovskaya zone of the Torgai trough in promising for finding rich exokarst zinc ores [5].

The formation of essentially zinc ores in karst performance was described by V. B. Fomin and G. N. Korobeinikov [19] on the Gelska area (the western end of the Gissar range), where sulfide mineralization is manifested at two levels: in karsted limestone of the Devonian and grained gravels of Cretaceous age. The mineral composition of the levels is the same: sphalerite, pyrite, quartz, calcite. In the deposits of karst, there is an industrial concentration of zinc. Oxidized zinc ores are developed on the border of siliceous gravelstones with underlying limestones, forming in the latter irregular, vein-veined forms, bodies composed of smithsonite. The model of the formation of such field, according to the authors, is the followings. Dissolution of limestone by infiltration waters with the formation of open cavities and voids. Weathering of siliceous gravels containing dispersed zinc mineralization and transportation of weathering products into karstic cavities. Sealing of karstic execution with partial recrystallization of zinc.

A similar method of formation is most probable for Shaimerden, only the limestone of the Sokolov suite, bearing stratified lead-zinc mineralization, served as the source of the ore material, which is confirmed by the presence of a distinct type of ore-bearing limestone [5]. Unfortunately, this type of mineralization has not yet been studied.

Extensively developed exokarst lead-zinc ores in the Karatau hills (ore occurrences Visejskoe, Shashtyube, Ashishai-Pridorozhny and others). Viseisky [6] developed with some karst cavities, made with iron-clay material with rich oxidized lead and zinc ores.

On the ore manifestation Ashishay-Pridorozhny oxidized ferruginous lead-zinc ores perform a karst funnel (figure 4). The lead content is up to 10%, zinc is 19.69%, copper is 0.06%, silver is 8.35 g/t.

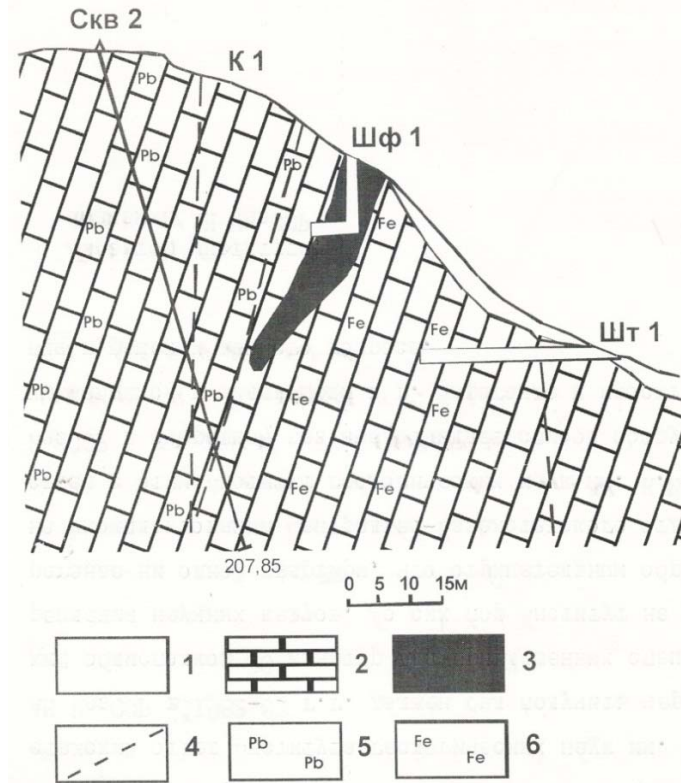


Figure 4 – Geological section of Ashishay-Pridorozhny area (according to V. V. Anokhin):
 1 – Quaternary loams and clays with fragments of limestones; 2 – limestones of the Lower Carboniferous;
 3 – red clay with lead mineralization; 4 – faults; 5 – impregnation of galena; 6 – ferrugination

Stratified poor lead-zinc ores are present in all the objects in the enclosing carbonate rocks. The conducted prospecting works were aimed at identifying industrial deposits of sulphide ores, ore-bearing karst deposits served as a search criterion. They were not paid attention in terms of their industrial value. The performed search works did not yield positive results. In the carbonate rocks, lead contents were found at about 1%, in single cases up to 2.5%. Timoshenko V.A. (1966), carrying out prospecting works in the Baizhansay region on the basis of studying lead-zinc manifestations for the first time expressed the idea of an independent industrial use of lead-rich and zinc-rich karst clays.

Exokarst lead-zinc mineralization in Kazakhstan was not considered and practically was not studied in the direction of industrial potential. The widespread development of carbonate rocks with stratified sulfide mineralization opens up prospects for prospecting industrial deposits of lead and zinc ores. Particular attention should be paid to the regions where karst bauxites occurring on carbonate rocks with poor dispersed lead-zinc mineralization (Turgai, Karatau, Sarysu-Teniz). Research aimed at identifying hypergenic deposits should be carried out in areas where there are objects localized in karst deposits (Karatau) and not properly evaluated.

Conclusion. Due to the discovery of the deposit of oxidized zinc ores of Shaimerden in northern Kazakhstan, where mineralization is localized in a karstic funnel and the presence of similar deposits in the world and in other regions of Kazakhstan, raises the question of the need for a detailed study of the regularity of localization of such deposits and their search and forecast criteria for expanding the mineral-raw material base of the Republic of Kazakhstan. At present, two regions have the greatest prospects for the discovery of karst deposits of lead and zinc: Bolshaya Karatau and Torgay, where there are known exokarst objects.

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СВИНЦОВО-ЦИНКОВЫЕ КАРСТЫ ШАЙМЕРДЕНОВСКОГО ТИПА

Аннотация. Әлемнің және Қазақстанның қорғасын мен мырыш экзокарст кен орындарының мысалында қорғасын-мырыш рудалары үшін дәстүрлі емес өнеркәсіптік тип перспективалары көрсетілген. Әлемдік тәжірибеде қорғасын-мырыш карст кенорындары бай кендердің қоры мен өндірісінде жетекші орындардың бірін алады. Металл мөлшері бойынша олар басқа өнеркәсіптік-генетикалық типтерді басып озады. Қорғасын мен мырыш экзокарст кенорындары металл өндірісінің өнеркәсіптік көзінің бірі болып табылады. Карбонат таужыныстары мен стратификацияланған қорғасын-мырыш кенорындары кең таралған экзокарст типті кенорындарының болашағы анықталмаған және жан-жақты бағалауды қажет етеді.

Түйін сөздер: карст, қорғасын-мырыш минералдануы, перспективалар, карбонат тізілімдері.

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СВИНЦОВО-ЦИНКОВЫЕ КАРСТЫ ШАЙМЕРДЕНОВСКОГО ТИПА

Аннотация. На примере экзокарстовых месторождений свинца и цинка мира и Казахстана показаны перспективы нетрадиционного для Республики промышленного типа месторождений свинцово-цинковых руд. В мировой практике карстовые свинцово-цинковые месторождения занимают одно из ведущих мест по запасам и добыче богатых руд. По содержанию металлов они превосходят все другие промышленно-генетические типы. Экзокарстовые месторождения свинца и цинка являются одним из промышленных источников добычи металлов. Перспективы этого типа оруденения в Казахстане, где карбонатные породы и стратифицированное свинцово-цинковое оруденение имеют широкое развитие, не определены и требуют всесторонней оценки.

Ключевые слова: карст, свинцово-цинковое оруденение, перспективность, карбонатные отложения.

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