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Earth sciences

On the matter of composition and technological properties of uranium ores of the Semizbai deposit (North Kazakhstan)

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ABSTRACT

Currently, uranium production occupies a decisive place in the world energy industry. In Kazakhstan, to meet the demand for uranium, hydrogenous deposits with technologically and economically favorable natural indicators are being developed, including the large Semizbai deposit. The deposit by genesis belongs to the hydrothermal-hydrogenous polygenic type in terrigenous sandy-clayey deposits. As a result of geological studies, the stratification of the ore-bearing deposits of the Semizbai suite was established: the lower and upper ore-bearing sub suites, the geometrization of the deposit was performed, and the morphology, number, and size of ore bodies were identified. Most of the balance reserves of the Semizbai deposit are concentrated in large and medium ore bodies. Analytical work and description of thin sections and polished sections under a microscope determined the material composition, textures, and structures of uranium ores, the main ore minerals, and their distribution in ores. When carrying out field and laboratory work, geological indicators of the deposit were obtained to select the technology for extracting ores. To select and justify the field development technology, special technological studies were carried out in the experimental area. Based on the geological indicators of uranium ores for the Semizbay deposit, well-in-situ leaching was chosen as the most rational for hydrogenous deposits. The characteristic of associated useful components of uranium ores is given, and the increased content of selenium, germanium, and scandium in them is established. The obtained research results can serve as a basis for improving the technology used for mining uranium ores and extracting associated components from them.

Keywords: hydrogenous uranium deposit, uranium-bearing terrigenous rocks, uranium minerals, types of ores, associated useful components, borehole underground leaching.

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Introduction

Kazakhstan in the world takes first place in uranium mining and the leading place in its natural resources, which is noted in official publications [[1], [2], [3]]. Among the developed deposits is Semizbai. Industrial mineralization and dispersion halos of uranium mineralization of the Semizbai deposit are established within the paleo valley of the same name at a distance of up to 36 km. With a paleo valley width of 2-7 km, taking into account the territory of its nearest framing, the deposit area is 370 km^2. According to the depression morphology, and differences in the degree of exploration and ore content, the deposit district is divided into six sections: North-Western, Western, Central, Eastern, Jamantuz, and Northern (Figure 1).

The accumulated factual material allows us to establish the main features and features of the location, morphology, and internal structure of all types of ore formations of the Semizbai deposit, located within the Semizbai depression [[4], [5], [6], [7]]. The geological and mineralogical features of deposits and their economic minerals are the main ones in choosing a rational mining technology and extracting associated valuable components from them. Such indicators are the basis for choosing a technology for the development of both technogenic [[8], [9]] and natural ores [[10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21]].

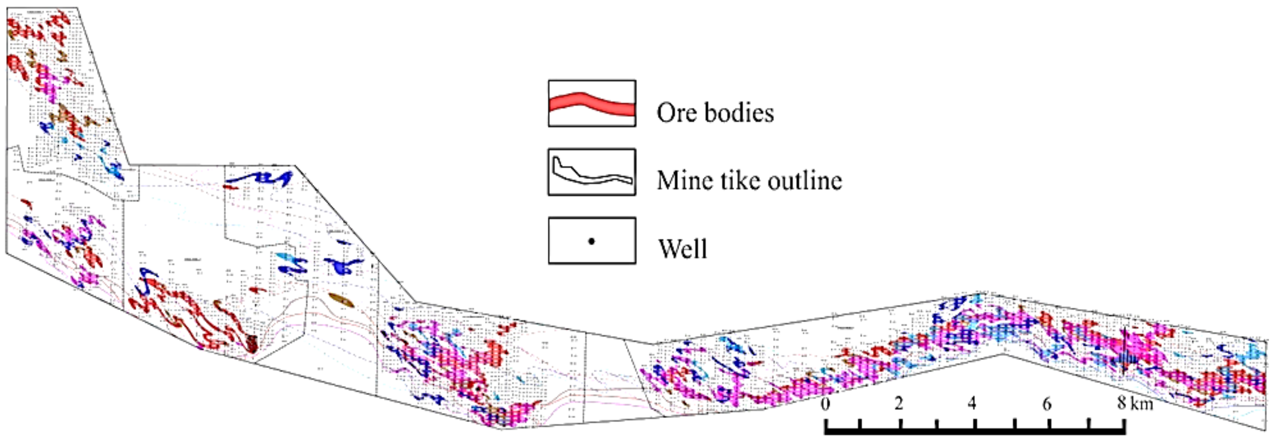


Figure 1 - Overview map of the ore content of the Semizbay deposit

Industrial uranium mineralization of the Semizbai deposit is represented by stratiform ore bodies, which are established in the lower part of the section of the Semizbai suite – from its basal layers to the silt-sand horizon inclusive. Within the identified productive stratum, ore formations are concentrated in permeable sediments at two levels – in the Lower Semizbai ore-bearing horizon, which combines conglomerate-gravelite and sandstone packs, and the Upper Semizbai ore-bearing horizon (USH), coinciding with the silt-sandstone stratigraphic horizon (Figure 2). The impermeable deposits of the clayey horizon separating them and the overlying formations of the regional aquiclude do not contain mineralization.

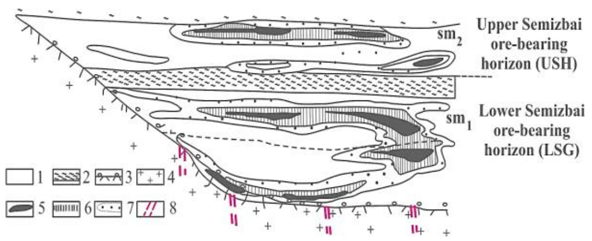


Figure 2 - Ore formations of different levels of the Southern ore-bearing zone: 1 - permeable horizons, 2 - water-resistant horizons, 3 - basal layers and permeable weathering crust; 4 - rocks of the Paleozoic basement; 5 - balance ore deposits; 6 - off-balance mineralization (not outlined in sections); 7 - anomalous zones with gamma activity of more than 30 µR/h

The balance ore deposits of the deposit are surrounded by poor ores, which in turn are replaced by extensive uranium dispersion halos, forming gamma-anomalous zones. The outer contour of the ore deposits is an isoline of 30 µR/h, which corresponds approximately to a uranium content of 0.001-0.002 %. The areas of the deposit with lower gamma activity are classified as completely barren formations, which have a normal background of 8-10 µR/h. The productive stratum includes all industrial mineralization of the deposit, occurs at depths of 26-180 m from the surface and has a variable thickness, which naturally increases from west to east along the long axis of the depression from 30 to 100 m.

Experimental part

The experiments were carried out according to the methodology, including fieldwork, testing, and preparation of selected samples, as microscopic and analytical studies. Mineralogical documentation of the core of more than 70 exploration wells was carried out, 2000 thin sections and polished sections were studied using radiography, chemical, spectral and schlich analyzes of ore samples were performed. For the diagnosis of individual minerals, X-ray diffraction, thermal and other types of analyzes were used. Sample preparation, preparation of thin sections and polished sections, and their microscopic description were carried out in the "Innovative Geological and Mineralogical Laboratory" of Satbayev University. Field geological studies and geometrization of the ore-bearing strata of the Semizbaiskoe deposit established 263 ore deposits, contoured with a cut-off uranium content of 0.03 %. 205 of them are in operation and include industrial reserves, and the remaining 58 are classified as off-balance sheets. The configuration of deposits in a generalized form is displayed on master plans and all geological and graphic documents (Figure 3).

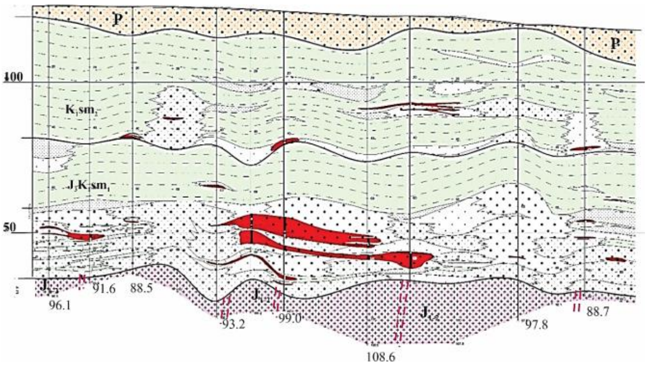


Figure 3 - Geological section

The parameters of mineralization and its statistical characteristics under various conditions, as well as determining the conditions for the localization of ore objects in the Central section of the deposit, were established according to exploratory drilling: first, a "cross" was drilled (PR 104-50 m with a total length of 740 and with a step of 6.25 m and a main line 230 with a length of 450 m with a step of 12.5 m), and then - an experimental operational exploration part with a network of wells 6.25x12.5 m in an area of 100x200 m (263 wells in total).

The study of the parameters, morphology, and conditions of ore occurrences showed that all deposits are represented by strongly flattened, discontinuous in area and thickness, stratiform bodies with a complex distribution of uranium mineralization. They are of the same type in structure but differ significantly in size and configuration. Thus, with an average thickness of all 205 industrial ore bodies of the deposit equal to 2.1 m, for some of them it ranges from 0.2 to 7.3 m, and the area, with an average value of 9000 m^2, varies from 4 to 930 thousand m^2.

The analysis of ore deposits of various morphological groups gives grounds to systematize them and identify several classes in terms of size and types according to the configuration in the plan (Table 1).

As can be seen from Table 1, four classes of ore deposits are distinguished by size at the Semizbai deposit:

– very large (area more than 250 thousand m^2), which include deposit No. 1-2-003 for the deposit with an area of about 1 million m^2, including 12.5 % of metal reserves, and deposit No. 1-2-001, which - 430 thousand m^2 and 9.2 %;

– large (100-250 thousand m^2);

– middle (40-99 thousand m^2);

– small (less than 40 thousand m^2).

Table 1 - Distribution of ore bodies by their size and morphological types

Morphological types of ore bodies	Classes of ore bodies by size				
	very large	*large*	*middle*	*small*	*total*
Ribbon-like	1	2	3	7	13
Elongated lenticular	3	6	9	57	75
Lenticular (isometric)	1	1	8	87	97
indeterminate form	-	2	16	2	20
Total	5	11	36	153	205

An analysis of the distribution of ore reserves by bodies shows that about 90 % of the balance reserves of the deposit are concentrated in large and medium ore bodies, including 70 % in 16 large and 5 very large bodies, the average area of which is 500 thousand m^2, containing 47 % of uranium ores of the Semizbai deposit. The bodies with the maximum size are also characterized by greater thickness, higher metal content, and productivity. At the same time, 153 small bodies (75 % of their total amount) contain only 11 % of uranium reserves.

Ore bodies not only differ significantly in size but also have a variety of shapes in plan, being elongated objects to varying degrees. Their length varies from 100 m to 5.2 km, and their width varies from 20 to 800 m with fluctuations in the ratio of length to width from 1 to 12. In this regard, three morphological types of ore bodies are distinguished: ribbon-like – narrow, winding, strongly elongated along strike, with an elongation factor (K_{elong}) of more than 5; elongated lenticular (K_{elong} 2-5) and lenticular (or isometric) - K_{elong} less than 2. For 20 ore deposits explored by single wells along a sparse network, the shape has not been reliably established. Research data show that over 50 % of the metal reserves are contained in elongated lenticular deposits (37 % of their total amount), and in all other types of deposits, the reserves are distributed approximately equally.

The average uranium content for individual ore bodies after averaging hurricane values varies from 0.041 to 0.240 %. Significantly greater limits of fluctuations are noted inside the ore bodies – for through complete intersections from 0.04 to 0.5 % and for some rare (before averaging) up to 2 %. In individual core samples, the metal content was found to be from 3-5 to 8 %. In individual core samples, the metal content was found to be from

3-5 to 8 %. In individual C*org* samples, the metal content was found to be from 3-5 to 8 %. The highest quality is characterized by ores in areas enriched in C*org* and sulfides, which, however, are randomly distributed within the deposits and do not form large independent accumulations.

The deposit as a whole is represented by ordinary ores, but the main reserves of metal (74 % are contained in the class of ores above 0.1 %, the uranium content which is 1.5 times higher than the average. It is also important to note that 65 % of the metal reserves are located in highly productive, central parts of ore deposits, which account for only 25 % of their area.

Research discussion of the results

A systematic geological, mineralogical, and technological study of the ores of the Semizbai deposit began from the moment of its discovery and continues at the present time.

Mineral composition of ores. Uranium mineralization at the Semizbai deposit has been established in all lithological varieties of rocks of the ore-bearing strata. Insignificant concentrations of uranium have also been found in the basement granites of the Semizbai depression. The composition of clasts of ore-bearing rocks is arkosic, polymictic, and less often quartz. Fragments of coalified organics are noted in significant amounts in separate interlayers. The most common accessory minerals are magnetite, titanomagnetite, ilmenite, spinel, leucoxene, zircon, sphene, apatite, tourmaline, garnet, epidote, and anatase.

The cement of the rocks is mostly sandy-argillaceous, silty-argillaceous, and clayey. Separate interlayers have a clay-carbonate and carbonate composition of cement. Cement is formed largely by authigenic minerals - kaolinite, montmorillonite, hydromicas, carbonates, sulfides, iron oxides and hydroxides, and uranium minerals.

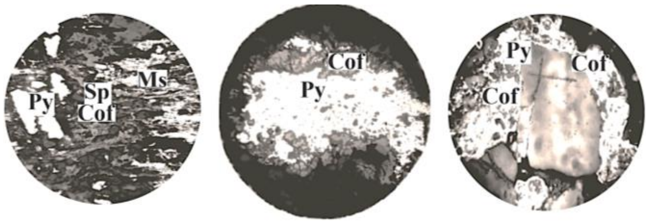
Uranium in ores is found in the mineral and adsorbed form. The latter is widely distributed, but in rich ores, the bulk of uranium is associated with mineral forms. The sorbed uranium in ores is associated with carbonized plant fragments, clay minerals of cement, and iron hydroxides. Uranium minerals are represented by coffinite, pitchblende (uraninite), uranium black, and rare secondary minerals. In addition, uranium-bearing ilmenite, titanomagnetite, and leucoxene are present in small amounts. In isolated cases, detrital brannerite is noted.

In some areas of ore bodies, increased radioactivity is due to radium-bearing barite and iron hydroxides.

The distribution of uranium minerals in the ores is uneven – in poor ores they are noted only in the form of small and rare segregations, in areas of rich mineralization they form dense dissemination and small nodules, sometimes completely replacing clayey cement and partially developing along the fragments. In most cases, pitchblende and coffinite are in close association with pyrite and marcasite.

Below is a description of uranium, uranium-containing, and accompanying minerals in the ores of the Semizbai deposit based on polished sections made by cementing a loose core.

Coffinite is one of the most common ore minerals. It occurs in almost all types of ores but is most characteristic of carbonatized varieties. It is in close association with sulfides. Coffinite forms irregularly shaped segregations, collomorphic crusts, and nested clusters ranging in size from thousandths of an mm to 1 cm (Figure 4).

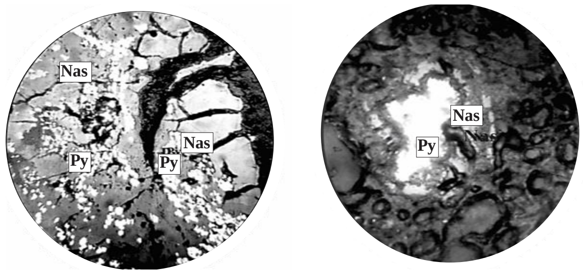


A B C

Figure 4 - Mineral composition of ores in polished section: A - pyrite (Py), marcasite (Ms), sphalerite (Sp) and coffinite (Cof) in medium-grained sandstone cement; B - coffinite (Cof) around pyrite nodules (Py); C - coffinite (Cof), developing after collomorphic pyrite (Py)

In ores, coffinite is represented by three generations. Coffinite I has a black color, it was isolated after microglobular pyrite, is pseudomorphically replaced by pitchblende I, and is identified from the preserved primary crystal forms. Coffinite II is black with brown reflections, reflectivity R = 8.2 %, microhardness H = 265 kg/mm^2, formed before marcasite after the main mass of pyrite. Coffinite III crystallized after marcasite. It has greenish-brown and light brown internal reflections, low reflectivity R = 4 %, and microhardness H = 205 kg/mm^2. Coffinite is confirmed by X-ray diffraction analysis.

Nasturan (uraninite) is much rarer than coffinite. It occurs together with it, as well as in the form of independent secretions and accumulations 0.003-2.0 mm in size. It forms outer zones in coffinite rims and accumulations around iron sulfides (Figure 5). It is also noted as a thin dissemination in the cement and less often as microveinlets in terrigenous fragments. In addition, relatively large (up to 5 mm) accumulations of pyrite-nasturan composition are found in spotted carbonate ores. There are two generations of Nasturan. The first, the earliest, is developed after coffinite I and has a low reflectivity R = 8–10%. Crystal lattice parameters a = 5.39 Å. Nasturan II is characterized by a higher reflectivity R = 15 %. Crystal lattice parameters a = 5.39 Å. Sometimes it contains small inclusions of galena.



A **B**

Figure 5 - Mineral composition of ores in polished section: A - *Nasturan* (Nas) with dissemination of fine-crystalline pyrite (Py); B - Nasturan (Nas) and uranium black (Nas) around accumulations of pyrite (Py) in siltstone

Uranium black forms loose accumulations in association with melnikovite and sooty organic matter and thin films on the surface of terrigenous fragments and segregations of pitchblende and coffinite; they are also present in a finely dispersed state in clayey cement.

Brannerite is rare in rich ores in the form of small (up to 0.5 mm) detrital grains.

Secondary uranium minerals are represented by *zippeite, uranophane*; they are found in small amounts in ores with organic matter and in carbonate rocks. They are found in areas of carbonate destruction in the form of thin yellow precipitates on the surface of minerals, powdery accumulations near pitchblende and coffinite.

Uranium-bearing minerals are represented by ilmenite, leucoxene, titanomagnetite, and anatase. They are usually found in rich ores in the form of single small (fractions of mm) grains and small clusters. The distribution of uranium in them is uniform.

Organic matter is widely distributed. Its content in terms of C*org* varies from tenths to 5 %. It is represented by carbonized plant residues (leaves, roots, stems, bark, trunks), coal detritus, accumulations of sooty carbonaceous matter. The content of uranium in carbonized plant residues varies widely, reaching 1 %. Uranium-enriched coals differ from barren coals by a higher degree of oxidation and a smaller amount of aromatic compounds. Noteworthy is the noticeable concentration of germanium, reaching 0.2 % in some samples.

Iron hydroxides are widely developed in ores. Their formation is associated both with the processes of sediment formation and with subsequent epigenetic transformations (hydrohematization, reservoir oxidation, gley reduction). They are represented by goethite, hydrogoethite, hydrohematite, which impregnate fragments of rocks and minerals and clayey cement, form clots, accumulations, films, point selections. In ore intervals, a significant amount of uranium and especially radium is sorbed on iron hydroxides.

Sulfides are represented by pyrite, marcasite, and melnikovite. Bravoite, sphalerite, chalcopyrite, galena are very rare.

Structural features of ores. In ordinary ores, uniformly dispersed, spotty, and mixed structures are most common; in rich ores, in addition, disseminated, clotted, and cementitious structures are common. Ores of other structures occur occasionally. Mixed structures are a combination of two or three different structures. The cement structures is characteristic of rich ores localized in medium- and coarse-grained sandstones, whose clayey cement is completely replaced by coffinite, pitchblende, and iron disulfides, which are closely intergrown with them.

Textures of ores. Based on the nature of segregations and the relationship of uranium minerals with other neoformations and terrigenous minerals, the following main textures of ores are established. The texture of peripheral rims is widespread in carbonate ores, as well as in rocks with clayey cement enriched in iron sulfides. Coffinite and Nasturan develop around accumulations of iron sulfides in the form of continuous and discontinuous rims. The concentric-zonal texture is due to the presence of zonal-collomorphic segregations of pyrite, in which individual zones are composed of coffinite. The corrosion texture is revealed in intergrowths of uranium minerals with iron sulfides, in which distinct corrosion contacts of pyrite or marcasite with coffinite and pitchblende developing over them are established. The relic texture is formed as a result of the replacement of pyrite and marcasite by uranium minerals, in which iron sulfides remain only in the form of relics. The mineral composition of ores and their textural and structural features are the basis for choosing the technology of deposit development and effective reagents.

Characteristics of associated useful components. Associated useful components such as selenium, germanium and scandium were found in the uranium ores of the deposit. The possibility of industrial use of these components still remains problematic due to low contents and requires technological solutions. The mineral forms of their occurrence and distribution in ores have not yet been sufficiently studied. Selenium is probably found as an isomorphic impurity in iron sulfides. Germanium is closely related to organic matter. However, when uranium is leached from the ores of the deposit, only scandium passes from the mentioned elements into solutions and accumulates, which in the future may be of industrial interest.

Neutron-activation, X-ray spectral, and chemical analyzes have established elevated contents of selenium (5-30 g/t), germanium (1-15 g/t), and scandium (2-7 g/t) in ores. In individual combined core samples in ore intervals, the content of germanium reaches 320 and scandium – 76 g/t. Elevated contents of germanium are noted in samples enriched with C*org*; the relationship between elevated contents of scandium and any constituent components of ores has not been established. The presence of selenium in uranium ores was established in 12 out of 1303 analyzed sectional samples. In one sample (4/1328), the selenium content reached 0.04 %. Any mineral forms of finding these elements have not been established. Presumably, selenium occurs as an isomorphic impurity in iron sulfides. Germanium is associated with C*org* (correlation coefficient is 0.7) and is distributed not only in ores, but also in host rocks.

The estimate of the expected reserves of associated components is determined in the ore mass, which in the process of in-situ leaching will possibly be treated with leaching reagents. Since the study of the distribution of selenium, germanium and scandium did not reveal a relationship between them and uranium, the average content of associated elements in the ore mass was taken to be the same as in the ore.

Table 2 shows the estimated amount of associated useful components (AUC) per tonne of balance reserves of uranium.

Table 2 - AUC/U ratio in uranium ores of the Semizbai deposit.

Components	AUC/U ratio, kg/t
Selenium	52
Germanium	12
Scandium	9

For the first time, the characteristics of the ores of the Semizbai deposit are given according to the results of preliminary exploration (V. Pigulsky et al., 1975), in which their division into natural types and technological grades took into account both the possibility of a traditional mining method and the use of Underground leaching (UL). This was based on three principles – permeability (K*l* separation level 0.5 m/day), carbonate content (2 % CO_2), and coal content (3 % C*org*), in connection with which the corresponding natural types of ores were distinguished.

At present, natural types of ores are separated only by their lithological composition, since they do not differ significantly in other features, in particular, in mineral composition. The following four types of ores have been established: 1) in clays and siltstones; 2) in clayey sands and sandstones; 3) in gravelstones and conglomerates with sandy-argillaceous cement; 4) in sandstones and conglomerates with carbonate cement. Due to the small distribution of ore in rocks enriched with carbonized organic matter, it is not distinguished as an independent natural type. The distribution of ore types in the deposit is given in Table 3.

Table 3 - Relative distribution of natural types of ores of the Semizbai deposit

Types of ores according to the lithological composition of rocks	Ratio, %	
	balance reserves	off-balance reserves
1. Clays and siltstones	14.5	23.1
2. Clay sands and sandstones	48.2	48.8
3. Coarse-clastic rocks with sandy-argillaceous cement	23.2	23.9
4. Clastic rocks with carbonate cement	14.1	4.2

As can be seen from Table 2, off-balance ores, to a greater extent than balance ores, develop over clay rocks. The clastic part of the ore (pebbles, gravel, and pieces of monolithic carbonate rocks that do not soak in water) in the ores of the Upper ore-bearing horizon (UOH) is 5-8%, Lower ore-bearing horizon (LOH) – 25-30 %; in general, about 20 % for the deposit.

Ore-bearing clays and siltstones occur predominantly in the form of thin layers among mineralized sandstones or in thicker layers limiting them from the side of the roof and soil. Uranium is associated mainly with dark gray and gray varieties of clays enriched in organic matter and iron sulfides. The C*org* content ranges from 0.2 to 8-5 % (occasionally up to 19.8 %); the number of sulfides, according to chemical analysis 1-5, in some cases 10 %. The content of uranium is mainly 0.04-0.07 %, occasionally up to 0.2 %. Its distribution is mainly finely dispersed, mainly in the adsorbed form. Nasturan, coffinite, and uranium black are fixed only in enriched areas.

Ore-bearing sandstones of various grain sizes are the most common type of ores. These are mainly gray and greenish-gray varieties with a high content of C*org* (0.25-7.0 %) and iron sulfides (0.5-5 %). Uranium mineralization is represented by nasturan, coffinite, and black uranium, which form dissemination and clots in areas enriched in sulfides. A significant part of uranium is in the adsorbed form in clay cement and carbonized organic matter. The uranium content fluctuates over a wide range, reaching 5-8 % in fragments of carbonized wood and near sulfide accumulations.

Ore-bearing gravel stones and conglomerates of gray, greenish-gray, and spotted color are characterized by poor sorting of the material. They also contain iron sulfides and fragments of carbonized wood. Uranium mineralization has an uneven patchy distribution. Uranium is in the adsorbed form in clay minerals and fragments of organic matter, but a significant part of it is contained in accumulations of pitchblende, coffinite, and black uranium in association with iron sulfides.

Ores in clayey rocks stand out sharply from the described types in terms of the content and distribution of uranium. They are characterized by a uniform distribution of metal and a lower average content (1.5-2 times lower than the average over the horizon). All other types do not differ significantly from each other in terms of uranium concentration and are characterized by a patchy distribution of mineralization. The enriched areas (clumps) in them are associated with the concentration of uranium minerals near pyrite accumulations and in fragments of the coalified mass.

The selected natural types of ores do not form independent ore bodies or large areas within them, they occur in complex thin interbedding with each other.

The results of chemical analyzes and data on the mineral composition of technological samples suggest that the ores of the deposit as a whole are aluminosilicate with a low content of carbonates.

The closest relationship of uranium is observed with sulfur and C*org*, which is explained, on the one hand, by the presence of a close paragenetic association of uranium minerals with iron sulfides and, on the other hand, by the sorption of uranium by carbonized plant residues and a close relationship between sulfur and C*org*. Uranium also has a weak but significant correlation with germanium and CO_2. The first is natural since both germanium and uranium have a direct correlation with C*org*. The second is manifested in the LOH and is apparently due to the regeneration and some concentration of uranium in the process of carbonatization of detrital rocks.

Deposit development technology. The Semizbai uranium deposit is being developed by the most rational for this type of deposit by underground well leaching (UWL). The use of UWL is based on three indicators of ore-bearing rocks: permeability (K_f ≥0.5 m/day), carbonate content (2 % CO_2) and coal content (3% Corg). At present, natural types of ores are separated only by their lithological composition, since they do not differ significantly in other features, in particular, in mineral composition. As mentioned above, four types of ores have been identified at the deposit. Due to the small distribution, ores in rocks enriched with carbonized organic matter are not distinguished as an independent natural type. The obtained research results are the initial basis for improving the technology in uranium ore production and effective reagents to increase the extraction of metals.

Conclusions

The results of the studies performed provided additional material for concluding that the ores of the Semizbai deposit were original of hydrothermal genesis, which as the Mesozoic-Cenozoic depression developed, were transformed and redeposited by hydrogenic processes in the artesian and expelled basins.

The obtained results of the laboratory and field geological study of the natural features of the uranium ores of the Semizbai deposit can serve as a basis for improving the technology of uranium mining and creating an initial base for extracting associated rare elements. Ores according to geological and technological indicators are divided as follows:

– in terms of uranium content in general for the deposit to ordinary monometallic ones. Selenium, germanium, and scandium are present in certain amounts;

– in terms of the form of uranium – to nasturan-coffinite with a significant proportion of metal in the adsorbed form on clay minerals and organic matter;

– according to the composition of the ore mass - to aluminosilicate rocks with a small number of carbonates (4-5%);

– in terms of the size of mineral aggregates and textural and structural features - to scattered-clot. The sizes of pitchblende-coffinite-sulfide aggregates are up to several mm, and a significant part of uranium is in the form of fine dissemination and in the sorbed form;

– the basis of ores is represented by sands and weakly cemented sandstones, gravel stones, conglomerates, siltstones, and clays soaking in water; the clastic part of the rocks is on average 20 %.

Currently, in addition to uranium, rare and rare-earth elements accompanying them are in demand. Assessing the associated useful components (AUC) and choosing a technology for extracting them from uranium ore solutions will increase the value and make it possible to develop even off-balance ores of uranium deposits.

Conflict of interest. The authors have no conflict of interest.

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Семізбай кенорнындағы уран кенінің заттық құрамы және технологиялық қасиеттері туралы (Солтүстік Қазақстан)

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ТҮЙІНДЕМЕ

Қазіргі уақытта уран өндіру әлемдік энергетикада елеулі орын алады. Қазақстанда уранға деген сұранысты қанағаттандыру үшін технологиялық және экономикалық жағынан қолайлы табиғи көрсеткіштерге ие гидрогендік кенорындар бар, солардың ішінде ірі Семізбай кенорны игерілуде. Кенорын генезисі бойынша терригендік құм-саз шөгінділердегі гидротермалық-гидрогендік, яғни полигендік типке жатады. Геологиялық зерттеулер нәтижесінде семізбай дестесінің рудалы түзілімдері стратификацияланған: төменгі және жоғарғы рудалы дестешелер бөлінген, кенорнынды геометризациялау жүргізілген, рудалы жатындардың морфологиясы, саны және өлшемдері анықталған. Кенорын баланстық қорының басым бөлігі ірі және орташа кен денелерде шоғырланған. Аналитикалық жұмыстар, шлифтер мен аншлифтерді микроскоппен сипаттау арқылы уран рудаларының заттық құрамын, бітімі мен құрылымын, негізгі кен минералдарын және олардың кендерде таралуы анықталған. Далалық және зертханалық жұмыстарды жүргізу кезінде кен өндіру технологиясын таңдауға негіз болатын кенорынның геологиялық көрсеткіштері алынды. Кен өндіру технологиясын таңдау және негіздеу үшін тәжірибелік бөлікшеде арнайы технологиялық зерттеулер жүргізілді. Семізбай кенорны үшін уран кендерінің геологиялық көрсеткіштеріне сүйене отырып, гидрогендік кенорындар үшін ең ұтымдысы ретінде жерасты ұңғымаларында шаймалау технологиясы таңдалған. Уран кендерінің ілеспе пайдалы компоненттерінің сипаттамасы берілген, олардағы селен, германий және скандий мөлшерінің жоғары екендігі анықталған. Алынған зерттеу нәтижелері уран кендерін өндіру және олардан ілеспе пайдалы компоненттерді айырып алу үшін қолданылатын технологияны жетілдіруге негіз бола алады.

	Түйін сөздер: уранның гидрогендік кенорны, уранды терригендік таужыныстары, уран кенінің минералдары, кен типтері, ілеспе пайдалы компоненттер, жерасты ұңғымаларда шаймалау.

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О вещественном составе и технологических свойствах урановых руд Семизбайского месторождения (Северный Казахстан)

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АННОТАЦИЯ

В настоящее время производство урана занимает определяющее место в мировой энергетике. В Казахстане для удовлетворения потребности в уране разрабатываются гидрогенные месторождения с технологически и эконически выгодными природными показателями, в числе которых и крупное Семизбайское месторождение. Месторождение по генезису относится с гидротермально-гидрогенному полигенному типу в терригенных песчано-глинистых отложениях. В результате геологических исследований установлена стратификация рудоносных отложений семизбайской свиты: нижний и верхний рудоносные горизонты, выполнена геометризация месторождения, выделена морфология, количество и размеры рудных залежей. Большинство балансовых запасов месторождения сосредоточены в крупных и средних рудных залежах. Аналитическими работами, описанием шлифов и аншлифов под микроскопом определен вещественный состав, изучены текстуры и структуры урановых руд, основные рудные минералы и их распределение в рудах. При проведении полевых и лабораторных работ получены геологические показатели месторождения для выбора технологии добычи руд. Для выбора и обоснования технологию разработки месторождения проведены специальные технологические исследования в экспериментальном участке. Исходя их геологических показателей урановых руд для Семизбайского месторождения выбрано подземное скважинное выщелачивание как самое рациональное для гидрогенных месторождений. Дана характеристика попутным полезным компонентам урановых руд, установлено повышенное содержание в них селена, германия и скандия. Полученные результаты исследований могут служить основой для совершенствования применяемой технологии добычи урановых руд и извлечения из них попутных полезных компонентов.

Ключевые слова: гидрогенное урановое месторождение, ураноносные терригенные породы, минералы урановых руд, типы руд, попутные полезные компоненты, подземное скважинное выщелачивание.

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