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GEOLOGICAL CHARACTERISTICS OF SANDS AND THE IMPACT OF THEIR PRODUCTION PROCESSES ON THE ENVIRONMENT

Abstract. This paper presents studies aimed at studying the geological characteristics of the sands of the Shoktashskoye field located in the southern region of the country. These sands are one of the main sources of building materials in the area. Referring to the quaternary deposits, the deposit mainly includes Alluvial and Aeolian formations. The predominant type is medium – grained sand with a particle size of 0,63–2,5 mm, which meets the requirements of standards for use in mortars and concretes. However, it should be borne in mind that the extraction and processing of sand can cause negative environmental consequences, affecting the environment and public health. Despite the widespread availability of sand resources, excessive extraction can lead to a local shortage of this material, which makes the issue of rational use and replenishment of reserves relevant.
Key words: *sand, environmental problem, mining, geology, rational use, processing, fraction.*

Құмдардың геологиялық сипаттамасы және оларды өндіру процестерінің қоршаған ортаға әсері

Аңдатпа. Бұл жұмыста елдің оңтүстік аймағында орналасқан Шоқтас кен орны құмдарының геологиялық сипаттамаларын зерттеуге бағытталған зерттеулер ұсынылған. Бұл құмдар аймақтағы құрылыс материалдарының негізгі көздерінің бірі болып табылады. Төрттік шөгінділерге негіздеме жасай отырып, кен орнына негізінен аллювиалды және эолдық түзілімдер жатады. Басым түрі – бөлшектердің мөлшері 0,63–2,5 мм болатын орташа түйіршікті құм, бұл ерітінділер мен бетондарда қолдануға арналған стандарттардың талаптарына сәйкес келеді. Алайда, құмды өндіру және өңдеу қоршаған ортаға және халықтың денсаулығына әсер ете отырып, жағымсыз экологиялық әсер етуі мүмкін екенін ескеру қажет. Құмды ресурстардың кең таралуына қарамастан, оларды шамадан тыс өндіру осы материалдың жергілікті тапшылығына әкелуі мүмкін.
Түйінді сөздер: *құм, экологиялық проблема, тау-кен, геология, ұтымды пайдалану, қайта өңдеу, фракция.*

Геологическая харакеристика песков и влияние процессов их производства на окружающую среду

Аннотация. В данной работе представлены исследования, направленные на изучение геологических характеристик песков Шокташского месторождения, расположенного в южном регионе страны. Эти пески являются одним из основных источников строительных материалов в данном районе. Относясь к четвертичным отложениям, месторождение включает преимущественно аллювиальные и эоловые образования. Преобладающим типом является среднезернистый песок с размером частиц 0,63–2,5 мм, что соответствует требованиям стандартов для использования в строительных растворах и бетонах. Однако следует учитывать, что добыча и переработка песка могут вызывать негативные экологические последствия, оказывая влияние на окружающую среду и здоровье населения. Несмотря на широкую распространенность песчаных ресурсов, чрезмерная их добыча может привести к локальному дефициту данного материала, что делает вопрос рационального использования и восполнения запасов актуальным.
Ключевые слова: *песок, экологическая проблема, добыча, геология, рациональное использование, переработка, фракция.*

Introduction

The sand formations of the southern regions of the Republic of Kazakhstan have a wide biological variability due to their origin, composition and conditions of formation. In this region, the sand massifs are mainly represented by Aeolian (formed by wind) and alluvial (riverine) deposits. Aeolian sands arise under the influence of wind processes and form deserts such as Kyzylkum and Muyun Kum. Alluvial sands are associated with the activity of rivers, such as the Syr Darya, and are found in floodplains and deltas.

The basis of the sands of the region is quartz, which gives them a light shade. Depending on the geological conditions of the area, they may contain feldspar, mica and other minerals [1]. The properties of sand are also affected by the presence of clay particles and organic material. The grain size varies from fine to coarse. Aeolian sands are usually well sorted and have rounded grains due to long-term wind transport, whereas alluvial sands are characterized by less sorting and angularity of grains due to their fluvial origin [2].

The relief of the sand massifs of southern Kazakhstan is diverse and is represented by dunes, dunes, sand ridges and plains. These landforms are subject to constant changes under the influence of wind and water, which affects the dynamics of the landscape and the distribution of sand deposits. The age of these deposits varies from the Quaternary period to the modern formations. A significant part of the sands was formed in the Late Cenozoic and continues to accumulate as a result of modern geological processes.

Thus, the sand massifs of southern Kazakhstan represent a complex and variable geological system, which is formed under the influence of natural factors and dynamic processes. The object under study is the Shtokman deposit. The Shoktas construction sand deposit is located in the Turkestan region, located at a distance of 1–5 km south-east of the Choktash station and 20–25 km south-east of the city of Kentau. It was explored in 1960, and subsequent additional exploration work was carried out in 1971–1972 by the St. George Mining and Processing Plant of the Southern State University on behalf of the Ministry of Construction of Heavy Industry Enterprises of the Kazakh SSR. The deposit is associated with the Upper Cretaceous deposits of the Koturbulak formation and includes three sections: the Main one, the Eastern one and the Shamat-Uzen one. The dimensions of the Main section are 1500 × 1000 m, and the thickness of the useful thickness varies from 8 to 24 m, on average reaching 12 m. The seam-like sand deposit at the Shamat–Uzen site has a thickness from 1,5 to 17,2 m, and the overburden capacity ranges from 1.3 to 5.0 m. clay rocks are found at the base of the deposit [3].

The mineral composition of the sand is represented by quartz (58%), feldspar (14%), quartzite fragments (12%), as well as small admixtures of sandstones, gypsum (0,2%) and mica (0,1%) [4].

The Shoktas construction is one of the largest sand deposits in the region, located in the south of the country. The sand extracted here is actively used in the construction industry due to its numerous advantages. The main directions of using the sand of the Shartashskoye deposit as a building material are numerous. Sand from the Aktash deposit is an important component for the production of concrete, including ready-mixed concrete, reinforced concrete products (precast concrete) and monolithic structures. It provides the necessary strength and durability of concrete structures. This sand is used to prepare building mixes necessary for laying asphalt and concrete roads. It is used as a filler in asphalt concrete mixtures, which helps to improve the quality of road surfaces [5]. Sand is a part of the solutions for masonry, plaster and cladding. Its use improves the adhesion and structure of building materials and serves as the basis for various mixtures. Shoktas sand is widely used to create dry building mixes such as plasters and cement or gypsum mortars, as well as as a component for the production of various fillers. It finds application in landscape design, for example, for laying paths, filling lawns and creating decorative elements. Sand is used to level the territory and fill back ditches and foundations, as well as as a filler. Sand from the Aktash deposit, as a rule, is characterized by a coarse-grained structure, high strength and stability. These qualities make it an ideal choice for a wide range of construction and finishing works, ensuring the durability and reliability of the facilities under construction [6].

Sand mining and production can lead to various environmental problems, especially if modern principles of sustainable development and environmental protection are not respected. It is necessary to note the main environmental aspects related to this process [7]. The extraction of sand from rivers, lakes, or other bodies of water disrupts the natural water balance. This leads to a decrease in water levels, which can provoke ecosystem degradation and the death of fish and other aquatic organisms, as well as change the riverbed, which negatively affects agriculture and water supply. Sand mining in coastal areas contributes to coastal erosion and destruction of natural landscapes. This can lead to the loss of habitats for flora and fauna, such as wetlands and beaches where birds nest [8]. Erosion processes also lead to soil loss, deterioration of water quality and reduction of biodiversity. The sand mining process can cause pollution of water bodies, especially if machinery is used that violates the bottom. Fine sand particles and harmful substances (such as fuels and oils) can enter the water, impairing its quality, which threatens the health of both aquatic ecosystems and humans, especially when this water is used for drinking. Sand mining operations often lead to the destruction of vegetation and the destruction of ecosystems, which causes a decrease in biodiversity. This is especially critical in regions with unique or rare species of animals and plants, as mining can interfere with the migration routes of animals such as fish. Mechanical extraction of sand on land can contribute to the formation of dust that spreads over considerable distances, worsening air quality and negatively affecting the health of local residents, which can lead to respiratory diseases. Heavy machinery such as excavators and dump trucks is often used in the mining process, which releases carbon dioxide and other pollutants into the atmosphere. In addition, waste remains that can contaminate soil and water if not disposed of properly. When sand is extracted near agricultural land, it can negatively affect the structure of the soil, complicating its use in agriculture. Sand mining can cause problems with salinization, erosion, and loss of fertility. In some cases, sand mining can threaten archaeological and historical sites, especially in places where mining is carried out near ancient structures or in areas of cultural value [9].

Sand mining management requires special attention to environmental ethics, which makes it possible to effectively control the consequences of this process. Taking into account the principles of sustainable development, public policy in the field of sand mining should focus on the impact on the quality of life of people and society as a whole [10].

Materials and methods

The study of the sand deposit was carried out by various methods depending on the objectives of the analysis, such as construction, geology and ecology. The following are the main methods on the basis of which the complex condition and suitability of the studied material as a building material were studied. The granulometric analysis included sieve analysis, laser diffraction, and sedimentation. Next, the size and distribution of sand particles were determined. As a result of this method, it was concluded that sand is used as a building material for concrete, filters, and road construction [11].

In addition, mineralogical analysis was carried out, which included methods of X-ray diffractometry (XRD), optical microscopy, transmission electron microscopy (TEM). Based on these methods, the mineral composition (quartz, feldspar, mica, and others) was determined. The results showed the possibility of using and evaluating the sand's resistance to external influences and its chemical resistance. A chemical analysis of the sands of the studied deposit was also carried out. Experimental work included titrimetric analysis methods, and the content of oxides such as SiO_2, Al_2O_3, Fe_2O_3, CaO, and others was determined. As a result, the application was clearly identified with the determination of the suitability of sand for the production of glass and building materials [12].

The physic-mechanical tests of the sands included methods for measuring density, water absorption, bulk density, and modulus of elasticity. The mechanical strength, porosity, and filtration coefficient of the sands were determined. Based on this, the applicability of choosing the right sand for concrete, mortars and drainage systems was shown. One of the most important indicators was environmental and sanitary studies using methods of heavy metal content analysis, radiation monitoring and microbiological analysis. As a result of these methods, the level of pollution and the safety of using sand in various fields of activity were determined. The applicability is sand quality control for the construction of residential facilities and sewage treatment plants. Sand is actively used in sewage treatment plants as an effective sorbent due to its accessibility, high porosity and ability to retain pollutants. The possibility of using the sand under study in cleaning systems was investigated. During mechanical filtration, the sand retains suspended particles. Also, when pollutants are adsorbed, it effectively absorbs organic substances, heavy metals, and petroleum products. In addition, with biological activity, sand creates an environment for microorganisms that contribute to the decomposition of pollutants. It should be noted that the following types of sand are used for water purification: quartz sand is the most common, it is highly chemically resistant; activated sand is subjected to chemical or thermal treatment to increase sorption properties; hydrophobic sand is specially treated to effectively remove petroleum products.

As a sorbent, sand is subjected to the following research methods: granulometric analysis – determines the fractional composition, the optimal particle size is 0,2–1 mm; adsorption capacity – is estimated by the degree of absorption of organic compounds and heavy metal ions; hydraulic conductivity – a critical parameter affecting the rate of water filtration; regeneration and durability – the possibility of repeated use of the material is analyzed. After determining the sorption properties of sand, its further use in sewage treatment plants is possible.: sand filters – provide deep wastewater treatment; infiltration zones – promote natural filtration through ground layers; filter cassettes – are used to purify industrial and stormwater runoff.

Results

As a result of the comprehensive analysis, the following data were obtained, on the basis of which the possibility of the applicability of sands as a building material and sorbent was determined. The chemical composition of sand is determined by its origin, but its main component is silicon dioxide (***SiO_2***) (table 1).

Table 1

Chemical composition of sand, %

Кесте 1

Құмның химиялық құрамы, %

Таблица 1

Химический состав песка, %

Component	Quartz sand	Comparative data	
		Carbonate sand	Polymineral sand
SiO_2 (silicon dioxide)	82,85	20–50	50–80
Al_2O_3 (aluminum oxide)	4,84	1–10	2–15
Fe_2O_3 (iron oxide)	1,47	0,1–3	0,5–5
CaO (calcium oxide)	2,78	20–50	2–10
MgO (magnesium oxide)	0,3	2–10	1–5
TiO_2 (titanium oxide)	0,55	0,05–0,2	0,1–1
K_2O, ***Na_2O*** (alkaline oxides)	0,44	0,1–5	0,5–4

Granulometric analysis allowed us to determine the size of sand particles and assess its compliance with the above-mentioned various fields of application (table 2).

Bulk weight 1,230–1,510 (average 1,375 g/cm^3): density 2,64–2,70 g/cm^3; modulus of fineness 1,4–3,1 (average 1,91), content of clay, silt and dust particles 4,5–48,9% (average 8,75%).

Sand can be recommended for use in masonry and plaster mortars, provided that the gravel fraction is pre-screened and cleaned of clay, silt and dust particles. Gravel, the average content in the mixture is 16,4%. The volume weight is 2,56–2,58 g/cm^3. The content of bream and needle grains is 4,4–8%; grains of weak rocks are 18,4–27,6%. Gravel samples at 50 cycles of freezing are frost-resistant. Gravel due to its significant clay content, weak frost resistance and significant grain content of weak rocks cannot be used as a coarse aggregate in concrete.

Table 2

Granulometric analysis of sand

Кесте 2

Құмды гранулометриялық талдау

Таблица 2

Гранулометрический анализ песка

Sand fraction	Particle size, mm	Content, %			Application
		Minimal	Maximum	Average	
Gravelly	2,5	4,74	19,36	8,7	Road foundations, building mixes
Large	1,25	10,51	36,62	20,00	Drainage, filters, reinforced concrete
Average	0,63	14,44	63,14	28,8	Concrete, filters
Small	0,315	37,24	84,37	47,5	Plastering works, masonry mortar
Silty	0,14	64,44	91,68	87,7	Clay solutions
	0.14 or less	12,6	35,57	26,3	

The deposit of the investigated sand is not flooded. Mining conditions are favorable for open-pit mining. The reserves were approved in categories ***B***, ***C1*** and ***C2*** (tables 3–8 and figures 1–3).

Table 3

Interplane distances and phase composition of sample No. 1

Кесте 3

№ 1 Үлгінің жазықтықаралық арақашықтықтары және фазалық құрамы

Таблица 3

Межплоскостные расстояния и фазовый состав образца № 1

d, Å	***I*** %	The mineral
1	2	3
7,19021	5,5	kaolinite
4,25638	18,7	quartz
3,84498	4,3	calcite
3,57404	3,6	kaolinite
3,47211	3,7	KPSH
3,34199	100,0	quartz
3,23966	12,5	KPSH

Продолжение таблицы 3

d, Å	***I*** %	The mineral
1	2	3
3,03447	9,1	calcite
2,45433	9,7	quartz
2,28003	9,0	quartz
2,23496	5,4	quartz
2,15929	2,7	KPSH
2,12596	5,6	quartz
1,97808	5,2	quartz
1,87450	2,8	calcite
1,81670	10,0	quartz
1,67095	5,3	quartz
1,65759	2,6	quartz

Note: All the above diffraction peaks belong only to the phases indicated above. Characteristic diffraction reflexes are noted, which make it possible to identify the phases present.

Table 4
Results of semi-quantitative X-ray phase analysis of sample No. 1
Кесте 4
№ 1 Үлгінің жартылай сандық рентгендік фазалық талдауының нәтижелері
Таблица 4
Результаты полуколичественного рентгенофазового анализа образца № 1

Name of the mineral	Formula	Concentration, %
quartz	SiO_2	77,1
kaolinite	$Al_2Si_2O_5(OH)_4$	8,9
calcite	$Ca(CO_3)$	7,2
KPSH	$KAlSi_3O_8$	6,8

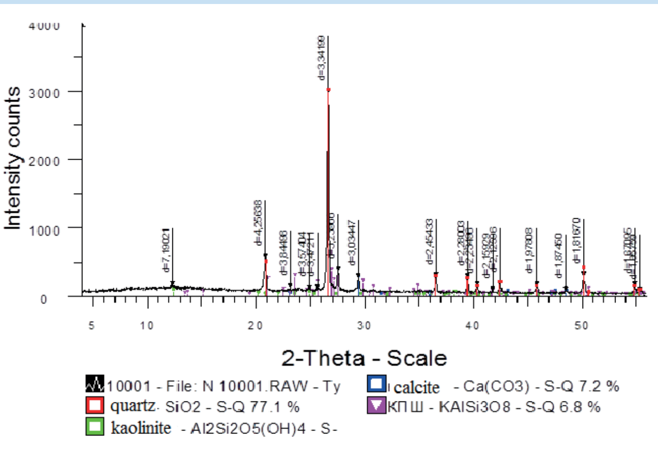

Figure 1. Diffractogram of sample No. 1.
Сурет 1. № 1 Үлгінің дифрактограммасы.
Рис. 1. Дифрактограмма образца № 1.

Table 5
Interplane distances and phase composition of sample No. 2
Кесте 5
№ 2 Үлгінің жазықтықаралық арақашықтықтары және фазалық құрамы
Таблица 5
Межплоскостные расстояния и фазовый состав образца № 2

d, Å	***I*** %	The mineral
4,25833	23,5	quartz
3,34394	100,0	quartz
2,45549	8,1	quartz
2,27901	8,5	quartz
2,23537	6,1	quartz
2,12558	5,7	quartz
1,97838	4,7	quartz
1,81631	10,9	quartz
1,67049	4,3	quartz
1,65825	3,4	quartz

Table 6
Results of semi-quantitative X-ray phase analysis of sample No. 2
Кесте 6
№ 2 Үлгінің жартылай сандық рентгендік фазалық талдауының нәтижелері
Таблица 6
Результаты полуколичественного рентгенофазового анализа образца № 2

Name of the mineral	Formula	Concentration, %
quartz	SiO_2	100

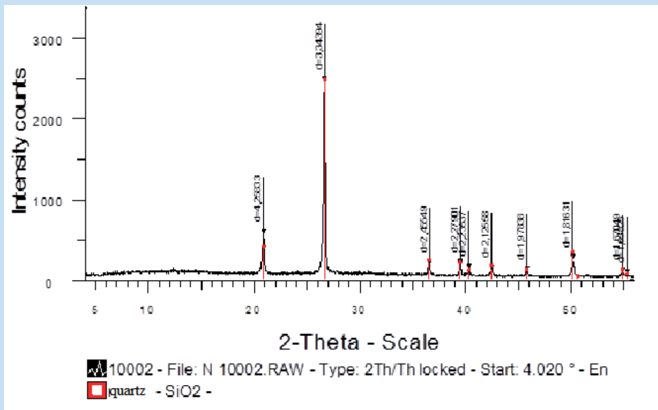

Figure 2. Diffractogram of sample No. 2.
Сурет 2. № 2 Үлгінің дифрактограммасы.
Рис. 2. Дифрактограмма образца № 2.

Table 7
Interplane distances and phase composition of sample No. 3
Кесте 7
№ 3 Үлгінің жазықтықаралық арақашықтықтары және фазалық құрамы
Таблица 7
Межплоскостные расстояния и фазовый состав образца № 3

d, Å	***I*** %	The mineral
14,68021	5,7	He ‘ll figure it out
7,60745	46,5	gypsum
4,25560	27,3	quartz
3,79958	13,8	gypsum
3,47533	4,6	KPSH
3,34251	100,0	quartz
3,24108	9,2	KPSH
3,06371	9,6	gypsum
2,86897	4,7	gypsum
2,68169	4,5	gypsum
2,45567	10,0	quartz
2,27889	8,2	quartz
2,23524	7,1	quartz
2,21603	3,5	gypsum
2,16229	3,8	KPSH
2,12704	8,7	quartz
1,97794	6,2	quartz
1,89692	4,3	gypsum
1,81645	11,9	quartz
1,67086	5,2	quartz
1,65866	3,0	quartz

Table 8
Results of semi-quantitative X-ray phase analysis of sample No. 3
Кесте 8
№ 3 Үлгінің жартылай сандық рентгендік фазалық талдауының нәтижелері
Таблица 8
Результаты полуколичественного рентгенофазового анализа образца № 3

Name of the mineral	Formula	Concentration, %
gypsum	$CaSO_4{\cdot}2H_2O$	48,8
quartz	SiO_2	44,0
He ‘ll figure it out	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2{\cdot}xH_2O$	4,3
KPSH	$KAlSi_3O_8$	2,9

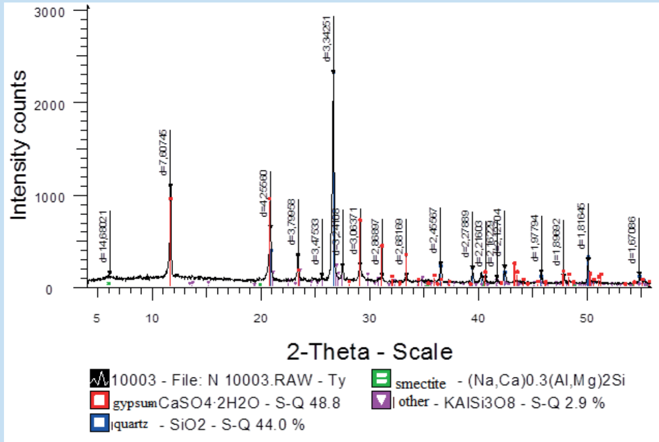

Figure 3. Diffractogram of sample No. 3.
Сурет 3. № 3 Үлгінің дифрактограммасы.
Рис. 3. Дифрактограмма образца № 3.

The diffractogram of the sand of the studied deposit is represented by graphs obtained using X-ray diffraction (XRD), reflecting its crystalline composition. This method allowed us to determine the composition of the minerals contained in three samples. An intense peak at 26.6° is a key indicator of the presence of quartz. Peaks in the range of 12–25° indicate the presence of clay impurities. A peak of about 29° indicated the presence of calcite, especially in carbonate sands.

Discussion

As the results of the experimental work and analyses have shown, the following conclusion can be drawn. The chemical composition has determined the suitability of sand for various industries, including construction, glass industry and filtration. A sufficiently high sio₂ content (82,85%) indicates the purity of quartz sand, which is especially important for the production of glass and concrete. The presence of Al_2O_3 (4,84%) indicates the presence of clay impurities or feldspar, which affects the strength of concrete. Fe_2O_3 (1,47%), when high in content, gives the sand a reddish hue and reduces the transparency of the glass. ***CaO*** and ***MgO*** (2,78; 0,3%) indicate carbonate impurities (calcite, dolomite), useful for cement production, but undesirable for the glass industry.

As is known, the fractional composition of sand affects the strength of concrete, drainage properties and filtration efficiency. Gravel-coarse sand (1,25–2,5 mm) improves concrete strength and drainage properties, but reduces the mobility of solutions. The average sand (0,63 mm) is optimal for building mortars and concretes. Fine sand 0,3 mm) increases the water consumption of concrete, but is useful in filtration systems. Dusty and clay particles (0,14%) degrade the strength of concrete and slow down the hardening process..

As the results of the X-ray phase analysis showed, the mineralogical composition of the sand was determined, which is important for assessing its chemical and mechanical properties. Quartz (peak at 26,6°) indicates the high chemical resistance and mechanical strength of the sand. Feldspars (peaks at 27–28°, 40–42°) may indicate increased alkalinity, which affects the durability of concrete. Clay minerals (kaolinite, montmorillonite, peaks of 12–25°) increase plasticity, but reduce filtration properties. Carbonates (calcite, peak 29,4°) reduce acid resistance, but are useful in cement mixtures. Hematite (***Fe_2O_3,*** peaks 24–33°) indicates the iron content, which is undesirable for glass production.

Based on the conducted research, it has been established that the process of sand extraction and processing is accompanied by a number of negative environmental consequences that can affect the environment and human health. The extraction of sand from rivers, lakes, and quarries leads to landscape changes, coastal destruction, and degradation of aquatic ecosystems. Destruction of animal and plant habitats – loss of natural habitat can reduce biodiversity. The occurrence of dust emissions during sand processing is accompanied by the formation of fine dust (contains silicon dioxide), which can cause diseases of the respiratory system. Water pollution caused by the flushing of sand particles and impurities (clay, metals) into reservoirs worsens water quality and can negatively affect aquatic organisms. In addition, the operation of crushing and screening plants creates high levels of noise and vibration, which negatively affects the environment and the health of workers. Sand transportation also leads to additional noise pollution. When processing sand, chemical reagents can be used (for example, to purify impurities), which leads to the risk of toxic substances entering the soil and reservoirs. Sand processing requires significant amounts of water (for example, during washing) and energy, which increases the burden on natural resources. Depletion of sand reserves – despite its prevalence, excessive extraction can lead to a local shortage of the material.

Conclusion

The Shoktas sand deposit, located in the Turkestan region, is one of the key sources of building materials in the region. The sands of the Shoktas deposit belong to Quaternary deposits and are mainly represented by Alluvial and Aeolian formations. Medium-grained sand with a particle size of 0,63–2,5 mm is mainly found, which meets the standards for use in mortars and concretes. Sand is characterized by high bulk density and optimal voidness, which makes it suitable for various building mixes. Before being used in specialized fields such as glass production or filtration systems, additional studies should be conducted to ensure compliance with established requirements. Strict control of mining, the use of more environmentally friendly processing technologies and the restoration of destroyed ecosystems are necessary to reduce environmental risks. An alternative would be the recycling of construction waste and the use of artificial sand.

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