Crossref
DOI: 10.31643/2028/6445.09
Earth and Planetary Sciences: Earth-Surface Processes

Assessment of the mineral composition, microstructure, and energy properties of the sample from the Shargun coal field based on instrumental analysis methods

[1] Sharopov Kh., [2] Makhmarezhabov D., [3*]Rabatuly M., [1] Daminov T., [3] Beisembay D.S., [3]Satbek B.A.

[1] *Islam Karim Tashkent State Technical University, Tashkent, Uzbekistan*
[2] *National Quality Assurance Agency for Education under the Administration of the President of the Republic of Uzbekistan, Tashkent, Uzbekistan*
[3]*Abylkas Saginov Karaganda Technical University, Karaganda, Kazakhstan*

** Corresponding author email: mukhammedrakhym@mail.ru*

Received: *March 5, 2026*
Peer-reviewed: *March 18, 2026*
Accepted: *May 8, 2026*

ABSTRACT
In this scientific article, the material composition and microstructure of the sample obtained from the Shargun coal deposit were studied based on complex instrumental methods. Based on the conducted research, the elemental composition was determined using an AL-NP-5010A X-ray fluorescence spectrometer, and microscopic analyses were carried out with an increase of up to 1600 times. The spectrometric analysis showed that the high intensities of silicon and aluminum are due to the high proportions of kaolin and quartz, which are aluminosilicates. Also, the detection of iron, calcium, and sulfur indicated the presence of additional sulfides in the iron and carbonate phases. Based on the results of microscopic analyses, it was established that the coal sample has a heterogeneous and porous structure, and the mineral inclusions within the organic matrix are located in a dispersed and clustered state, characterized by micro porousness. At the same time, the proportion of the mineral phase area according to the morphometric assessment was 18-27%, and the micro-porousness coefficient was in the range of 0.12-0.20. It was observed that the angular shape of the particles and the polydisperse granulometric composition correspond to the Rosin distribution. From the integral analysis of the obtained results, it was established that the high content of aluminosilicates and iron oxides increases the susceptibility to ash formation and slagging processes. Also, the presence of porous microstructures and microcracks made it possible to increase the reactivity of the process of heat treatment and gasification.

Keywords: spectrometric analysis, Microscopic analysis, granulometric composition, fluorescent spectrometer, Shargun coal.

Information about authors:

Sharopov Khusanjon Ne'mat ogli	*PhD student of the Mining Department of Islam Karim Tashkent State Technical University, 100095, Almazar district, Universitetskaya street 2, Tashkent, Uzbekistan. E-mail: sharopovhusanjon@gmail.com; ORCID ID: https://orcid.org/0009-0001-2042-3057*
Makhmarezhabov Dilmurod Bakhtiyarovich	*DSc, Associate Professor, Chief Inspector of the National Quality Assurance Agency for Education under the Administration of the President of the Republic of Uzbekistan, 100100, Bobur Street, 30, Tashkent, Uzbekistan. E-mail: dmahmarejabov@mail.ru; ORCID ID: https://orcid.org/0000-0002-7708-6485*
Rabatuly Mukhammedrakhym	*Ph.D., Associate Professor, Department of Development of Mineral Deposits of Abylkas Saginov Karaganda Technical University, 100027, Ave. Nursultan Nazarbayev, 56, Karaganda, Kazakhstan. E-mail: mukhammedrakhym@mail.ru; ORCID ID: https://orcid.org/0000-0002-7558-128X*
Daminov Temurbek Zokir ogli	*PhD student of the Mining Department of Islam Karim Tashkent State Technical University, 100095, Almazar district, Universitetskaya street 2, Tashkent, Uzbekistan. E-mail: daminov.temurbek@tdtu.uz; ORCID ID: https://orcid.org/0009-0007-2798-2752*
Beisembay Daryn Sagyntaiuly	*Master's student, Department of Development of Mineral Deposits of Abylkas Saginov Karaganda Technical University, 100027, Ave. Nursultan Nazarbayev, 56, Karaganda, Kazakhstan. E-mail: sagynta1evv09@gmail.com; ORCID ID: https://orcid.org/0009-0002-4225-487X*
Satbek Balgynbek Aybaruly	*Master's student, Department of Development of Mineral Deposits of Abylkas Saginov Karaganda Technical University, 100027, Ave. Nursultan Nazarbayev, 56, Karaganda, Kazakhstan. E-mail: balgynbekoff@gmail.com; ORCID ID: https://orcid.org/0009-0006-6408-8445*

Indroduction

The modernization of Uzbekistan's energy sector has become one of the country's foremost policy priorities, with particular emphasis on ensuring energy security and the smart use of domestic fuel and raw material resources. The Energy Strategy of the Republic of Uzbekistan until 2030 identifies two key strategic objectives: the gradual improvement of energy efficiency and the reduction of the environmental impact of energy production [1].

This strategy, revised in 2026, places special emphasis on the efficient use of local fuel resources

- including the country's existing coal reserves - through comprehensive processing, increased energy output, and the adoption of waste-free technologies for extracted coal minerals. When coal is used as an energy source, several properties are critically important: its thermic value, ash content, mineral composition, and the concentration of harmful impurities. A thorough scientific investigation of the material composition of coal raw materials, therefore, forms the practical foundation for implementing the national energy strategy [2].

The Shargun coal mine is one of the most significant domestic fuel sources, situated in the southern part of the Republic. Its coal is intended for use in thermal power plants (TPPs), various local industrial enterprises, and centralized district heating systems. Similarly, the Angren coal mine, located in the Kurama and Chatkal mountain ranges, serves as the primary fuel source for Angren TPP JSC. The material composition of coal from both the Shargun and Angren deposits directly influences a range of key technological parameters during combustion:

1) Melting temperature and degree of slag formation;

2) Fouling and deposit buildup in the heat-transfer sections of boilers;

3) Accelerated corrosion of equipment components;

4) Emissions of CO_2 and other harmful gases into the atmosphere;

5) Overall energy efficiency.

One of the central challenges in achieving the energy efficiency targets set out in the national strategy [3] is balancing increased energy output with environmental sustainability. Meeting these goals requires accurate quantification of key elemental constituents in coal - including silicon, calcium, sulfur, aluminum, and iron - alongside the implementation of appropriate processing technologies [4]. For example, sulfur content in coal minerals has a direct bearing on environmental performance, while aluminum and silicon are primary contributors to ash and slag-related problems.

Within the framework of Uzbekistan's 2030 strategy, expanding electricity generation capacity and optimizing the role of coal in the national fuel mix are both explicit objectives. Achieving these aims requires scientifically grounded analysis of coal quality and the application of optimized enrichment and processing technologies. In this context, modern analytical methods - particularly X-ray fluorescence spectrometry (XRF) - enable rapid and accurate determination of coal's material composition using standard laboratory equipment.

In this study, the material composition of a Shargun coal sample was analyzed using an AL-NP-5010A X-ray fluorescence spectrometer. The results carry direct practical relevance to the goals of the national energy strategy: improving energy efficiency, ensuring environmental sustainability, and advancing waste-free coal processing technologies. The findings provide a scientific basis for refining and optimizing coal enrichment methods.

Experimental part

The subjects of this study are representative brown coal samples of grade B-1 obtained from two deposits: the Shargun coal deposit in the Surkhandarya region, located in the south of Uzbekistan, and the Angren coal deposit in the Tashkent region. Both deposits play a significant role in the republic's solid fuel and energy system, serving as primary fuel sources for local heating networks, thermal power plants, and industrial enterprises [5].

Prior to analysis, all coal samples were prepared under laboratory conditions to ensure their representativeness. Sample preparation followed established standard procedures (Fig. 1), encompassing drying, crushing, screening, grinding, and mixing stages [6].

The samples were dried to a constant mass at temperatures between 70°C and 100°C, eliminating the influence of residual moisture on sample weight and ensuring the required analytical accuracy [7]. The dried samples were subsequently ground to a particle size of 0.074 mm, as this fine fraction optimizes the interaction between X-rays and the sample surface, improving measurement reliability [8].

An AL-NP-5010A X-ray fluorescence spectrometer and associated laboratory equipment were used to determine the elemental composition of the coal samples. XRF analysis is a modern analytical method for the in-depth investigation of elemental composition in solid materials. The method is based on the excitation of atoms within the analyzed samples under the influence of radiation and the emission of a characteristic secondary fluorescence spectrum, the intensity of which is proportional to the elemental concentration. The XRF method is widely used for the rapid and comparatively high-precision determination of the oxide composition of coal and mineral raw materials.

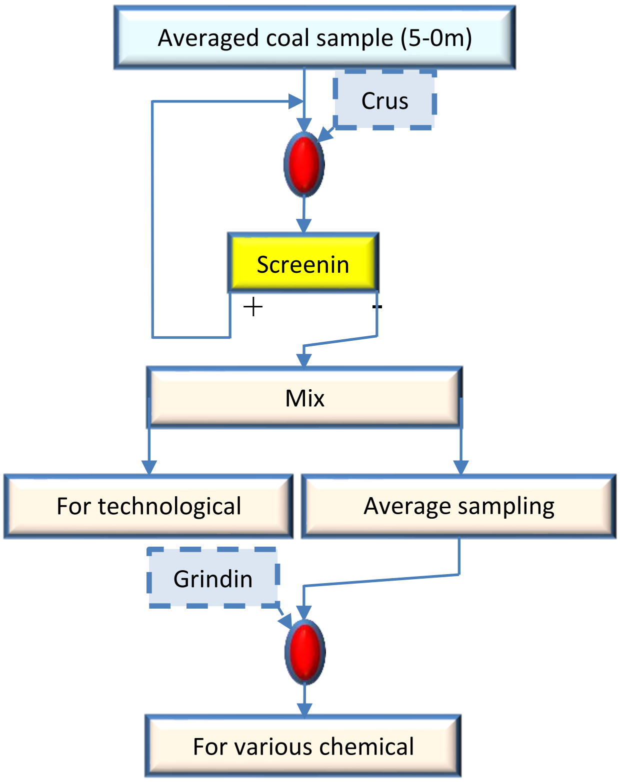

Figure 1 - Sample preparation scheme for research

The analysis was carried out at an accelerating voltage of 45 kV and a current of 300 µA, providing optimal energy conditions for the detection of various elements in the coal. Based on the analysis results, the major elements with high probability of occurrence were identified: silicon, aluminum, calcium, iron, and sulfur - elements that govern the mineral composition and ash-forming properties of the coal. The elevated concentrations of Si and Al indicate the presence of clay minerals, which serve as the primary factor responsible for increased ash yield during coal combustion. Since iron compounds may occur in the form of oxides or sulfides, they raise the risk of slag formation on the steam boiler surfaces at TPPs and accelerate the corrosion process. Sulfur content, in turn, is the principal cause of the formation of harmful combustion by-products [9].

The analytical data reported here were obtained under scientific project AL-9124093979, 'Development of Coal Enrichment and Gas Production Technology for the Construction Materials Industry'. These results constitute a preliminary analytical report on the mineral-chemical composition of Shargun coal and provide a scientific basis for evaluating its energy efficiency and industrial applicability.

Results and Discussion

X-ray fluorescence spectrometric analysis of the Shargun coal sample was performed using an AL-NP-5010A spectrometer, and the material and mineralogical-chemical composition was determined from well-resolved spectral peaks. The results are summarized in Tables 1 and 2. The highest spectral intensities corresponded to silicon (Si), with characteristic peaks at approximately 1.74 keV and intensities of 7,000–8,000 cps, indicating the predominance of aluminosilicate mineral phases. Aluminum (Al) peaks were recorded at approximately 1.49 keV with intensities of 4,500–5,500 cps, confirming the presence of aluminosilicate clay minerals such as kaolinite - $Al_2Si_2O_5$ $(OH)_4$ and $(K_{0.75}$ $(H_3O)_{0.25})$ Al_2 (Si_3Al) O_{10} $((H_2O)_{0.75}$ $(OH)_{0.25})_2$ [10].

Table 1 - Elemental composition of the Shargun coal sample (XRF analysis)

T/r	Elements	I (cps)	Quantity, %
1	Carbon (C)	6703.0	40.585
2	Nitrogen (N)	5080.0	30.758
3	Oxygen (O)	3576.0	21.652
4	Aluminium (Al)	87.0	0.527
5	Silicon (Si)	25.00	0.151
6	Phosphorus (P)	19.00	0.115
7	Sulphur (S)	18.00	0.109
8	Sodium (Na)	522.00	3.161
11	Calcium (Ca)	33.00	0.200
12	Iron (Fe)	149.00	0.902
13	Gallium (Ga)	13.00	0.079
14	Germanium (Ge)	12.00	0.073
15	Arsenic (As)	32.00	0.194
16	-	-	-

Table 2 - Elemental composition of the Angren coal sample (XRF analysis)

T/r	Elements	B-1	
		I (cps)	Quantity, %
1	Carbon (C)	6621	47.2
2	Oxygen (O)	5257	37.5
3	Aluminium (Al)	698	5
4	Silicon (Si)	464	3.3
5	Phosphorus (P)	347	2.5
6	Sulphur (S)	262	1.9
7	Iron (Fe)	209	1.5
8	Calcium (Ca)	167	1.1

A spectral peak in the energy range of approximately 2.30-2.35 keV, recorded at a moderate intensity of 2,000-3,000 cps, is attributed to sulfur (S). This finding indicates the presence of sulfide minerals such as pyrite (FeS_2) and provides scientific justification for the formation of SO_2 during coal combustion [11].

Iron (Fe) peaks were detected at approximately 6.4 keV, with intensities in the range of 1,500-2,500 cps. The presence of iron-bearing minerals in the coal is a key factor promoting slagging and deposit formation in thermal equipment during combustion [12].

Calcium (Ca) peaks were recorded at 3.69 keV at low-to-medium intensities of 1,000-1,800 cps, indicating the presence of carbonate minerals such as calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$). Calcium compounds exert a significant influence on coal combustion behavior and ash mineralogy, particularly in determining ash melting temperature and slagging tendency [13]. Furthermore, the relatively high intensities of Low-energy peaks (1-3 keV) compared to the overall spectrum indicate that the mineral fraction of the coal is substantial relative to its organic fraction, which is characteristic of brown coal.

A comprehensive interpretation of the XRF results confirms that the elevated intensities of Si and Al reflect the predominance of aluminosilicate minerals in the Shargun coal sample, while the detection of Fe and S signals the presence of pyrite (FeS_2) and related sulfide phases. These characteristics collectively increase ash yield during combustion, promote slagging, and reduce the operational efficiency of TPP steam boiler units [14]. The low intensity of heavy metal peaks in the high-energy spectral region further indicates that metallic components are present only at trace levels, with aluminosilicate phases dominating the mineral fraction [15].

Based on the obtained spectral data, it can be concluded that the Shargun coal sample is a relatively high-ash fuel, and its direct use requires optimization of combustion and processing parameters. The high concentrations of Si and Al reduce heat exchange efficiency when the coal is used directly as fuel in thermal power plants and industrial applications. The presence of sulfur and its conversion into toxic gases during combustion poses environmental risks - providing scientific justification for the implementation of gas purification technologies prior to atmospheric discharge.

The XRF analysis results for the sample obtained from the Angren coal deposit (Table 2) show that this coal differs significantly from Shargun coal in terms of its chemical and mineralogical composition.

The carbon content of the sample is 47.2%, which is higher than that recorded for the Shargun coal sample. However, the elevated oxygen content (37.5%) also indicates a high degree of oxidation in this sample [16].

Spectral analysis revealed that the aluminum and silicon contents in the Angren brown coal are 5.0% and 3.3%, respectively, both higher than the corresponding values for the Shargun coal. The predominance of aluminosilicate minerals such as kaolinite and quartz were confirmed in this sample. These elevated concentrations lead to substantial ash formation and slag buildup on equipment surfaces during combustion [17]. Furthermore, the sulfur content of the Angren brown coal sample is 1.9%, which is considerably higher than that of the Shargun coal sample.

Overall, the XRF spectral data obtained from Figures 2 and 3 confirm that the coal samples from both the Shargun and Angren deposits belong to the brown coal type, are characterized by the predominance of aluminosilicate mineral phases, and require thorough technological evaluation prior to their use in industrial, energy, and broader economic applications.

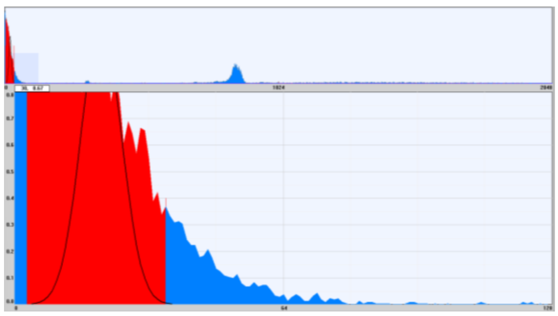

Figure 2 - Spectral intensity of the elements present in coal samples from the Shargun deposit

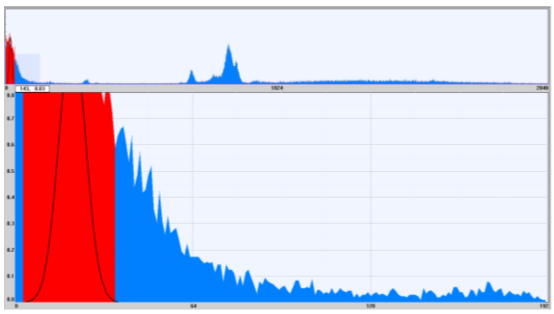

Figure 3 - Spectral intensity of elements present in coal samples from the Angren brown coal deposit

Morphological and particle size analysis of the Shargun coal sample was carried out using optical microscopy at magnifications ranging from 50× to 2,000×. At 50× magnification, particles displayed irregular, angular, and polyhedral geometries (Fig. 4), consistent with the fragmentation patterns produced by mechanical grinding.

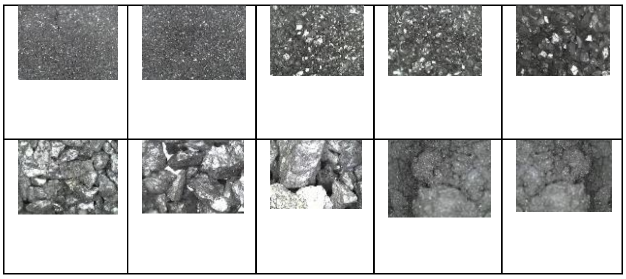

Figure 4 - Microscopic images of a sample from the Shargun coal deposit

The magnified images clearly reveal that the coal particles possess polyhedral, multi-angular, and irregular geometric shapes. This morphology confirms the high mechanical resistance of the coal to grinding and its rigid fractional composition. The angular structure of the particles indicates a dense mineralogical arrangement and the presence of inorganic mineral phases, including quartz and aluminosilicates [18].

Visual morphometric analysis indicated that the average equivalent particle diameter ranged from approximately 0.2 to 2.5 mm. Particle shape was assessed using the circularity factor (Equation 1):

$$C = \frac{4\pi S}{P^2} \quad (1)$$

where S is the projected particle area, and P is the particle perimeter. The measured values of C<0.7 confirms that the particles possess angular and irregular morphologies, reflecting the mechanical strength of the coal and its response to grinding.

At magnifications of 200-400×, light-colored mineral inclusions with high reflectivity were identified within the organic matrix. The area fraction of these mineral phases, determined by image segmentation, ranged from $F_m/F_t \approx 0.20$ to 0.27, where Fm is the mineral phase area, and Ft is the total image area. These values confirm a significant mineral content and are consistent with the Si and Al intensities recorded by XRF. The morphology of these inclusions - predominantly platy and granular - is characteristic of silicate phases, particularly kaolinite ($Al_2Si_2O_5(OH)_4$) and quartz (SiO_2) [[19], [20], [21], [22]].

At magnifications of 800-1,000×, a well-developed porous structure was clearly visible. Porosity was quantified by image analysis according to Equation 2:

$$\Upsilon = \frac{V_p}{V_t} \quad (2)$$

where Vp is the pore volume, and Vt is the total volume. The calculated porosity ranged from γ=0.10 to 0.20, consistent with the high porosity characteristic of brown coal. This pore structure is a key parameter governing the reactivity, adsorption capacity, and desorption behavior of the material [23]. At 1,600× magnification, mineral inclusions were observed to be distributed within the organic matrix as discrete, fine-grained clusters. The average mineral particle diameter ranged from approximately 5 to 60 µm, and the particle size distribution followed a log-normal function (Equation 3):

$$f(d) = \frac{1}{d\sigma\sqrt{2\pi}} \exp\left(-\frac{(lnd-\mu)^2}{2\sigma^2}\right) \quad (3)$$

This distribution is consistent with the natural sedimentary origin of the mineral phases [24, 25].

Comparative analysis of fractions at equivalent magnification revealed that finer fractions exhibit more uniform and finely dispersed mineral phases, whereas coarser fractions contain larger, heterogeneously distributed mineral inclusions. The particle size distribution of the granulometric composition was characterized using the Rosin–Rammler equation (Equation 4):

$$R(d) = \exp\left[-\left(\frac{d}{d_o}\right)^n\right] \quad (4)$$

where d_0 is the characteristic diameter and n is the distribution modulus.

Microphotographs also revealed lamellar (platy) textures, indicating a low degree of coalification (metamorphism) and the presence of vitrinite and inertinite macerals in the organic fraction.

The integrated microstructural and spectrometric analysis demonstrates that the Shargun coal sample is a brown coal characterized by a heterogeneous, highly mineralized, and porous structure with a substantial mineral fraction. This is reflected in the ash formation relationship (Equation 5):

$$S_{osh} < SiO_2+Fe_2O_3+Al_2O_3 \quad (5)$$

which shows that increasing concentrations of SiO_2, Fe_2O_3, and Al_2O_3 directly raise the ash yield upon combustion. Accordingly, microscopic analysis of the mineral phases and their spatial distribution within the coal matrix provides scientific justification for the necessity of comprehensive beneficiation (enrichment) of Shargun coal prior to its use as fuel.

Conclusions

Combined XRF spectrometric and optical microscopic analyses - carried out at magnifications of up to 1,600× - enabled a comprehensive mineralogical, chemical, and microstructural characterization of coal from the Shargun deposit. The high spectral intensities of silicon and aluminum confirm an elevated content of aluminosilicate minerals, primarily kaolinite and quartz. The detection of iron, calcium, and sulfur signals the presence of pyrite and related sulfide phases, as well as carbonate minerals.

Microscopic imaging revealed a heterogeneous particle morphology characterized by angular and polyhedral forms, with mineral inclusions dispersed in clusters throughout the organic matrix. The mineral phase area fraction ranged from 0.20 to 0.27, and the polydisperse particle size distribution confirms that the sample belongs to the brown coal type, distinguished by a highly mineralized and highly porous structure with microporosity values of γ=0.10-0.20.

Integrated interpretation of the analytical results indicates that the elevated concentrations of aluminosilicates and iron oxides increase the coal's susceptibility to ash formation and slagging during combustion. At the same time, the developed porous microstructure and the presence of microcracks enhance reactivity during thermal treatment and gasification. Taken together, these findings demonstrate that comprehensive beneficiation of Shargun coal is a necessary prerequisite for its efficient and environmentally responsible use as a fuel source.

Conflict of interest. On behalf of all authors, the corresponding author declares that there is no conflict of interest.

***CRediT author statement*:** **M. Rabatuly:** Conceptualization, Methodology, Software; **Kh. Sharopov:** Data Curation, Writing - Original Draft Preparation; **D. Makhmarezhabov, B. Satbek:** Visualization, Investigation; **T. Daminov, D. Beisembay:** Software, Validation.

Cite this article as: Sharopov Kh, Makhmarezhabov D, Rabatuly M, Daminov T, Beisembay DS, Satbek BA. Assessment of the mineral composition, microstructure, and energy properties of the sample from the Shargun coal field based on instrumental analysis methods. Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources. 2028; 344(1):90-98. https://doi.org/10.31643/2028/6445.09

Шарғұн көмір кен орнынан алынған үлгінің минералдық құрамын, микроқұрылымын және энергетикалық қасиеттерін аспаптық талдау әдістері негізінде бағалау

[1] Шаропов Х., [2] Махмарежабов Д., [3] Рабатулы М., [1] Даминов Т., [3] Бейсембай Д.С., [3] Сатбек Б.А.

[1]*Ислам Каримов атындағы ташкент Мемлекеттік Техникалық Университеті, Ташкент, Өзбекстан*
[2]*Өзбекстан Республикасы Президенті Әкімшілігі жанындағы Білім сапасын қамтамасыз ету ұлттық агенттігі, Ташкент, Өзбекстан*
[3]*Ә. Сағынов атындағы Қарағанды техникалық университеті, Қарағанды, Қазақстан*

Мақала келді: *5 наурыз 2026*
Сараптамадан өтті: *18 наурыз 2026*
Қабылданды: *8 мамыр 2026*

ТҮЙІНДЕМЕ
Бұл ғылыми мақалада Шарғұн көмір кен орнынан алынған үлгінің заттық құрамы мен микроструктурасы кешенді аспаптық әдістер негізінде зерттелді. Жүргізілген зерттеулер нәтижесінде элементтік құрам AL-NP-5010A рентген-флуоресценттік спектрометр көмегімен анықталды, микроскопиялық талдаулар 1600 есеге дейін үлкейтумен жүргізілді. Спектрометриялық талдау нәтижесінде кремний мен алюминий элементтерінің жоғары интенсивтілігі каолин мен кварцтың алюмосиликаттар түріндегі жоғары үлесіне байланысты екені көрсетілді. Сондай-ақ темір, кальций және күкірт элементтерінің анықталуы темір құрамдас және карбонатты фазаларда қосымша сульфидтердің бар екенін көрсетеді. Микроскопиялық талдау нәтижелеріне сүйене отырып, көмір үлгісінің әртекті және кеуекті құрылымы бар екені, ал органикалық матрица ішіндегі минералдық қосындылар дисперсті және кластерлі күйде орналасқаны, микрокеуектілікпен сипатталатыны анықталды. Сонымен қатар, морфометриялық бағалау бойынша минералды фаза ауданының үлесі 18–

27 % құрайды, ал микрокеуектілік коэффициенті 0,12–0,20 аралығында болды. Бөлшектердің бұрыштық пішіні мен полидисперсті гранулометриялық құрамы Розин таралуына сәйкес келетіні атап өтілген. Алынған нәтижелердің интегралдық талдауы негізінде алюмосиликаттар мен темір оксидтерінің жоғары құрамы күл түзілу және шлак түзілу процестеріне бейімділікті арттыратыны анықталды. Сонымен қатар, кеуекті микроқұрылымдар мен микрожарықтардың болуы термиялық өңдеу және газдандыру процестерінде реактивтіліктің жоғарылауына мүмкіндік береді.

Түйін сөздер: спектрометриялық талдау, микроскопиялық талдау, гранулометриялық құрам, флуоресцентті спектрометр, Шарғұн көмірі.

Авторлар туралы ақпарат:

Шаропов Хусанжон Неъмат угли	*Ислам Карим атындағы Ташкент мемлекеттік техникалық университетінің PhD докторанты, 100095, Алмазар ауданы, Университетская көшесі 2, Ташкент, Өзбекстан. E-mail: sharopovhusanjon@gmail.com; ORCID ID: https://orcid.org/0009-0001-2042-3057*
Махмарежабов Дилмурод Бахтиярович	*DSc, доцент, Өзбекстан Республикасы Президенті Әкімшілігі жанындағы Білім сапасын қамтамасыз ету ұлттық агенттігінің бас инспекторы, 100100, Бобур Көшесі, 30, Ташкент, Өзбекстан. E-mail: dmahmarejabov@mail.ru; ORCID ID: https://orcid.org/0000-0002-7708-6485*
Рабатұлы Мұхаммедрахым	*PhD докторы, Әбілқас Сағынов атындағы Қарағанды техникалық университетінің Пайдалы қазбалар кенорындарын өндіру кафедрасының қауымдастырылған профессоры, 100027, Нұрсұлтан Назарбаев даңғ. 56, Қарағанды, Қазақстан. E-mail: mukhammedrakhym@mail.ru; ORCID ID: https://orcid.org/0000-0002-7558-128X*
Даминов Темурбек Зокир угли	*Ислам Карим атындағы Ташкент Мемлекеттік Техникалық Университетінің PhD докторанты, 100095, Алмазар ауданы, Университетская көшесі, 2, Ташкент, Өзбекстан. E-mail: daminov.temurbek@tdtu.uz; ORCID ID: https://orcid.org/0009-0007-2798-2752*
Бейсембай Дарын Сағынтайұлы	*Магистрант, Әбілқас Сағынов атындағы Қарағанды техникалық университетінің Пайдалы қазбалар кенорындарын өндіру кафедрасының қауымдастырылған профессоры, 100027, Нұрсұлтан Назарбаев даңғ. 56, Қарағанды, Қазақстан. E-mail: sagynta1evv09@gmail.com; ORCID ID: https://orcid.org/0009-0002-4225-487X*
Сатбек Балғынбек Айбарұлы	*Магистрант, Әбілқас Сағынов атындағы Қарағанды техникалық университетінің Пайдалы қазбалар кенорындарын өндіру кафедрасының қауымдастырылған профессоры, 100027, Нұрсұлтан Назарбаев даңғ. 56, Қарағанды, Қазақстан. E-mail: balgynbekoff@gmail.com; ORCID ID: https://orcid.org/0009-0006-6408-8445*

Оценка минерального состава, микроструктуры и энергетических свойств образца из Шаргунского угольного поля на основе методов инструментального анализа

[1] Шаропов Х., [2] Махмарежабов Д., [3] Рабатулы М., [1] Даминов Т., [3] Бейсембай Д.С., [3] Сатбек Б.А.

[1] Ташкентский государственный технический университет имени Ислама Каримова, Ташкент, Узбекистан
[2] Национальное агентство по обеспечению качества образования при Администрации Президента Республики Узбекистан, Ташкент, Узбекистан,
[3] А.Карагандинский технический университет имени А. Сагинова, Караганда, Казахстан

Поступила: *5 марта 2026*
Рецензирование: *18 марта 2026*
Принята в печать: *8 мая 2026*

АННОТАЦИЯ

В данной научной статье изучены вещественный состав и микроструктура образца, полученного из Шаргунского угольного месторождения, на основе комплексных инструментальных методов. По результатам проведённых исследований определён элементный состав с использованием рентгенофлуоресцентного спектрометра AL-NP-5010A, а микроскопические анализы выполнены при увеличении до 1600 раз. Проведённый спектрометрический анализ показал, что высокая интенсивность элементов кремния и алюминия обусловлена значительной долей каолина и кварца в виде алюмосиликатов. Также обнаружение элементов железа, кальция и серы свидетельствует о присутствии дополнительных сульфидов в железосодержащих и карбонатных фазах. На основании результатов микроскопических анализов установлено, что образец угля обладает неоднородной и пористой структурой, а минеральные включения в органической матрице расположены в дисперсном и кластерном состоянии, характеризуемом микропористостью. При этом доля площади минеральной фазы, по морфометрической оценке, составляет 18–27 %, а коэффициент микропористости находится в диапазоне 0,12–0,20. Отмечено, что угловатая форма частиц и полидисперсный гранулометрический состав соответствуют распределению Розина. В результате интегрального анализа полученных данных установлено, что высокое содержание алюмосиликатов и оксидов железа повышает склонность к процессам золообразования и шлакования. Кроме того, наличие пористых микроструктур и микротрещин позволяет повысить реакционную способность процессов термообработки и газификации.

	Ключевые слова: спектрометрический анализ, Микроскопический анализ, гранулометрический состав, флуоресцентный спектрометр, Шаргунский уголь.
	Информация об авторах:
Шаропов Хусанжон Неъмат угли	*PhD докторант Ташкентского государственного технического университета имени Ислама Карима, 100095, Алмазарский район, ул. Университетская, 2, Ташкент, Узбекистан. E-mail: sharopovhusanjon@gmail.com; ORCID ID: https://orcid.org/0009-0001-2042-3057*
Махмарежабов Дилмурод Бахтиярович	*Доктор педагогических наук, доцент, главный инспектор Национального агентства по обеспечению качества образования при Администрации Президента Республики Узбекистан, 100100, ул. Бобура, 30, Ташкент, Узбекистан. E-mail: dmahmarejabov@mail.ru; ORCID ID: https://orcid.org/0000-0002-7708-6485*
Рабатулы Мухаммедрахым	*PhD, ассоциированный профессор кафедры Разработки месторождений полезных ископаемых Карагандинского технического университета имени Абылкаса Сагинова, 100027, пр. Нурсултана Назарбаева, 56, Караганда, Казахстан. E-mail: mukhammedrakhym@mail.ru; ORCID ID: https://orcid.org/0000-0002-7558-128X*
Даминов Темурбек Зокир угли	*PhD докторант Ташкентского государственного технического университета имени Ислама Карима, 100095, Алмазарский район, ул. Университетская, 2, Ташкент, Узбекистан. E-mail: daminov.temurbek@tdtu.uz; ORCID ID: https://orcid.org/0009-0007-2798-2752*
Бейсембай Дарын Сагынтайулы	*Магистрант кафедры Разработки месторождений полезных ископаемых Карагандинского технического университета имени Абылкаса Сагинова, 100027, пр. Нурсултана Назарбаева, 56, Караганда, Казахстан. E-mail: sagynta1evv09@gmail.com; ORCID ID: https://orcid.org/0009-0002-4225-487X*
Сатбек Балгынбек Айбарулы	*Магистрант кафедры Разработки месторождений полезных ископаемых Карагандинского технического университета имени Абылкаса Сагинова, 100027, пр. Нурсултана Назарбаева, 56, Караганда, Казахстан. E-mail: balgynbekoff@gmail.com; ORCID ID: https://orcid.org/0009-0006-6408-8445*

References

[1] Resolution of the President of the Republic of Uzbekistan dated October 4, 2019 No. PP-4477 On Approving the Strategy for the Transition of the Republic of Uzbekistan to a Green' Economy for the Period 2019-2030. Тошкент. 2019.

[2] Law of the Republic of Uzbekistan dated 23.11.2020 No. ЗРУ-648 'On Subsoil. Tashkent. 2020.

[3] Law of the Republic of Uzbekistan On Rational Use of Energy. April 25, 1997, No. 412-I. Tashkent. 1997.

[4] Law of the Republic of Uzbekistan No. 754-XII of 09.12.1992 On Environmental Protection. Tashkent. 1992.

[5] Decree of the President of the Republic of Uzbekistan dated October 4, 2019 No. PP-4477 On Approving the Strategy for the Transition of the Republic of Uzbekistan to a Green Economy for the Period 2019-2030.

[6] Ma F, Tao Y, Xian Y. Study on maceral liberation characteristics of ball grinding and rod grinding for low-rank coal. International Journal of Coal Preparation and Utilization. 2022; 42:2923-2939.

[7] Akkoyunlu M T, Pekel E, Akkoyunlu M C, Pusat S, Ozkan C, and Kara S S. Determination of effective parameters for coal moisture content determination using a 'design of experiment' method. International Journal of Coal Preparation and Utilization. 2018; 38:443-450.

[8] Dai S, Hou X, Ren D, & Tang Y. Surface analysis of pyrite in the No. 9 coal seam, Wuda Coalfield, Inner Mongolia, China, using high-resolution time-of-flight secondary ion mass-spectrometry. International Journal of Coal Geology. 2003; 55(2-4):139-150.

[9] Bekpulatov J M, Makhmarezhabov D B, Umirzokov A A. On the possibility of waste-free use of mineral resources of the Angrensky Brain coal deposit. E3S Web of Conferences. EDP Sciences. 2024; 491:08.

[10] Vassilev S V, Vassileva C G. Mineralogy of combustion wastes from coal-fired power stations. Fuel Processing Technology. 1996

[11] Vassilev S V, et al. An overview of the organic and inorganic phase composition of biomass. Fuel. 2012; 94:1-33.

[12] Raask E. Mineral impurities in coal combustion: behavior, problems, and remedial measures. CRC Press. 1985.

[13] Rabatuly M, Demin VF, Kenetaeva AA, Steflyuk YuYu, Toshov JB. Evaluation of modern methods and techniques for calculating parameters during coal bed degassing. Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources. 2025; 334 (3):110-120. https://doi.org/10.31643/2025/6445.33

[14] Ward C R. Coal geology and coal technology. 1984.

[15] Alikulov Sh, Toshov J, Mussin R, Rabatuly M, Tolovkhan B, Bogzhanova Zh, Gabitova A. Study of rational solution parameters during in-situ uranium leaching. Mining of Mineral Deposits. 2025; 19(1):37-46. https://doi.org/10.33271/mining19.01.037

[16] Van Krevelen D W. Coal: Typology-physics-chemistry-constitution. 1993.

[17] Reid W T. External corrosion and deposits: boilers and gas turbines. 1970.

[18] Stach E, Mackowyky M-Th, Teichmüller M, Taylor GH, Chandra D, Teichmüller R. (Eds.), Stach's Textbook of Coal Petrology, Gebruder Borntraeger, Berlin. 1982.

[19] O'Keefe JM, Bechtel A, Christanis K, Dai S, DiMichele WA, Eble CF, Hower JC. On the fundamental difference between coal rank and coal type. International Journal of Coal Geology. 2013; 118:58-87.

[20] Kelisbekov AK, Daniyarov NA. Prospects of application in the coal industry of multi-motor plate conveyor with frequency-controlled electric drive. Scientific, technical and production-economic journal Coal, M. 2020; 5:45-48. https://doi.org/10.18796/0041-5790-2020-5-45-48

[21] Safarov JE, Sultanova ShA, Najafli MR, Ponasenko AS, Samandarov DI, Usenov AB, Mirkomilov AM, Dadayev GT, Huseynli M, Makhmudova LA. Modeling of equilibrium heat and mass transfer in three-dimensional connected media. Processes of Petrochemistry and oil Refining. PPOR. 2026; 27(2):521-534.

[22] Vassilev SV. Mineral matter in coal and its transformations. Fuel. 2005

[23] Vassilev S V, Vassileva C G. Mineralogy of combustion wastes from coal-fired power stations. Fuel Processing Technology. 1996; 47(3):261-280.

[24] Kenetayeva AA, Usupayev SE, Kryazheva TV, Rabatuly M. Demethanization of coal seams in the Karaganda basin. IOP Conference Series: Earth and Environmental Science. 2021; 677(4), https://doi.org/10.1088/1755-1315/677/4/042118

[25] Rabatuly M, Myrzathan SA, Toshov JB, Nasimov J, Khamzaev A. Views on drilling effectiveness and sampling estimation for solid ore minerals. Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources. 2026; 336(1):5-14. https://doi.org/10.31643/2026/6445.01