

ISSN 2518-170X (Online)

ISSN 2224-5278 (Print)

**NEWS OF THE NATIONAL ACADEMY
OF SCIENCES OF THE REPUBLIC
OF KAZAKHSTAN, SERIES OF
GEOLOGY AND TECHNICAL SCIENCES**

№5

2026

ISSN 2518-170X (Online)

ISSN 2224-5278 (Print)



N E W S
OF THE NATIONAL ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN,
SERIES OF GEOLOGY AND TECHNICAL
SCIENCES

5 (479)

September – Oktober 2026

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, 2026

The scientific journal News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences has been indexed in the international abstract and citation database Scopus since 2016 and demonstrates stable bibliometric performance.

The journal is also included in the Emerging Sources Citation Index (ESCI) of the Web of Science platform (Clarivate Analytics, since 2018).

Indexing in ESCI confirms the journal's compliance with international standards of scientific peer review and editorial ethics and is considered by Clarivate Analytics as part of the evaluation process for potential inclusion in the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), and Arts & Humanities Citation Index (AHCI).

Indexing in Scopus and Web of Science ensures high international visibility of publications, promotes citation growth, and reflects the editorial board's commitment to publishing relevant, original, and scientifically significant research in the fields of geology and technical sciences.

«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық реферативтік және ғылымиметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық реферативтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылмды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

Индексирование в Scopus и Web of Science обеспечивает высокую международную востребованность публикаций, способствует росту цитируемости и подтверждает стремление редакционной коллегии публиковать актуальные, оригинальные и научно значимые исследования в области геологии и технических наук.

EDITOR-IN-CHIEF

ZHURINOV Murat Zhurinovich, Doctor of Chemical Sciences, Professor, Academician of IAAS and NAS RK, General Director of the Research Institute of Petroleum Refining and Petrochemicals (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=6602177960>; <https://www.webofscience.com/wos/author/record/2017489>

DEPUTY EDITOR-IN-CHIEF

ABSADYKOV Bakhyt Narikbayevich, Doctor of Technical Sciences, Professor, Academician of NAS RK, Satbayev University (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=6504694468>; <https://www.webofscience.com/wos/author/record/2411827>

EDITORIAL BOARD:

ABSAMETOV Malis Kudysovich, Doctor of Geological and Mineralogical Sciences, Professor, Academician of NAS RK, Director of the U.M. Akhmedsafa Institute of Hydrogeology and Geoecology (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=56955769200>; <https://www.webofscience.com/wos/author/record/1937883>

ZHOLTAEV Geroy Zholtaevich, Doctor of Geological and Mineralogical Sciences, Professor, Honorary Academician of NAS RK (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=57112610200>; <https://www.webofscience.com/wos/author/record/1939201>

SNOW Daniel, PhD, Associate Professor, Director, Aquatic Sciences Laboratory, University of Nebraska (Nebraska, USA), <https://www.scopus.com/authid/detail.uri?authorId=7103259215>; <https://www.webofscience.com/wos/author/record/1429613>

SELTMAN Reimar, PhD, Head of Petrology and Mineral Deposits Research in the Earth Sciences Department, Natural History Museum (London, Great Britain), <https://www.scopus.com/authid/detail.uri?authorId=55883084800>; <https://www.webofscience.com/wos/author/record/1048681>

PANFILOV Mikhail Borisovich, Doctor of Technical Sciences, Professor at the University of Nancy (Nancy, France), <https://www.scopus.com/authid/detail.uri?authorId=7003436752>; <https://www.webofscience.com/wos/author/record/1230499>

SHEN Ping, PhD, Deputy Director of the Mining Geology Committee of the Chinese Geological Society, Member of the American Association of Economic Geologists (Beijing, China), <https://www.scopus.com/authid/detail.uri?authorId=57202873965>; <https://www.webofscience.com/wos/author/record/1753209>

FISCHER Axel, PhD, Associate Professor, Technical University of Dresden (Dresden, Germany), <https://www.scopus.com/authid/detail.uri?authorId=35738572100>; <https://www.webofscience.com/wos/author/record/2085986>

AGABEKOV Vladimir Enokovich, Doctor of Chemical Sciences, Academician of NAS of Belarus, Honorary Director of the Institute of Chemistry of New Materials (Minsk, Belarus), <https://www.scopus.com/authid/detail.uri?authorId=7004624845>

CATALIN Stefan, PhD, Associate Professor, Technical University of Dresden (Dresden, Germany), <https://www.scopus.com/authid/detail.uri?authorId=35203904500>; <https://www.webofscience.com/wos/author/record/1309251>

JAY Sagin, PhD, Associate Professor, Nazarbayev University (Astana, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=57204467637>; <https://www.webofscience.com/wos/author/record/907886>

FRATTINI Paolo, PhD, Associate Professor, University of Milano - Bicocca (Milan, Italy), <https://www.scopus.com/authid/detail.uri?authorId=56538922400>

NURPEISOVA Marzhan Baysanovna, Doctor of Technical Sciences, Professor of Satbayev University (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=57202218883>; <https://www.webofscience.com/wos/author/record/AAD-1173-2019>

RATOV Boranbay Tovbasarovich, Doctor of Technical Sciences, Professor, Head of the Department of Geophysics and Seismology, Satbayev University (Almaty, Kazakhstan), <https://www.scopus.com/authid/detail.uri?authorId=55927684100>; <https://www.webofscience.com/wos/author/record/1993614>

RONNY Berndtsson, Professor, Director of the Centre for Advanced Middle Eastern Studies, Lund University (Lund, Sweden), <https://www.scopus.com/authid/detail.uri?authorId=7005388716>; <https://www.webofscience.com/wos/author/record/1324908>

MIRLAS Vladimir, PhD, Professor, Eastern R&D Center, Ariel University (Ariel, Israel), <https://www.scopus.com/authid/detail.uri?authorId=8610969300>; <https://www.webofscience.com/wos/author/record/53680261>

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Owner: «Central Asian Academic Research Center» LLP (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Communications of the Republic of Kazakhstan № KZ50VPY00121155, issued on 05.06.2025
Thematic scope: *geology, hydrogeology, geography, mining and chemical technologies of oil, gas and metals*
Periodicity: 6 times a year.

<http://www.geolog-technical.kz/index.php/en/>

© «Central Asian Academic Research Center» LLP, 2026.

БАС РЕДАКТОР

ЖҰРЫНОВ Мұрат Жұрыңұлы, химия ғылымдарының докторы, профессор, ХҒАҚ және ҚР ҰҒА академигі, Мұнай өңдеу және мұнай-химиясы ғылыми-зерттеу институтының бас директоры (Алматы, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=6602177960>; <https://www.webofscience.com/wos/author/record/2017489>

БАС РЕДАКТОРДЫҢ ОРЫНБАСАРЫ:

АБСАДЫҚОВ Бақыт Нәрікбайұлы, техника ғылымдарының докторы, профессор, ҚР ҰҒА академигі, Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университеті (Алматы, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=6504694468>; <https://www.webofscience.com/wos/author/record/2411827>

РЕДАКЦИЯ АЛҚАСЫ:

ӨБСӘМЕТОВ Мәліс Құдысұлы, геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, У.М. Ахмедсафин атындағы Гидрогеология және геоэкология институтының директоры (Алматы, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=56955769200>; <https://www.webofscience.com/wos/author/record/1937883>

ЖОЛТАЕВ Герой Жолтайұлы, геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА құрметті академигі (Алматы, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=57112610200>; <https://www.webofscience.com/wos/author/record/1939201>

СНОУ Дэниел, PhD, қауымдастырылған профессор, Небраска университетінің Су ғылымдары зертханасының директоры (Небраска, АҚШ), <https://www.scopus.com/authid/detail.uri?authorId=7103259215>; <https://www.webofscience.com/wos/author/record/1429613>

ЗЕЛБТМАНН Раймар, PhD, Жер туралы ғылымдар бөлімінің петрология және пайдалы қазбалар кен орындары саласындағы зерттеулерінің жетекшісі, Табиғи тарих мұражайы (Лондон, Ұлыбритания), <https://www.scopus.com/authid/detail.uri?authorId=55883084800>; <https://www.webofscience.com/wos/author/record/1048681>

ПАНФИЛОВ Михаил Борисович, техника ғылымдарының докторы, Нанси университетінің профессоры (Нанси, Франция), <https://www.scopus.com/authid/detail.uri?authorId=7003436752>; <https://www.webofscience.com/wos/author/record/1230499>

ШЕН Пин, PhD, Қытай геологиялық қоғамының Тау-кен геологиясы комитеті директорының орынбасары, Американдық экономикалық геологтар қауымдастығының мүшесі (Бейжің, Қытай), <https://www.scopus.com/authid/detail.uri?authorId=57202873965>; <https://www.webofscience.com/wos/author/record/1753209>

ФИШЕР Аксель, PhD, қауымдастырылған профессор, Дрезден техникалық университеті (Дрезден, Германия), <https://www.scopus.com/authid/detail.uri?authorId=35738572100>; <https://www.webofscience.com/wos/author/record/2085986>

АГАБЕКОВ Владимир Енокович, химия ғылымдарының докторы, Беларусь ҰҒА академигі, Жаңа материалдар химиясы институтының құрметті директоры (Минск, Беларусь), <https://www.scopus.com/authid/detail.uri?authorId=7004624845>

КАТАЛИН Стефан, PhD, қауымдастырылған профессор, Дрезден Техникалық университеті (Дрезден, Германия), <https://www.scopus.com/authid/detail.uri?authorId=35203904500>; <https://www.webofscience.com/wos/author/record/1309251>

САҒЫНТАЕВ Жанай, PhD, қауымдастырылған профессор, Назарбаев университеті (Астана, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=57204467637>; <https://www.webofscience.com/wos/author/record/907886>

ФРАТТИНИ Паоло, PhD, қауымдастырылған профессор, Бикокк Милан университеті (Милан, Италия), <https://www.scopus.com/authid/detail.uri?authorId=56538922400>

НҮРПЕЙІСОВА Маржан Байсанқызы, техника ғылымдарының докторы, Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университетінің профессоры (Алматы, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=57202218883>; <https://www.webofscience.com/wos/author/record/AAD-1173-2019>

РАТОВ Боранбай Товбасарович, техника ғылымдарының докторы, профессор, «Геофизика және сейсмология» кафедрасының меңгерушісі, Қ.И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университеті (Алматы, Қазақстан), <https://www.scopus.com/authid/detail.uri?authorId=55927684100>; <https://www.webofscience.com/wos/author/record/1993614>

РОННИ Беридтссон, профессор, Таяу Шығысты заманауи зерттеу орталығының директоры, Лунд университеті (Лунд, Швеция), <https://www.scopus.com/authid/detail.uri?authorId=7005388716>; <https://www.webofscience.com/wos/author/record/1324908>

МИРІАС Владимир, PhD, профессор, Ариэль университетінің Шығыс ғылыми-зерттеу орталығы (Ариэль, Израиль), <https://www.scopus.com/authid/detail.uri?authorId=8610969300>; <https://www.webofscience.com/wos/author/record/53680261>

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Меншіктеуші: «Орталық Азия академиялық ғылыми орталығы» ЖШС (Алматы қ.).

Қазақстан Республикасының Ақпарат және коммуникациялар министрлігінің Ақпарат комитетінде 05.06.2025 ж. берілген № KZ50VPY00121155 мерзімдік басылым тіркеуіне қойылу туралы куәлік. Тақырыптық бағыты: *геология, гидрогеология, география, тау-кен ісі, мұнай, газ және металдардың химиялық технологиялары*

Мерзімділігі: жылына 6 рет.

<http://www.geolog-technical.kz/index.php/en/>

ГЛАВНЫЙ РЕДАКТОР

ЖУРИНОВ Мурат Журинович, доктор химических наук, профессор, академик МАН и НАН РК, Генеральный директор НИИ нефтепереработки и нефтехимии (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=6602177960>; <https://www.webofscience.com/wos/author/record/2017489>

ЗАМЕСТИТЕЛЬ ГЛАВНОГО РЕДАКТОРА

АБСАДЫКОВ Бахыт Нарикбаевич, доктор технических наук, профессор, академик НАН РК, Казахский национальный исследовательский технический университет им. К.И. Сатпаева (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=6504694468>; <https://www.webofscience.com/wos/author/record/2411827>

РЕДАКЦИОННАЯ КОЛЛЕГИЯ:

АБСАМЕТОВ Малис Кудысович, доктор геолого-минералогических наук, профессор, академик НАН РК, директор Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=56955769200>; <https://www.webofscience.com/wos/author/record/1937883>

ЖОЛТАЕВ Герой Жолтаевич, доктор геолого-минералогических наук, профессор, почетный академик НАН РК (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=57112610200>; <https://www.webofscience.com/wos/author/record/1939201>

СНОУ Дэниел, PhD, ассоциированный профессор, директор Лаборатории водных наук Университета Небраски (Небраска, США), <https://www.scopus.com/authid/detail.uri?authorId=7103259215>; <https://www.webofscience.com/wos/author/record/1429613>

ЗЕЛЬТМАНН Раймар, PhD, руководитель исследований в области петрологии и месторождений полезных ископаемых в Отделе наук о Земле Музея естественной истории (Лондон, Великобритания), <https://www.scopus.com/authid/detail.uri?authorId=55883084800>; <https://www.webofscience.com/wos/author/record/1048681>

ПАНФИЛОВ Михаил Борисович, доктор технических наук, профессор Университета Нанси (Нанси, Франция), <https://www.scopus.com/authid/detail.uri?authorId=7003436752>; <https://www.webofscience.com/wos/author/record/1230499>

ШЕН Пин, PhD, заместитель директора Комитета по горной геологии Китайского геологического общества, член Американской ассоциации экономических геологов (Пекин, Китай), <https://www.scopus.com/authid/detail.uri?authorId=57202873965>; <https://www.webofscience.com/wos/author/record/1753209>

ФИШЕР Аксель, PhD, ассоциированный профессор, Технический университет Дрезден (Дрезден, Берлин), <https://www.scopus.com/authid/detail.uri?authorId=35738572100>; <https://www.webofscience.com/wos/author/record/2085986>

АГАБЕКОВ Владимир Енокович, доктор химических наук, академик НАН Беларуси, почетный директор Института химии новых материалов (Минск, Беларусь), <https://www.scopus.com/authid/detail.uri?authorId=7004624845>

КАТАЛИН Стефан, PhD, ассоциированный профессор, Технический университет Дрезден (Дрезден, Германия), <https://www.scopus.com/authid/detail.uri?authorId=35203904500>; <https://www.webofscience.com/wos/author/record/1309251>

САГИНТАЕВ Жанай, PhD, ассоциированный профессор, Назарбаев университет (Астана, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=57204467637>; <https://www.webofscience.com/wos/author/record/907886>

ФРАТТИНИ Паоло, PhD, ассоциированный профессор, Миланский университет Бикокк (Милан, Италия), <https://www.scopus.com/authid/detail.uri?authorId=56538922400>

НУРПЕИСОВА Маржан Байсановна, доктор технических наук, профессор Казахского национального исследовательского технического университета им. К.И. Сатпаева (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=57202218883>; <https://www.webofscience.com/wos/author/record/AAD-1173-2019>

РАТОВ Боранбай Товбасарович, доктор технических наук, профессор, заведующий кафедрой «Геофизика и сейсмология», Казахский национальный исследовательский технический университет им. К.И. Сатпаева (Алматы, Казахстан), <https://www.scopus.com/authid/detail.uri?authorId=55927684100>; <https://www.webofscience.com/wos/author/record/1993614>

РОННИ Берндтссон, профессор, Директор Центра современных ближневосточных исследований, Лундский университет (Лунд, Швеция), <https://www.scopus.com/authid/detail.uri?authorId=7005388716>; <https://www.webofscience.com/wos/author/record/1324908>

МИРЛАС Владимир, PhD, профессор, Восточный научно-исследовательский центр, Университет Ариэля (Ариэль, Израиль), <https://www.scopus.com/authid/detail.uri?authorId=8610969300>; <https://www.webofscience.com/wos/author/record/53680261>

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Собственник: ТОО «Центрально-Азиатский академический научный центр» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и коммуникаций и Республики Казахстан № KZ50VPY00121155, выданное 05.06.2025 г.

Тематическая направленность: *геология, гидрогеология, география, горное дело и химические технологии нефти, газа и металлов*

Периодичность: 6 раз в год.

<http://www.geolog-technical.kz/index.php/en/>

© ТОО «Центрально-Азиатский академический научный центр», 2026.

CONTENTS

Akbayeva L.KH., Akhmetova Zh.A., Doskenova B.B., Aktayev M.R., Baubek N.A. Assessment of the Radiocapacity of Atomic Lake at the Semipalatinsk Nuclear Test Site.....	8
Aliyev I.N., Kazimov Sh.P., Mammadova G.G., Manafov R.G., Gurbanov G.A. Measures for Removing Carbonate Scale Deposits Formed in the Wellbore and Downhole Equipment.....	26
Azizov B.M., Mammadov H.N. Some Aspects of Predicting Underground Hydrocarbon Reserves Based on Multispectral Satellite Imagery.....	45
Baibatsha A.B., Duczmal-Czernikiewicz A., Bulegenov K., Muratkhanov D. Geology of the Formation of Mineral Associations in the Arganat'y Ore Occurrence (Eastern Balkhash), Kazakhstan.....	62
Bashirov R., Zakenov S., Rzaev E., Bashirova G., Nurshakhanova L. Scientific Principles for Selecting Powder Materials for Laser Cladding in the Restoration of Components in the Oil and Gas Industry.....	74
Beisseyev S.A., Dossaliyev K.S., Tulekbayeva A.K., Alsheriyeu E.T., Ivakhnyuk G.K. Recommendations for Hazard Identification and Occupational Safety Risk Analysis Considering Geological and Technical Factors.....	89
Dossymbekova Zh.B., Issayeva L.Z., Assubayeva S.K., Zhumabay N.Zh., Baudagulova G.T. Petrophysical Characteristics of Bayan Deposit Rocks and Scheelite Deposition with Rare Earth Impurities.....	109
Galiyev S.Zh., Annakulov T.J., Sabirova L.B., Axanaliyev N.E. Mathematical Modeling of the Dependence of Open-Pit Excavator Productivity on Particle Size Distribution and the Loosening Coefficient of Blasted Rock Mass.....	125
Guvalov A.A., Aghazade M.E., Ibraimbayeva G.B., Stanevich V.T., Vyshar O.V. Study of Ash Obtained from Household Waste Incineration as a Mineral Additive.....	142
Iovbak A.S., Sennikov M.N. Modelling of Hydraulic Flow Redistribution in Parallel Pump Systems.....	160
KosolapYu.G., KropisYu.N., Nikitina V.A., Kononenko R.V., Komar E.V. Prediction of the Thermal Conductivity of Aqueous Electrolyte Solutions for Calculations of Mining and Geological Systems.....	177
Krasikov V.A., Losev A.N., Nikanorov M.S., Kukartseva S.V., Tsyganko E.N. Prediction of Crushing Equipment Productivity at Mining Enterprises Using the Random Forest Algorithm.....	192

Kurashkin S.O., Korableva G.V., Vakhrusheva I.A., Cherniaeva P.D., Lepekina Y.A. Prediction of Energy Consumption of a Mining Enterprise Crushing and Screening Complex Using Machine Learning Methods.....	208
Kurmanbayev O., Baidautetova G., Jangulova G., Sarsembekova Z., Bayanbek R. Concept of Processing Static GNSS Measurements in Geodynamic Monitoring of Almaty.....	224
Makhmarejabov D., Kuttybayev A., Umirzokov A., Daminov T., Sharopov Kh. Evaluation of the Compositional Differences of Fuel Types Obtained from the Angren Coal Mine.....	243
Mukaliyev Zh.K., Zhumatayeva Zh.M., Turganaliyev S.R. GIS-Based Geomorphometric Assessment of Topographic Erosion Potential at the Semipalatinsk Test Site.....	256
Mukhambetov B., Nasiyev B., Kanat T., Zhumin B. Geocological Assessment and Phytomeliorative Restoration of Degraded Arid Lands in the Atyrau Region of Western Kazakhstan.....	273
Murtazin Ye.Zh., Toktar A.T., Rakhimova V.S., Sapargaliyev D.S. Assessment of Groundwater Recharge and Resources in Mangystau Sand Massifs, Western Kazakhstan.....	290
Oralbekova L.M., Baibotayeva A.D., Kenzhalieva G.D., Naukenova A.S., Kocherov E.N. Intelligent Digital Platform for Solid Waste Management: Shymkent Smart Waste.....	309
Oralova A.T., Tshshkovskaya Ye.A., Tsoy N.K., Matonin V.V., Timoshenko P.S. Research on the Fractional Composition of Oil by Spectroscopic Methods.....	325
Panfilov I.A., Gorbachev S.I., Puchkova O.S., Oleynikova O.O., Modina M.A. Prediction of the Technical Condition of Bearing Units of Mining Equipment Using Vibration Parameters and Machine Learning.....	340
Ratov B.T., Khomenko V.L., Kuttybayev A.E., Kamyshatskyi O.F., Zhailiyev A.O. Hydraulic Characteristics of an Improved System for Real-Time Drilling Fluid Density Measurement.....	356
Ryszhana A., Amangossova A.G., Kadasheva Zh.K., Yessenamanova Zh.S., Abdinov R.Sh. Geocological-Chemical Assessment of Technogenic Contamination of the “Tukhlaya Balka” Filtration Fields Area.....	376
Shutkina E.V., Babkina A.V., Zhuravlev M.V., Kleshko I.I., Kozenkova G.L. Automatic Assessment of Crushed Rock Particle Size Distribution Based on Computer Vision Methods.....	398
Zholtayev G.Zh., Umarbekova Z.T., Mashrapova M.A., Amanbaev R.A., Karatayeva G.M. Model of Gold Mineralization Formation at the Bestobe Deposit (Northern Kazakhstan).....	414

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC
OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES

ISSN 2224-5278

Volume 5.

Number 479 (2026), 243–255

<https://doi.org/10.32014/2026.2518-170X.701>

UDC: 662.66.016:543.42

IRSTI: 52.47.01

©**Makhmarejabov D.¹, Kuttybayev A.², Umirzokov A.^{1*}, Daminov T.¹,
Sharopov Kh.¹, 2026.**

¹Tashkent State Technical University, Tashkent, Uzbekistan;

²Satbayev University, Almaty, Kazakhstan.

*E-mail: a_umirzoqov@mail.ru

EVALUATION OF THE COMPOSITINAL DIFFERENCES OF FUEL TYPES OBTAINED FROM ANGREN COAL MINE

Makhmarejabov Dilmurod — Doctor of Technical Sciences, Professor, Tashkent State Technical University, Tashkent, Uzbekistan,

E-mail: dmahmarejabov@mail.ru, <https://orcid.org/0000-0002-7708-6485>;

Kuttybayev Aidar — Candidate of Technical Sciences, Professor, Satbayev University, Almaty, Kazakhstan,

E-mail: a.kuttybayev@satbayev.university, <https://orcid.org/0000-0003-3997-8324>;

Umirzokov Azamat — PhD, Associate Professor, Tashkent State Technical University, Tashkent, Uzbekistan,

E-mail: a_umirzoqov@mail.ru, <https://orcid.org/0000-0002-9609-179X>;

Daminov Temurbek — PhD student, Tashkent State Technical University, Tashkent, Uzbekistan,

E-mail: daminov.temurbek@tdtu.uz, <https://orcid.org/0009-0007-2798-2752>;

Sharopov Khusanjon — PhD student, Tashkent State Technical University, Tashkent, Uzbekistan,

E-mail: sharopovhusanjon@gmail.com, <https://orcid.org/0009-0001-2042-3057>.

Abstract. Introduction. Differences in the material and elemental composition of coal used as an energy fuel directly affect combustion efficiency, heat balance, ash and slag formation, and environmental performance. This study aims to comparatively evaluate the elemental and mineral composition of 2 BR, B - 2, and B - 1 coal grades from the Angren coal deposit supplied to the Angren Thermal Power Plant. **Methods.** Samples of 2 BR, B-2, and B-1 coal were analyzed using X-ray fluorescence (XRF) analysis with an AL-NP-5010A spectrometer after sample preparation in accordance with applicable standards. The contents of the principal elements, including carbon, aluminum, silicon, phosphorus, sulfur, iron, and calcium, were determined and comparatively evaluated. The relationship between the organic carbon fraction and mineral components was assessed in terms of their potential influence on combustion processes. **Results.** The B-1 sample contained the highest carbon content (47.2%) and the lowest total content of the

analyzed mineral elements Al, Si, P, S, Fe, and Ca (15,3%). The 2BR sample was characterized by higher contents of silicon, phosphorus, and sulfur, whereas B-2 exhibited the highest iron content. These differences indicate a higher proportion of combustible carbon in B-1 and potentially more favorable conditions for heat release. The increased concentrations of mineral and sulfur-bearing components in 2BR and B-2 may contribute to greater ash formation, slagging, and the generation of sulfur-containing gaseous products during combustion. *Discussion and Conclusion.* The predominance of the carbon fraction in B-1 is consistent with favorable combustion characteristics and useful heat release associated with the exothermic oxidation of carbon ($\Delta H = -393.55$ kJ/mol). The higher mineral and sulfur contents of 2BR and B-2 may increase heat losses and environmental impacts. Therefore, coal beneficiation, blending with suitable additives, and/or flue-gas treatment should be considered before their use as energy fuels.

Keywords: coal fuel, carbon, coal brand, environmental hazard, exothermic process, slagging

Funding: This research AL-9124093979- Carried out within the framework of the scientific project “Development of coal enrichment and gas extraction technology for the needs of building materials industrial enterprises”.

For citations: Makhmarejabov D., Kuttybayev A., Umirzokov A., Daminov T., Sharopov Kh. Evaluation of the Compositional Differences of Fuel Types Obtained from the Angren Coal Mine. *News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences.* 2026. No.5. Pp. 243–255. DOI: <https://doi.org/10.32014/2026.2518-170X.701>

©Махмарежабов Д.Б.¹, Куттыбаев А.², Өмірзоков А.А.^{1*}, Даминов Т.З.¹, Шаропов Х.Н.¹, 2026.

¹Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан;

²Satbayev University, Алматы, Қазақстан.

*E-mail: a_umirzoqov@mail.ru

АНГРЕН КӨМІР КЕН ОРНЫНАН АЛЫНҒАН ОТЫН ТҮРЛЕРІНІҢ ҚҰРАМЫНДАҒЫ АЙЫРМАШЫЛЫҚТАРДЫ БАҒАЛАУ

Махмарежабов Дилмурод — техника ғылымдарының докторы, профессор, Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан,
E-mail: dmahmarejabov@mail.ru, <https://orcid.org/0000-0002-7708-6485>;

Қуттыбаев Айдар — техника ғылымдарының кандидаты, профессор, Satbayev University, Алматы, Қазақстан,
E-mail: a.kuttybayev@satbayev.university, <https://orcid.org/0000-0003-3997-8324>;

Өмірзоков Азамат — PhD, техника ғылымдарының кандидаты, доцент, Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан,
E-mail: a_umirzoqov@mail.ru, <https://orcid.org/0000-0002-9609-179X>;

Даминов Темірбек — PhD докторант, Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан,

E-mail: daminov.temurbek@tdtu.uz, <https://orcid.org/0009-0007-2798-2752>;

Шаропов Хусанжон — PhD докторант, Ташкент мемлекеттік техникалық университеті, Ташкент, Өзбекстан,

E-mail: sharopovhusanjon@gmail.com, <https://orcid.org/0009-0001-2042-3057>.

Аннотация. *Өзектілігі.* Энергетикалық отын ретінде пайдаланылатын көмірдің заттық және элементтік құрамындағы айырмашылықтар оның жану тиімділігіне, жылу балансына, күл мен қож түзілуіне, сондай-ақ қоршаған ортаға түсетін экологиялық жүктемеге тікелей әсер етеді. Көмір құрамындағы органикалық көміртекті фаза мен минералдық компоненттердің арақатынасы жылу бөліну қарқындылығын және жану процесінің ерекшеліктерін анықтайтын маңызды факторлардың бірі болып табылады. Зерттеудің мақсаты-Ангрен көмір кен орнының Ангрен жылу электр станциясына жеткізілетін 2BR, В-2 және В-1 маркалы көмірлерінің элементтік және минералдық құрамын салыстырмалы бағалау және олардың отындық сипаттамаларына ықпалын анықтау. *Әдістер.* Зерттеу нысаны ретінде 2BR, В-2 және В-1 маркалы көмір үлгілері алынды. Үлгілердің элементтік құрамы рентгендік-флуоресценттік (XRF) талдау әдісімен AL-NP-5010A спектрометрін пайдалана отырып анықталды. Зерттеу алдында көмір үлгілері қолданыстағы стандарттар мен әдістемелік талаптарға сәйкес дайындалды. Көмір құрамындағы негізгі элементтердің, атап айтқанда көміртек, алюминий, кремний, фосфор, күкірт, темір және кальцийдің мөлшері анықталып, олардың өзара арақатынасына салыстырмалы талдау жүргізілді. Алынған нәтижелер негізінде органикалық көміртекті фаза мен минералдық компоненттердің жану процесіне ықтимал әсері бағаланды. *Нәтижелер.* В-1 үлгісінде көміртектің ең жоғары мөлшері-47,2% және зерттелген минералдық элементтердің (Al, Si, P, S, Fe және Ca) ең төмен жиынтық мөлшері – 15,3% анықталды. 2BR үлгісінде кремний, фосфор және күкірт мөлшерінің жоғары екені байқалды, ал В-2 үлгісі темірдің ең жоғары мөлшерімен сипатталды. Бұл айырмашылықтар В-1 көмірінде жанғыш көміртекті фазаның салыстырмалы үлесі жоғары екенін көрсетеді. Сонымен қатар, 2BR және В-2 құрамындағы минералдық және күкіртті компоненттердің жоғары мөлшері күл мен қож түзілуін, сондай-ақ күкірт құрамды газ тәрізді өнімдердің пайда болуын арттыруы мүмкін. *Талқылау және қорытынды.* В-1 көміріндегі көміртекті фазаның басым болуы көміртектің экзотермиялық тотығу реакциясымен ($\Delta H = -393,55 \text{ кДж/моль}$) байланысты тиімді жылу бөлінуімен үйлеседі. Ал 2BR және В-2 көмірлеріндегі минералдық және күкіртті компоненттердің жоғары мөлшері жану кезінде қосымша жылу шығындары мен экологиялық әсердің артуына ықпал етуі мүмкін. Осыған байланысты аталған көмір маркаларын энергетикалық отын ретінде пайдаланар алдында алдын ала байыту, тиісті энергетикалық қоспалармен араластыру және/немесе түтін газдарын тазарту технологияларын қолдану мәселесін қарастыру қажет.

Түйін сөздер: көмір отыны, көміртегі, көмір маркасы, экологиялық қауіп, экзотермиялық процесс, кож түзілуі

©Махмарежабов Д.¹, Куттыбаев А.², Умирзоков А.^{1*}, Даминов Т.¹,
Шаропов Х.¹, 2026.

¹Ташкентский государственный технический университет,
Ташкент, Узбекистан,

²Satbayev University, Алматы, Казахстан.

*E-mail: a_umirzoqov@mail.ru

ОЦЕНКА РАЗЛИЧИЙ В СОСТАВЕ ВИДОВ ТОПЛИВА, ПОЛУЧЕННЫХ С АНГРЕНСКОГО УГОЛЬНОГО МЕСТОРОЖДЕНИЯ

Махмарежабов Дилмурод — доктор технических наук, профессор, Ташкентский государственный технический университет, Ташкент, Узбекистан,

E-mail: dmahmarejabov@mail.ru, <https://orcid.org/0000-0002-7708-6485>;

Куттыбаев Айдар — кандидат технических наук, профессор, Satbayev University, Алматы, Казахстан,

E-mail: a.kuttybayev@satbayev.university, <https://orcid.org/0000-0003-3997-8324>;

Умирзоков Азамат — PhD, кандидат технических наук, доцент, Ташкентский государственный технический университет, Ташкент, Узбекистан,

E-mail: a_umirzoqov@mail.ru, <https://orcid.org/0000-0002-9609-179X>;

Даминов Темурбек — докторант PhD, Ташкентский государственный технический университет, Ташкент, Узбекистан,

E-mail: daminov.temurbek@tdtu.uz, <https://orcid.org/0009-0007-2798-2752>;

Шаропов Хусанджон — докторант PhD, Ташкентский государственный технический университет, Ташкент, Узбекистан,

E-mail: sharopovhusanjon@gmail.com, <https://orcid.org/0009-0001-2042-3057>.

Аннотация. *Введение.* Различия в элементном и минеральном составе углей, используемых в качестве энергетического топлива, оказывают существенное влияние на эффективность их сжигания, тепловой баланс, интенсивность золо- и шлакообразования, а также экологические характеристики теплоэнергетических процессов. В связи с этим сравнительное исследование состава углей различных марок представляет практический интерес для оценки их потенциальных топливных свойств и определения рациональных направлений использования в теплоэнергетике. *Цель.* Провести сравнительную оценку элементного и минерального состава, а также потенциальных топливных характеристик углей марок 2BR, В-2 и В-1 Ангрэнского угольного месторождения, поставляемых для использования на Ангрэнской тепловой электростанции. *Методы.* Исследованы образцы углей марок 2BR, В-2 и В-1. Элементный состав определяли методом рентгеноспектрального анализа с использованием спектрометра XRF AL-NP-5010A после предварительной подготовки проб в соответствии с установленными стандартами и методическими требованиями. Проведен

сравнительный анализ содержания основных исследуемых элементов, включая углерод, алюминий, кремний, фосфор, серу, железо и кальций. На основе полученных данных оценены соотношения углеродной составляющей и исследуемых минеральных компонентов, а также их потенциальное влияние на процессы горения и образования золошлаковых остатков. *Результаты.* Установлено, что образец угля марки В-1 характеризуется наиболее высоким содержанием углерода - 47,2 % - и наименьшим суммарным содержанием исследованных элементов Al, Si, P, S, Fe и Ca - 15,3 %. В образце марки 2BR выявлено повышенное содержание кремния, фосфора и серы, тогда как уголь марки В-2 характеризуется наиболее высокой концентрацией железа. Полученные результаты указывают на различия в элементном составе исследованных образцов и позволяют предположить наличие у угля марки В-1 более благоприятных потенциальных топливных характеристик. Повышенное содержание компонентов, связанных с минеральной частью угля, и серы в образцах 2BR и В-2 может способствовать увеличению образования золошлаковых остатков и выбросов серосодержащих газов при сжигании. *Обсуждение и заключение.* Сравнительный анализ элементного состава показал, что уголь марки В-1 отличается более высоким содержанием углерода, что потенциально может оказывать положительное влияние на его теплотворные характеристики. При этом полное окисление углерода сопровождается выделением теплоты в соответствии с экзотермической реакцией, стандартная энтальпия которой составляет $\Delta H^\circ = -393,55$ кДж/моль. Более высокое содержание отдельных минеральных компонентов и серы в углях марок 2BR и В-2 может обуславливать увеличение количества золошлаковых остатков и экологической нагрузки при их энергетическом использовании. Для повышения эффективности применения исследованных углей целесообразно рассмотреть возможность предварительного обогащения, смешивания с другими видами топлива или применения современных технологий очистки дымовых газов. Полученные результаты могут использоваться при предварительной оценке качества угольного топлива и выборе направлений его дальнейшего исследования.

Ключевые слова: угольное топливо, углерод, марка угля, экологическая опасность, экзотермический процесс, шлакообразование

Introduction. Currently, coal fuel is considered the main source of strategic economic and political importance among the types of fuel in the energy sector and systems of the Republic of Uzbekistan. In Uzbekistan, which is developing economically, the demand for electricity and fuel energy is also increasing sharply, and at the same time, the inability of natural gas extracted from the territory of the Republic to meet all energy needs, as well as the presence of gas exports, necessitates the effective and rational use of coal as a substitute for gas energy, and its effective use is becoming one of the main scientific and practical tasks.

In recent years, the volume of coal used as fuel in thermal power plants in

Uzbekistan has increased rapidly, and the number of new power units has been put into operation. At the same time, the material composition of different grades of coal used as fuel differs significantly from each other. Such differences directly affect the combustion efficiency of coal, the amount and effect of ash and slag generated, as well as the efficiency of equipment operation and its impact on the environment (Benson and others, 1999).

From an ecological point of view, the combustion of coal depends on the quantity of the main mineral components in its composition (Ward, 1999). In particular, the number of elements such as silicon, iron, aluminum, sulfur, and calcium are one of the main factors determining heat exchange processes, slagging in steam boilers, the composition of flue gases released into the air, and at the same time the amount of harmful substances released into the atmosphere. In particular, the use of coal-based fuels, which currently emit sulfur tetroxide and other gases, is causing environmental problems. This situation is expected to lead to an increase in air pollution levels in large industrial and energy enterprises in the Republic of Uzbekistan and adjacent areas.

Also, the wrong choice of coal brand as fuel and its use without proper study of its material composition are factors that negatively affect the environment. The increase in the amount of ash and slag waste generated after the use of coal mass as fuel, and the problems associated with their storage and processing, lead to pollution of soil and water sources, which increases environmental risks at industrial energy enterprises. Therefore, it is possible to ensure environmental safety by conducting a materially in-depth practical and scientific study of coal brands used as fuel in industrial and energy enterprises.

Economically, the presence of beneficial and harmful additives in coal is a factor that directly determines the cost of generating electricity. The use of low-grade coal as fuel results in additional energy losses during the combustion process, various technological interruptions, and, at the same time, an increase in various maintenance costs.

Taking into account these factors and serious environmental hazards, a comparative study of the material composition of 2BR, B-2, and B-1 coal produced from coal mined from the Angren coal field in the Republic of Uzbekistan using modern X-ray spectral analysis methods is a scientifically and practically urgent task. Such studies may allow improving environmental and economic efficiency at Angren Thermal Power Plant, which uses this fuel, by purposefully selecting the coal brand, refining it, enriching it before burning it, or adapting it to combustion processes (Basu, 1999).

The main goal of this research is to determine the main elements and substances based on them in the material composition of 2BR, B-2 and B-1 coal mined from the Angren coal mine using X-ray spectral analysis methods, to assess the structural differences of the minerals found in their composition, and to form relevant and substantiated conclusions based on the results obtained in terms of fuel efficiency, environmental and economic efficiency.

Materials and Methods. The objects of this study were selected as coal grades 2BR, B-2 and B-1, which are used as fuel at the Angren Thermal Power Plant in Uzbekistan. These coal grades are of great importance in the production of electricity in our Republic, due to their widespread use at the Angren Thermal Power Plant. Coal samples of grades 2BR, B-2 and B-1 were taken from samples of coal mass in real conditions supplied by “Uzbekkumir” JSC to Angren TPP JSC for the purpose of conducting scientific project research on the topic of “Development of coal enrichment and gas extraction technology for the needs of construction materials industrial enterprises” funded by the state program at Tashkent State Technical University.

Before submitting the coal samples for laboratory analysis, drying, cleaning, homogenization, and spectral analysis were carried out in accordance with the requirements of standards such as ISO 18283: 2006, ISO 9516-1: 2018, and ISO 1171: 2010.

Samples of grades 2BR, B-2, and B-1 taken from the Angren coal mine were subjected to X-ray spectral analysis (Setup X-ray) using an XRF AL-NP-5010A spectrometer to determine their elemental and mineral composition (Figure 1). This method is distinguished by its ability to quickly and accurately determine the main and secondary elements and substances in coal samples (Tiainen et al., 1999; Bekpulatov et al., 2024).



Figure 1. XRF AL-NP-5010A brand spectrometer device.

The spectral readings obtained from coal samples of grades 2BR, B-2, and B-1 were processed using special software and the corresponding results were recorded. Mineralogical differences between coal grades were also substantiated by comparative analysis of the intensities generated for each element.

The analyses were carried out on an XRF AL-NP-5010A spectrometer equipped with a high-power X-ray source. During the measurement process, X-rays are focused on the sample surface, resulting in characteristic radiation spectra. Based on the obtained spectral lines, the characteristic peaks of the elements present are identified and their values are found.

In practical and research processes, the presence of the spectral intensities of chemical elements such as C, O, Al, Si, S, Fe, and Ca as major elements has been analyzed. These indicated elements are the main mineral part of coal and at the same time the main component elements that determine ash formation, efficiency during combustion and environmental performance.

Results. The classification of spectral intensities by energy indices made it possible to determine the chemical structural states of coal, the binding energy of minerals and the participation of the total mass in combustion processes, and its main physicochemical properties (Figure 2).

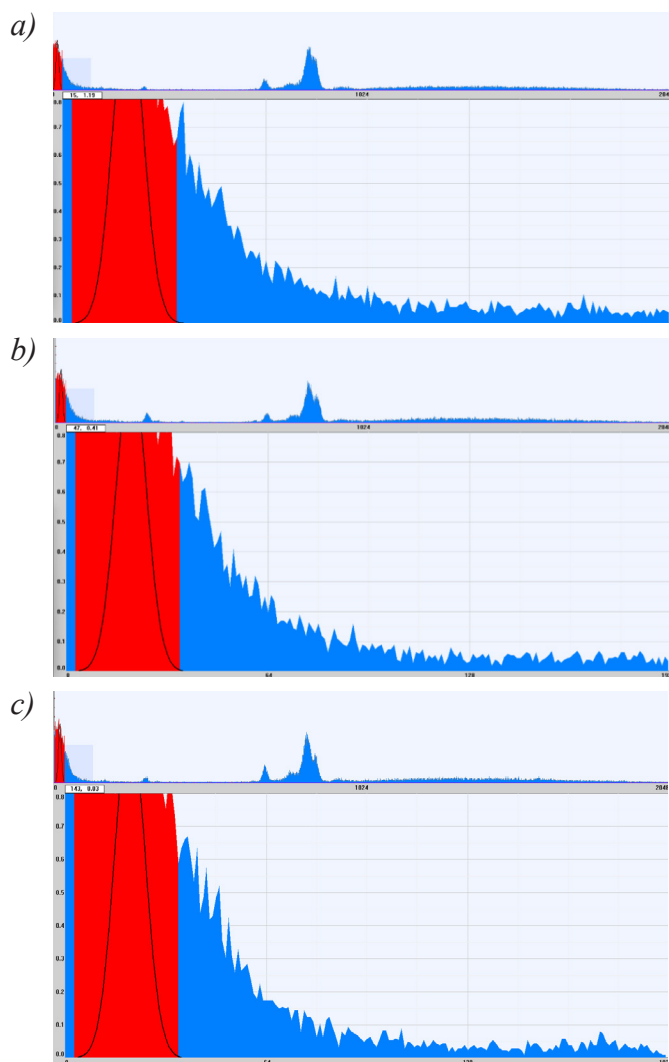


Figure 2. Spectral intensity of the elements present in the composition of coal samples of grades 2BR (a), B-2 (b), and B-1 (c) obtained from the Angren coal mine.

The results of spectral analysis of 2BR, B-2, and B-1 coal samples showed that the ratio between the organic carbon phase and the mineral components present in the samples varied significantly (Table 1).

Table 1. Number of major elements found in coal samples.

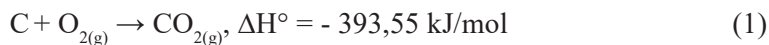
Item name	2BR		B-2		B-1	
	I (cps)	Quantity, %	I (cps)	Quantity, %	I (cps)	Quantity, %
C	6371	44.7	6225	43.7	6621	47.2
O	5128	36	5055	35.5	5257	37.5
Al	869	6	878	6.2	698	5
Si	613	4.3	596	4.2	464	3.3
P	489	3.4	447	3.1	347	2.5
S	401	2.8	327	2.3	262	1.9
Fe	147	1	450	3.1	209	1.5
Ca	251	1.8	266	1.9	167	1.1

From Table 1, when comparing the differences in the composition of coal samples of grades 2BR, B-2 and B-1, it can be seen that the B-1 coal sample had the highest carbon content, which was 47.2%. This indicator was 43.7 and 44.7% in samples of B-2 and 2BR brands, respectively, which indicates a higher combustion energy of B-1 brand coal. The oxygen content in the B-1 brand sample was 37.5%, which indicates a higher oxidation level of the coal in this sample compared to other brands. In samples of B-2 and 2BR brands, this indicator was 35.5 and 36%, respectively.

The research analysis shows that the B-2 and 2BR coal samples have significantly higher Al content than B-1, with the B-2 sample containing 6.2% and the 2BR sample containing 6%, while the B-1 coal sample contained 5%. The Si content was also low in the B-1 coal sample, at 3.3%, and in the B-2 and 2BR grades, at 4.2% and 4.3%, respectively. Based on these indicators, it is likely that the B-2 and 2BR coal samples will have high ash content. The amounts of P and S, which are considered harmful additives in the samples, were found to be the highest in the 2BR coal sample. In this coal sample, P was 3.4% and S was 2.8%. These figures indicate that the B-1 and B-2 coal samples contain less phosphorus and sulfur than 2BR, with phosphorus being 2.5% and 3.1% and sulfur being 1.9% and 2.3%, respectively.

Also, according to the analysis of metal elements, the highest iron content was determined in the B-2 sample, which was 3.1. The B-1 and 2BR grades have 1.5% and 1%, respectively, indicating a high probability of ash slagging in B-2 grade coal. Calcium content is higher in B-2 and 2BR, which affects the melting temperature of the ash.

Discussion. The energy of combustion of coal is determined by the percentage of organic matter in its composition. The combustion of coal, which has a high carbon content, can be represented by the following exothermic reaction (Elliott, 1980) (1):



This chemical reaction is the main source of heat generation, and the high energy intensity in the low-energy region in the spectral analysis of the B-1 coal sample suggests a relatively higher contribution of the carbonaceous phase (Riazi et al., 2015; Yusufu et al., 2012). In coal samples 2BR and B-2, the presence of significant proportions of other mineral components along with carbon and organic phases leads to a decrease in the amount of heat released during the combustion of the coal mass.

The total heat balance released from a coal mass during its combustion can be expressed by the following formula (2):

$$Q_{\text{all}} = Q_{\text{comb.}} - (Q_{\text{min.phas.}} + Q_{\text{loss}} + Q_{\text{los.gas-rays}}) \quad (2)$$

where, Q_{all} - the total heat balance amount released from the coal mass during the combustion process; $Q_{\text{comb.}}$ - the amount of heat released from the oxidation of carbon and volatile substances in the coal; $Q_{\text{min.phas.}}$ - the amount of heat spent on the mineral in the sample mass; Q_{loss} - the amount of heat lost due to ash formation after the combustion process; $Q_{\text{los.gas-rays}}$ - the amount of heat lost by radiation of gases formed during the combustion process (Karayigit et al., 2006).

In the samples of coal of grades 2BR and B-2, the increase in the amount of $Q_{\text{min.phas.}}$ and Q_{loss} showed that the increase in the amount of waste is the main factor causing the decrease in energy efficiency. At the same time, the high proportion of the mineral phases present in the total mass of the sample indicates the presence of structures in which aluminosilicates and iron oxides are common (Fig. 3). As a result of the adhesion interaction of these phases at high temperatures, eutectic mixtures are formed at low temperatures (Raask, 1985), and this reaction proceeds as follows (3):



These eutectic compounds liquefy at temperatures between 1100 and 1200°C and adhere to the walls of steam boilers, leading to the formation of a slag layer (Gupta et al., 1999; Bryers, 1999).

The presence of sulfur compounds in the composition of coal creates step-by-step oxidation reactions during combustion (4,5):



This raises the possibility that the 2SO_3 that is eventually formed will react with water vapor to form sulfuric acid (6):



This low-temperature reaction leads to corrosion of metal structural equipment in thermal power plants, which reduces their service life by several times. The high sulfur intensity in 2BR and B-2 coal samples indicates the activity of this chemical process [15].

Calcium-containing compounds present in the mineral composition of coal mass rarely have the ability to form bonds with SO_2 (6):



However, based on the analysis results, the low ratio of calcium to sulfur is not sufficient to fully ensure the neutralization process. As a result, some of the gases produced are released into the atmosphere (Ma et al., 2018).

Based on the results obtained and the analyses performed, thermodynamic and kinetic analyses in a simulated form show that high carbon content in B-1 coal and the weak bonding phases of other adjacent minerals ensure a high combustion rate of B-1, which is explained by the Arrhenius equation (Arisoy et al., 2015) (7):

$$k = A \cdot e^{-\frac{E_a}{RT}} \quad (7)$$

Here, the predominance of the combustible organic carbon phase as the active energy E_a is relatively low. In coals of grades 2BR and B-2, the abundance of mineral phases leads to a decrease in the combustion energy (Wang et al., 2012).

Based on the above analyses, it is shown that the B-1 coal sample has high combustion efficiency and low slagging, as well as relatively good environmental performance (Sager, 1999). In the case of 2BR and B-2 coal samples, the high content of adjacent, harmful minerals, the formation of complex chemical and thermodynamic processes during combustion, require enrichment, mixing with other energy additives, or the introduction of gas purification technologies before using them as fuel in the thermal energy system.

At the same time, the following results were obtained from the analysis of technogenic waste samples collected at JSC “Angren Thermal Power Plant,” which is the main consumer of the Angren coal deposit.

Table 2. Certain physicochemical indicators of industrial waste samples from the Angren Thermal Power Plant.

Samples	Moisture, %	Volatile Matter, %	Ash Content, %
A-1	3.57	8.1	85.93
A-2	3.15	15.0	78.25
A-3	0.35	2.5	96.69

The moisture content of the technogenic samples of the Angren Thermal Power Plant was 3.57%, 3.15%, and 0.36% for samples A-1, A-2, and A-3, respectively.

The mass loss upon heating was 14.07%, 21.75%, and 3.31%, respectively. The content of volatile fractions was 8.1% in A-1, 15.0% in A-2, and 2.5% in A-3.

Considering of these results in conjunction with the elemental composition of the coal allows for the description of structural changes in the combustion process of Angren coal. While the carbon content in the initial coal samples ranged from 43.7 to 47.2%, mineral components are concentrated in ash and slag products after coal combustion. Therefore, technogenic samples, particularly the A-3 fly ash sample, are characterized by a low content of organic and volatile components and a high proportion of mineral residue.

Overall, the B-1 coal sample is characterized by the highest carbon content (47.2%) and the lowest total content of mineral elements Al, Si, P, S, Fe, and Ca (15.3%). A higher content of Si, P, and S was noted in the 2BR sample. These structural differences indicate that the ratios of organic and mineral components in various samples of Angren coal are not identical and can be evaluated as one of the factors influencing their combustion properties and the composition of the resulting ash and slag waste.

Conclusion. A comparative physicochemical study was conducted on samples of 2BR, B-2, and B-1 coal mined from the Angren coal mine and supplied as fuel to “Angren IES” JSC based on X-ray spectral analysis. The study confirms that the thermodynamic efficiency, heat balance and environmental performance of the organic carbon phase in coal are the main factors determining the heat balance and environmental performance of the coal. Also, the dominance of the organic carbon phase in the 2BR coal sample is characterized by a high exothermic $\Delta H^\circ = -393.55$ kJ/mol during combustion, which provides useful heat release. This is explained by the reduction in energy loss in the heat balance between the mineral phases in the sample and justifies the high combustion efficiency of B-1 grade coal.

The high content of related minerals in the composition of 2BR and B-2 brand coal samples leads to heat loss, as most of the heat released during combustion is spent on these minerals. It also increases the formation of slag at low melting temperatures in the presence of aluminosilicate and iron oxides. At the same time, the oxidation of sulfide minerals leads to the formation of SO_2 , SO_3 gases, which increases environmental hazards.

The results of the study indicate that the high energy efficiency of B-1 grade coal and the poor quality of 2BR and B-2 grade coal cannot be directly used at “Angren IES” JSC or other industrial enterprises. At the same time, it is recommended to process 2BR and B-2 coal to obtain a higher quality of fuel.

References

- Arisoy A., Beamish B. (2015). Reaction kinetics of coal oxidation at low temperatures. Fuel. – Vol. 159. – P. 412-417. <https://doi.org/10.1016/j.fuel.2015.06.054> (in Eng.).
- Backman R., Hupa M., Skrifvars B.J. (1999). Predicting superheater deposit formation in boilers burning biomasses. Impact of Mineral Impurities in Solid Fuel Combustion. – Boston, MA: Springer US. – P. 405-416. https://doi.org/10.1007/0-306-46920-0_30 (in Eng.).

Basu K. (1999). The Development of Power Technologies for Low-Grade Coal. Impact of Mineral Impurities in Solid Fuel Combustion. – Boston, MA: Springer US. – P. 33-44. https://doi.org/10.1007/0-306-46920-0_3 (in Eng.).

Bekpulatov J.M., Makhmarezhabov D.B., Umirzokov A.A. (2024). On the possibility of waste-free use of mineral resources of the Angrensky Brain coal deposit. E3S Web of Conferences. – Vol. 491. – P. 02018. <https://doi.org/10.1051/e3sconf/202449102018> (in Eng.).

Benson S.A., Sondreal E.A. (1999). Ash-related issues during combustion and gasification. Impact of Mineral Impurities in Solid Fuel Combustion. – Boston, MA: Springer US. – P. 1-21. https://doi.org/10.1007/0-306-46920-0_1 (in Eng.).

Bryers R.W. (1999). Factors critically affecting fireside deposits in steam generators. Impact of Mineral Impurities in Solid Fuel Combustion. – Boston, MA: Springer US. – P. 105-131. https://doi.org/10.1007/0-306-46920-0_7 (in Eng.).

Demirbas A. (2007). Utilization of coal as a source of chemicals. Energy Sources, Part A. – Vol. 29(8). – P. 677-684. <https://doi.org/10.1080/009083190957810> (in Eng.).

Elliott M.A. et al. (1981). Chemistry of Coal Utilization: Second Supplementary Volume. – New York. – 2151 p. (in Eng.).

Gupta R.P., Wall T.F., Baxter L. (1999). The thermal conductivity of ash deposits: particulate and slag structures. Impact of Mineral Impurities in Solid Fuel Combustion. – Boston, MA: Springer US. – P. 65-84. https://doi.org/10.1007/0-306-46920-0_5 (in Eng.).

Karayigit A.I. et al. (2006). Mass balance of major and trace elements in a coal-fired power plant. Energy Sources, Part A. – Vol. 28(14). – P. 1311-1320. <https://doi.org/10.1080/009083190910523> (in Eng.).

Kök M. V. (2005). Temperature-controlled combustion and kinetics of different rank coal samples. Journal of Thermal Analysis and Calorimetry. – Vol. 79(1). – P. 175-180. <https://doi.org/10.1007/s10973-004-0581-6> (in Eng.).

Ma H., Zhou L., Ma S., Wang Z., Cui Z., Zhang W., Li J. (2018). Reaction mechanism for sulfur species during pulverized coal combustion. Energy & Fuels. – Vol. 32(3). – P. 3958-3966. <https://doi.org/10.1021/acs.energyfuels.7b03868> (in Eng.).

Raask E. (1985). Mineral Impurities in Coal Combustion: Behavior, Problems, and Remedial Measures. – CRC Press. (in Eng.).

Riazi M.R., Gupta R. (eds.). (2015). Coal Production and Processing Technology. – CRC Press. – 519 p. <https://doi.org/10.1201/b19352> (in Eng.).

Sager M. (1999). Environmental aspects of trace elements in coal combustion. Toxicological & Environmental Chemistry. – Vol. 71(1-2). – P. 159-183. <https://doi.org/10.1080/02772249909358790> (in Eng.).

Tiainen M. S. et al. (1999). Determination of amorphous material in peat ash by X-ray diffraction. Impact of Mineral Impurities in Solid Fuel Combustion. – Boston, MA: Springer US. – P. 217-224. https://doi.org/10.1007/0-306-46920-0_15 (in Eng.).

Wang L. et al. (2012). A critical review on additives to reduce ash related operation problems in biomass combustion applications. Energy Procedia. – Vol. 20. – P. 20-29. <https://doi.org/10.1016/j.egypro.2012.03.004> (in Eng.).

Ward C. R. (1999). Mineral characterization for combustion: the contribution from the geological sciences. Impact of Mineral Impurities in Solid Fuel Combustion. – Boston, MA: Springer US. – P. 23-32. https://doi.org/10.1007/0-306-46920-0_2 (in Eng.).

Yusufu M. I., Ariaahu C. C., Igbabul B. D. (2012). Production and characterization of activated carbon from selected local raw materials. African Journal of Pure and Applied Chemistry. – Vol. 6(9). – P. 123-131. <https://doi.org/10.5897/AJPAC12.022> (in Eng.).

Zhang' D., Jackson P. J., Vuthaluru H. B. (1999). Low-rank coal and advanced technologies for power generation. Impact of Mineral Impurities in Solid Fuel Combustion. – Boston, MA: Springer US. – P. 45-64. https://doi.org/10.1007/0-306-46920-0_4 (in Eng.).

Publication Ethics and Publication Malpractice in the journals of the Central Asian Academic Research Center LLP

For information on Ethics in publishing and Ethical guidelines for journal publication see <http://www.elsevier.com/publishingethics> and <http://www.elsevier.com/journal-authors/ethics>.

Submission of an article to the journals of the Central Asian Academic Research Center LLP implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see <http://www.elsevier.com/postingpolicy>), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The Central Asian Academic Research Center LLP follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service <http://www.elsevier.com/editors/plagdetect>.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/ or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the Central Asian Academic Research Center LLP.

The Editorial Board of the Central Asian Academic Research Center LLP will monitor and safeguard publishing ethics.

Requirements for articles design for publication in the journal are available on the websites:

**[www:nauka-nanrk.kz](http://www.nauka-nanrk.kz)
<http://www.geolog-technical.kz/index.php/en/>
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)**

Managing Editor: *T. Apendiyev*
Editors: *D.S. Alenov, A.Shormakova*
Computer layout: *G.D. Zhadyranova*

Signed for print: Oktober 14, 2026
Format: 70×90 1/16. 26.5 printed sheets. Order No. 5.

*«Central Asian Academic Research Center» LLP
Almaty, Shevchenko Street, 28*