



20th Balkan Mineral Processing Congress

PROCEEDINGS BOOK

Editors

Esra Baştürkcü

Yusuf Enes Pural

Zeynep Üçerler Çamur

APRIL 9-11

2026

İSTANBUL

TÜRKİYE





20th Balkan Mineral Processing Congress

PROCEEDINGS BOOK

Editors

Esra Baştürkcü
Yusuf Enes Pural
Zeynep Üçerler Çamur

ISBN: 978-975-7946-48-9

*Publishing of Proceedings was sponsored by YMGV
(Turkish Mining Development Foundation)*

All rights reserved. No part of this publication may be reproduced or transmitted in any form or any means, electronic or mechanical, including photocopy, recording or any information storage and retrieval system, without permission in writing from the Turkish Mining Development Foundation.

YMGV
Turkish Mining Development Foundation
(Yurt Madenciliđini Geliřtirme Vakfı)

Harbiye, Cumhuriyet Cad. 295/5 Daire:110 Őiřli
34367-Istanbul/TÜRKİYE

Web : www.ymgv.org.tr
e-mail : ymgv@ymgv.org.tr

©2026 YMGV

ISBN : 978-975-7946-48-9

Published by
YMGV

This congress is dedicated to the memory of Prof. Dr. Güven ÖNAL.



*Prof. Dr. Güven ÖNAL
(1940-2024)*

*President of Balkan Mineral Processing Scientific Committee
(1995-2024)*

*President of Balkan Mineral Processing Science Academy
(2001-2024)*

Dear Readers,

Putting together the proceedings of a congress is, in many ways, a quieter kind of work. One that happens behind the scenes while everything else is taking shape. As the editorial board of BMPC 2026, we have had the privilege of being close to this process from early on, and this volume is the result of that collective effort.

Of the 139 papers included, 13 are plenary presentations, 86 are oral, and 40 are poster contributions. The most active sessions in terms of submissions were Hydrometallurgy, Pyrometallurgy and Bio-Processing with 22 papers, Flotation and Surface Chemistry Processes with 20, and Material Analysis and Mineral Characterization with 18, together accounting for more than 43% of all contributions. These figures reflect where much of the current research energy in the field is concentrated, though the breadth of topics across all 16 sessions points to a community that remains wide in its interests.

Geographically, Türkiye led with 65 contributions, followed by Albania with 11 and Kosovo with 6. Beyond the immediate region, researchers from Finland, Germany, Norway, Brazil, Algeria, and Australia were also among the contributors, reflecting a community that has quietly but steadily grown in reach over the years.

We would like to thank all authors for their submissions and their patience through the review and editing process. Our gratitude also goes to the reviewers, whose careful evaluations were essential in maintaining the scientific quality of this collection.

We hope this volume serves as a useful reference, and perhaps as a starting point for new collaborations.

Dr. Esra BAŞTÜRKÇÜ Dr. Yusuf Enes PURAL Dr. Zeynep ÜÇERLER ÇAMUR
Editorial Board, BMPC 2026 Proceedings

Since 1973: Advancing Mineral Processing Together

For several decades, a significant number of researchers and specialists in the Balkan region have devoted their efforts to advancing the science and practice of mineral processing. Their work has focused on establishing and improving industrial concentration processes, expanding production capacities, optimizing operational performance, enhancing energy efficiency in processes and equipment, and developing innovative machinery and technologies. Through these sustained efforts, mining and mineral processing activities in the Balkans have achieved steady progress and continue to play an important role in the region today.

This long-standing scientific endeavor has led to the emergence of many distinguished researchers in mineral processing across the Balkan region. In 1973, the first Balkan Mineral Processing Committee (BMPC) was established by its founding members: Prof. Dr. Kiriak Petrov Kovachev (Bulgaria), Prof. Dr. Parachiv Ilie (Romania), Prof. Dr. Dusan Salatic (Serbia), and Prof. Dr. Zeki Doğan (Türkiye).

The Balkan Mineral Processing Congress (BMPC) has been held for more than fifty years. The first Balkan Mineral Processing Conference took place in Varna, Bulgaria, from November 12 to 15, 1973. During the final session of that event, the Balkan Mineral Processing Scientific Committee (BMPSC) for Conferences was formally established. Today BMPSC has 27 active members from Albania (3), Bosnia-Herzegovina (2), Bulgaria (2), Greece (3), Republic of Kosovo (3), Moldova (1), Montenegro (3), North Macedonia (3), Romania (3), Slovenia (1), Türkiye (3), and 12 honorary members from Albania (2), Bulgaria (2), North Macedonia (1), Romania (3), Serbia (1), Türkiye (3).

In early meetings of BMPSC, the Committee decided that a Balkan Mineral Processing Conference would be organized every two years (later changed to three years), each time hosted by a different Balkan country. A major milestone in the development of BMPC occurred during the 9th Balkan Mineral Processing Conference, held in Istanbul (Türkiye) from September 11 to 13, 2001, under the chairmanship of Prof. Dr. Güven Önal. At that time, the event evolved from a “Conference” into a “Congress,” reflecting its growing scientific impact, the increasing number of participants, and the high quality of the papers presented. To date, nineteen (19) conferences/congresses have been successfully organized in various Balkan countries, including Albania (2), Bosnia-Herzegovina (1), Bulgaria (3), Greece (1), Republic of Kosovo (1), Romania (3), North Macedonia (1), Serbia (3), and Türkiye (3).

Following the establishment of the Balkan Mineral Processing Scientific Committee, the Balkan Mineral Processing Science Academy (BMPSA) was founded in 2001. Its founding members included Prof. Dr. Güven Önal (Türkiye), Prof. Dr. Zeki Doğan (Türkiye), Prof. Dr. Gülhan Özbayoğlu (Türkiye), Prof. Dr. Suna Atak (Türkiye), Prof. Dr. Dusan Salatic (Serbia), Prof. Dr. Nadezda Calic (Serbia), and Prof. Dr. Parachiv Ilie (Romania). Today, BMPSA has 43 members, including founding members, full members, and corresponding members; unfortunately, some of these distinguished members have passed away. Prof. Dr. Güven Önal served as the President of both the Balkan Mineral Processing Scientific Committee from 1995 and the Balkan Mineral Processing Science Academy from 2001 until his passing on March 31, 2024. Following his leadership, Prof. Dr. Fatma Arslan has continued this responsibility as President.

Participation in the activities of the Balkan Mineral Processing Scientific Committee has created a strong connection between regional scientific development and global

technological trends. It has also provided valuable opportunities for direct interaction among researchers, designers, equipment manufacturers, and investors from the Balkan region and beyond. Over time, the BMPC has evolved into a well-established international event held every three years, attracting participants not only from the Balkan countries but also from many other parts of the world.

The XXth Balkan Mineral Processing Congress (BMPC 2026) was held in Istanbul, Türkiye, on April 9-11, 2026, for the fourth time in the country. The congress is organized by the Mineral Processing Engineering Department of the Mining Faculty at Istanbul Technical University, in cooperation with the Turkish Mining Development Foundation (YMGV). This congress is the first one after Prof. Güven Önal's loss and is dedicated to the memory of Prof. Dr. Güven Önal.

I would like to express my sincere gratitude to the Head of the Mineral Processing Engineering Department, Prof. Dr. Murat Olgaç Kangal, and to the President of the Turkish Mining Development Foundation, Mr. Ali Türkoğlu, for their leadership in organizing this congress. I also extend my thanks to the secretaries of the organizing committee, Prof. Dr. Feridun Boylu and Prof. Dr. Gülay Bulut (BMPSC Secretary), and to Assoc. Prof. Dr. Genc Demi (BMPSC Vice President), to all members of the Balkan Mineral Processing Scientific Committee, to the members of the organizing committee, and to all participants whose contributions have made this congress both valuable and memorable. Without their dedication and support, this congress would not have been possible.

Finally, I would also like to extend our sincere appreciation to the sponsoring organizations and institutions whose generous support has significantly contributed to the successful organization of BMPC 2026.

Prof. Dr. Fatma ARSLAN

President

Balkan Mineral Processing Scientific Committee

Balkan Mineral Processing Science Academy

Dear Participants,

The Mining Development Foundation of Turkey has, since its establishment, continued its efforts to support the development of mining and mineral processing in Türkiye, to promote the effective utilization of domestic resources, and to contribute to the dissemination of scientific knowledge through congresses, conferences, and publications.

The XXth Balkan Mineral Processing Congress (BMPC 2026), held in Istanbul on April 9–11, 2026, represents a well-established regional platform that enables the exchange of scientific and technical knowledge in the field of mineral processing. Organized in cooperation with the Department of Mineral Processing Engineering of the Faculty of Mines at Istanbul Technical University, the congress continues a long-standing tradition of collaboration and knowledge sharing across the Balkan region and beyond.

Over time, BMPC has evolved into an international platform where researchers, engineers, and industry representatives come together to discuss technological developments, operational challenges, and new approaches. The congress supports not only scientific exchange but also the strengthening of professional networks and the development of regional collaborations.

At a time when our Foundation marks its 40th anniversary, the organization of the Balkan Mineral Processing Congress for the 20th time demonstrates both the continuity of institutional knowledge and its transformation into a scientific platform with international recognition.

This year's congress holds additional significance as it is the first BMPC organized following the passing of the late Prof. Dr. Güven Önal, who made important contributions to the Turkish mining sector and the Balkan mineral processing community. Prof. Dr. Güven Önal, who served for many years as the President of the Mining Development Foundation of Turkey and played a key role in shaping its current institutional structure, also held long-term leadership positions within the Balkan Mineral Processing Scientific Committee (BMPSC) and the Balkan Mineral Processing Science Academy (BMPSA). Through these roles, he guided the institutional and scientific development of BMPC and made pioneering contributions to its establishment as an international platform. We remember him with respect, gratitude, and deep appreciation.

As the Mining Development Foundation of Turkey, we would like to express our sincere thanks to the Ministry of Energy and Natural Resources of the Republic of Türkiye, Istanbul Technical University, the Faculty of Mines, and the Department of Mineral Processing Engineering, as well as to all institutions and organizations that contributed to the organization of the congress. We also extend our gratitude to our sponsors, invited speakers, session chairs, authors, reviewers, members of the organizing and scientific committees, and all participants.

We are pleased to present this proceedings book to the national and international mining and mineral processing community and hope that it will serve as a valuable resource for future studies.

M. Ali TÜRKOĞLU
Chairman of the Board
Mining Development Foundation of Turkey

Dear Colleagues,

It is a great honor and privilege to present the proceedings of the 20th Balkan Mineral Processing Congress (BMPC 2026).

Since its inception in 1973 in Varna, Bulgaria, the Balkan Mineral Processing Congress has evolved into a well-established and respected scientific platform, bringing together researchers, academics, and industry professionals from across the region and beyond. Over the decades, BMPC has played a significant role in promoting knowledge exchange, fostering collaboration, and advancing the field of mineral processing.

The 20th edition of the Congress proudly continues this strong tradition by addressing contemporary challenges and emerging opportunities in mineral processing and extractive metallurgy. Particular emphasis has been placed on innovative and sustainable approaches in mineral beneficiation, recycling of secondary resources, critical raw materials, and environmentally responsible processing technologies.

This volume comprises a total of 139 scientific papers, contributed by researchers from 30 different countries, reflecting the truly international character of the congress. The contributions are organized across 16 thematic sections, covering a broad spectrum of topics and demonstrating the diversity and interdisciplinary nature of current research in mineral processing.

The papers included in this proceedings volume represent a high level of scientific quality and provide valuable insights into current research trends, technological advancements, and industrial applications. We believe that this collection will serve as an important reference for both academic researchers and industry practitioners.

I would like to express my sincere gratitude to all authors for their valuable contributions, to the members of the Scientific and Organizing Committees for their dedicated efforts, and to all reviewers for their careful evaluations, which have ensured the high quality of this publication.

I also extend my appreciation to all participants, sponsors, and supporting institutions whose contributions have made BMPC 2026 a successful and impactful event.

I hope that this volume will inspire further research, strengthen international collaboration, and contribute to innovation in the field of mineral processing.

Yours sincerely,

Prof. Dr. Murat Olgaç KANGAL

Chairman, BMPC 2026

BALKAN MINERAL PROCESSING SCIENTIFIC COMMITTEE MEMBERS

President: Prof. Dr. Fatma ARSLAN, Türkiye

Vice President: Assoc. Prof. Dr. Genc DEMI, Albania

Secretary: Prof. Dr. Gülay BULUT, Türkiye

Members

MSc. Ekita FETAHU TOSKA,
Albania

Asst. Prof. Dr. Kimet FETAHU,
Albania

Prof. Dr. Ljiljana TANKOSIĆ,
Bosnia and Herzegovina

Prof. Dr. Nedžad ALIC, Bosnia
and Herzegovina

Prof. Dr. Irena GRIGOROVA,
Bulgaria

Prof. Dr. Marinela PANAYOTOVA,
Bulgaria

**Prof. Dr. Georgios N.
ANASTASSAKIS,** Greece

Prof. Dr. Maria TAXIARHOU,
Greece

**Asst. Prof. Dr. Panagiotis
ANGELOPOULOS,** Greece

Prof. Dr. Igor NICOARA, Moldova
Alen ŠTULIĆ, Montenegro

Boško ŠLJIVANČANIN,
Montenegro

Branislav VUKOVIĆ, Montenegro

Prof. Dr. Afrodita ZENDELSKA,
North Macedonia

Prof. Dr. Boris KRSTEV, North
Macedonia

Mrs. Davor TONEVSKI, North
Macedonia

Dr. Habib BASHOLLI, Republic of
Kosovo

Prof. Dr. Naser PEĆI, Republic of
Kosovo

Prof. Dr. Nurten DEVA, Republic
of Kosovo

Dr. Alexandru MIHAI, Romania

Dr. Gelu MARACINEANU,
Romania

**Prof. Dr. Traistă Eugen
NICOLAE,** Romania

Prof. Dr. Slavomír Hredzák,
Slovakia

Prof. Dr. Ayhan Ali SİRKECİ,
Türkiye

Honorary Members

Prof. Dr. Vladimir PEZA, Albania

Prof. Dr. Avni KALTANI, Albania

Prof. Dr. Nadezda DAVCHEVA, Bulgaria

Prof. Dr. Ivan NISHKOV, Bulgaria

Prof. Dr. Boris FIDANCHIEV, North Macedonia

Prof. Dr. Sanda KRAUSZ, Romania

Dr. Lilliana CIOBANU, Romania

Dr. Viorica CIOCAN, Romania

Prof. Dr. Nadezda CALIC, Serbia

Prof. Dr. Suna ATAK, Türkiye

Prof. Dr. Gülhan ÖZBAYOĞLU, Türkiye

Prof. Dr. Neşet ACARKAN, Türkiye

XX BALKAN MINERAL PROCESSING CONGRESS ORGANIZING COMMITTEE

President

Ali TÜRKOĞLU, Head of Turkish Mining Development Foundation, Türkiye

Prof. Dr. Murat Olgaç KANGAL, Head of Mineral Processing Eng. Depart.,
ITU, Türkiye

Secretary

Prof. Dr. Feridun BOYLU, Mineral Processing Eng. Depart., ITU, Türkiye

Prof. Dr. Gülay BULUT, Mineral Processing Eng. Depart. ITU, Türkiye

Members

Prof. Dr. Mustafa KUMRAL, Dean of Faculty of Mines ITU, Türkiye

Ali EMİROĞLU, Vice Head of Turkish Mining Development Foundation,
Türkiye

Prof. Dr. Ayhan Ali SİRKECİ, Mineral Processing Eng. Depart., ITU, Türkiye

Prof. Dr. Orhan ÖZDEMİR, Mineral Processing Eng. Depart., ITU, Türkiye

Prof. Dr. Fırat BURAT, Mineral Processing Eng. Depart., ITU, Türkiye

Assoc. Prof. Dr. Birgül BENLİ, Mineral Processing Eng. Depart., ITU, Türkiye

Assoc. Prof. Dr. Hüseyin BAŞTÜRKCÜ, Mineral Processing Eng. Depart., ITU,
Türkiye

Assoc. Prof. Dr. Mustafa ÖZER, Mineral Processing Eng. Depart., ITU, Türkiye

Dr. Kudret Tahsin PEREK, Mineral Processing Eng. Depart., ITU, Türkiye

Dr. Şükriye Beste AYDIN, Mineral Processing Eng. Depart., ITU, Türkiye

Dr. Esra BAŞTÜRKCÜ, Mineral Processing Eng. Depart., ITU, Türkiye

Dr. Yusuf Enes PURAL, Mineral Processing Eng. Depart., ITU, Türkiye

Res. Asst. Dr. Zeynep ÜÇERLER ÇAMUR, Mineral Processing Eng. Depart.,
ITU, Türkiye

Res. Asst. Tülay TÜRK, Mineral Processing Eng. Depart., ITU, Türkiye

Res. Asst. Oğuzhan Mert GÜRKAN, Mineral Processing Eng. Depart., ITU,
Türkiye

Res. Asst. Ceyda GÜRKAN, Mineral Processing Eng. Depart., ITU, Türkiye

Res. Asst. Nazlım İlkyaz DİNÇ, Mineral Processing Eng. Depart., ITU,
Türkiye

Res. Asst. Yunus Emre ÇAVDAR, Mineral Processing Eng. Depart. ITU,
Türkiye

Res. Asst. Gülşah GÜVEN, Mineral Processing Eng. Depart., ITU, Türkiye

Res. Asst. Tülin ULUCAN, Mineral Processing Eng. Depart., ITU, Türkiye

Res. Asst. Ulaş USLU, Mineral Processing Eng. Depart., ITU, Türkiye

Berna BABA, Mineral Processing Eng. Depart., ITU, Türkiye

Eng. Zeynep AKTUNA ÜSTÜNDAĞ, Mineral Processing Eng. Depart., ITU,
Türkiye

Gülseren KOÇER, Turkish Mining Development Foundation, Türkiye

Ferah DUKUL, Turkish Mining Development Foundation, Türkiye

XX BMPC SCIENTIFIC COMMITTEE

Assoc. Prof. Dr. Boris ALBIJANIC,
Australia

Prof. Dr. N. Emre ALTUN, Türkiye

Prof. Dr. Cüneyt ARSLAN, Türkiye

Prof. Dr. Seher ATA, Australia

Dr. Khandjamts BATJARGAL, Mongolia

Prof. Dr. Oktay BAYAT, Türkiye

Prof. Dr. Zarife Bajraktari GASHI,
Kosovo

Prof. Dr. Saeed Chehreh CHELGANI,
Sweden

Prof. Dr. Mohamed CHETTIBI, Algeria

Prof. Dr. Mehmet S. ÇELİK, Türkiye

Prof. Dr. Üner ÇOLAK, Türkiye

Prof. Dr. Hao DU, China

Prof. Dr. Hasan ERGİN, Türkiye

Prof. Dr. Lev FILIPPOV, France

Prof. Dr. Helmut FLACHBERGER,
Austria

Prof. Dr. Zhiyong GAO, China

Prof. Dr. Ferihan GÖKTEPE, Türkiye

Prof. Dr. Alim GÜL, Türkiye

Prof. Dr. Sebahattin GÜRMEŒ, Türkiye

Prof. Dr. Anh H. NGUYEN, Australia

Prof. Dr. Stoyan I. KARAKASHEV,
Bulgaria

Assoc. Prof. Dr. Jože KORTNIK,
Slovenia

Prof. Dr. Przemyslaw B. KOWALCZUK,
Norway

Dr. Ozan KÖKKILIÇ, Canada

Prof. Dr. Haldun KURAMA, Türkiye

Prof. Dr. İlgin KURŞUN, Türkiye

Assoc. Prof. Dr. Malibongwe MANONO,
South Africa

Prof. Dr. İslam MUSTAFAYEV,
Azerbaijan

Prof. Dr. Hasan Can OKUTAN, Türkiye

Prof. Dr. Şafak Gökhan ÖZKAN,
Türkiye

Prof. Dr. Marinela PANAYOTOVA,
Bulgaria

Dr. Martin RUDOLPH, Germany

Prof. Dr. André Carlos SILVA, Brazil

Prof. Dr. Elenice Maria Schons SILVA,
Brazil

Prof. Dr. Ayhan Ali SİRKECİ, Türkiye

Prof. Dr. Hikmet SİS, Türkiye

Prof. Dr. Xuming WANG, USA

Dr. Ünzile YENİAL ARSLAN, Australia

Prof. Dr. A. Ekrem YÜCE, Türkiye

Assoc. Prof. Dr. Jan ZAWALA,
Poland

PARTICIPATING COUNTRIES

Albania (11)	Japan (1)
Albania-Kosovo (1)	Kosovo (6)
Algeria (5)	Kosovo-North Macedonia-Türkiye (1)
Algeria-India (1)	Mexico-Germany-Finland (1)
Australia (2)	North Macedonia (2)
Austria (1)	North Macedonia-Albania-Türkiye-Kosovo (1)
Bosnia and Herzegovina (5)	Norway (3)
Bosnia and Herzegovina-Montenegro (1)	Romania (5)
Brazil (3)	Serbia-Bosnia and Herzegovina (1)
Bulgaria (3)	Slovenia (1)
Canada (1)	South Africa (1)
Chile-Finland (2)	Sweden (1)
Finland (3)	Türkiye (65)
Finland-Ghana (1)	Türkiye-Australia (2)
Finland-Türkiye (1)	Türkiye-France (1)
France (1)	Türkiye-Germany (1)
Germany (1)	Türkiye-South Africa (1)
Hungary (1)	USA (1)

Total: 139

Türkiye: 65

Other Countries: 74

TABLE OF CONTENTS

PLENARY PAPERS

REVIEW OF THE CONCEPT AND MEASUREMENT OF HYDROPHOBICITY	1
Cyril T. O'CONNOR	
THE USE OF ECO-FRIENDLY COLLECTORS FOR FELDSPAR FLOTATION	11
Lev O. FILIPPOV; Inna V. FILIPPOVA	
WASTE FROM SOME NONFERROUS BASE METALS EXTRACTION AS SOURCE OF CRITICAL METALS	22
Marinela PANAYOTOVA; Irena GRIGOROVA; Vladko PANAYOTOV	
EXPLOITATION OF NATURAL RESOURCES THE ECONOMIC AND ENVIRONMENTAL IMPACT OF	47
THEIR UTILIZATION	
Nurten DEVA	
APPLICATION OF AI IN MINERAL PROCESSING: EVOLUTION, INDUSTRIAL UPTAKE, AND CURRENT .	55
USE	
Saeed Chehreh CHELGANI	
FLOTATION 4.0: GREENER, SMARTER, SUSTAINABLE	66
Przemysław B. KOWALCZUK	
INTEGRATING ADVANCED SEPARATION TECHNIQUES FOR SUSTAINABLE RECOVERY OF CRITICAL	76
METALS FROM DEEP-SEA FERROMANGANESE CRUSTS	
Gjergj DODBIBA; Cheng-En LEE	
ORE SILOS AND FLOW PROBLEMS	83
Ayhan Ali SİRKEÇİ	
NIOBIUM AND TANTALUM CONCENTRATION	92
Elenice Maria Schons SILVA; Amanda Paranhos MACEDO; Raydse Linny Silva SOUZA; Jaciany Mayara Batista SOARES; André Carlos SILVA	
ELECTROSTATIC SEPARATION AFTER TRIBOELECTRIC CHARGING IN THE PROCESSING OF	106
PRIMARY RAW MATERIALS – STATUS QUO IN RESEARCH AND OUTLOOK FOR POTENTIAL APPLICATIONS	
Helmut FLACHBERGER; Dominic PREM	
EFFECTS OF ULTRASOUND ON SETTLING BEHAVIOUR OF SOME CRITICAL RAW MATERIALS	116
Şafak Gökhan ÖZKAN	
BONDING MECHANISMS IN BRIQUETTING OF RECYCLED WASTE POWDERS – USED COFFEE	135
GROUNDS GRANULATE	
Jože KORTNIK; Lara ANŽIČ	
EFFECT OF WASTE ROCK DILUTION ON THE FLOTATION OF MAIN CRITICAL RAW MATERIALS	146
(CRM)	
Maria SINCHE-GONZALEZ	
COAL PROCESSING, AGGLOMERATION AND BRIQUETTING	
EVALUATION OF THE WASHABILITY CHARACTERISTICS OF ZONGULDAK COAL SEAMS: THE CASE	154
OF ÇATALAĞZI COAL PREPARATION PLANT	
Eljona MUNISHI; Valona PROKSHI; Albina RAMA; Elona IDRIZI; Omer GUCATI; Leutrim BOGIQI; Berat SINANI; Mehmet BİLEN	
EXTRACTION OF TAR FROM LOW-RANK TURKISH COALS BY PYROLYSIS FOR CARBON FIBER	164
PRODUCTION	
Ensar Eray METE; Hüma VELİDEDEOĞLU; Kerim ÇELİK; Yunus Emre ÇAVDAR; Muhammed Fatih CAN; Alper SARIOĞLAN; Hasan Can OKUTAN; Feridun BOYLU; Mehmet Sabri ÇELİK	
MODELING OF COMPOSITE COAL-BASED BRIQUETTES AIMED AT REDUCING SULFUR EMISSIONS	174
INTO THE ATMOSPHERE	
Nedžad ALIĆ; Rusmir RAZIĆ	
VALUE-ADDED CONVERSION of ZONGULDAK HARD COALS: INTEGRATED APPROACHES FOR	188
INJECTION COAL, ACTIVATED CARBON, and INDUSTRIAL APPLICATIONS	
Faik ALP; Serdar YILMAZ; Mehmet BİLEN; İhsan TOROĞLU	

SECOND-STAGE SEPARATION DENSITY CONTROL IN A GRAVITY-FED THREE-PRODUCT DENSE MEDIUM CYCLONE	198
Yusuf Enes PURAL; Mustafa ÖZER; Fırat BURAT; Feridun BOYLU	
COMMINUTION AND CLASSIFICATION	
INVESTIGATION OF THE EFFECTS OF ORE ABRASIVITY INDEX ON BALL WEAR IN WET BALL MILLING OPERATIONS WITH LAB SCALE TESTS	203
Yağız Kerem YALÇIN; Ahmet YAKAR; İbrahim GÖKTAŞ	
EVALUATION OF COMPUTER APPLICATIONS FOR COMMINUTION CIRCUIT DESIGN	215
Kudret Tahsin PEREK; Jemshit RECEPOV; Ceyda TUNÇOK	
CONSERVATION, REHABILITATION AND RECYCLING IN MINERAL PROCESSING	
ANALYSIS OF THE REUSE POTENTIAL OF SOLID WASTES AFTER HCL LEACHING FROM A CIRCULAR ECONOMY PERSPECTIVE USING MICROSCOPE IMAGES AND MACHINE LEARNING	223
Tuğba Deniz TOMBAL KARA; Burçin KAYMAKOĞLU; Nevzat Yağız TOMBAL	
ENVIRONMENTALLY FRIENDLY LEACHING OF LITHIUM-ION BATTERY WITH FORMIC ACID PROCESS OPTIMIZATION AND KINETIC INSIGHTS	238
Muammer KAYA; Hossein DELAVANDANI	
DEWATERING, WASTE WATER TREATMENT	
CREATING VALUE FROM WATER IN MINING	246
Riina SALMIMIES; Nina HARJULA; Elsi STRAND	
EFFECT OF FLOCCULANT DOSAGE AND WATER TYPE ON THE SEDIMENTATION BEHAVIOR OF SULFIDE IRON ORE TAILING	251
Argun ÇİPER; Yunus Emre ÇAVDAR; Orhan ÖZDEMİR	
EDUCATION, SUSTAINABILITY IN MINERAL PROCESSING	
ALIGNMENT OF ALBANIAN GEO-MINING LEGISLATION WITH THE LEGISLATION OF BALKAN COUNTRIES AND THE EUROPEAN UNION	259
Ekita TOSKA; Kimet FETAHU; Habib BASHOLLI; Lavdie MOISIU	
AN OVERVIEW OF MINERAL PROCESSING INNOVATIONS IN BULGARIA	267
Irena GRIGOROVA; Teodora YANKOVA; Mihail PETROV; Nikolay NESTOROV	
APPLICATION OF THE CIRCULAR ECONOMY IN THE MINING SECTORS OF BOSNIA AND HERZEGOVINA: FROM A LINEAR TO A SUSTAINABLE CIRCULAR MODEL THROUGH WASTE VALORIZATION	275
Nedžad ALIĆ; Admir SOFTIĆ; Alma NUHANOVIĆ	
RECOLTIVATION OF ORE FIELDS AFTER EXPLOITATION - METHODOLOGY OF COLLECTION OF FUNDS FOR RECOLTIVATION	287
Jahir GASHI; Habib BASHOLLI	
FLOTATION AND SURFACE CHEMISTRY PROCESSES	
A SUSTAINABLE APPROACH OF FLOTATION-BASED RECYCLING OF VIRGIN AND POST-CONSUMER MULTIPLE PLASTICS WITH DETERMINATION OF THEIR SURFACE CHARACTERISTICS	293
Cemal Cem BAKIR; Murat Olgaç KANGAL; Zeynep ÜÇERLER ÇAMUR; Tülay TÜRK	
COMPARATIVE PERFORMANCE OF NaCN and SMBS DEPRESSANTS IN THE FLOTATION OF THE UZBEKISTAN Pb–Zn ORE	301
Sinem DOĞAN; Mert SARIKAYA	
EFFECT OF PULP AERATION ON LEAD-ZINC FLOTATION PERFORMANCE	307
Irmak DEMIREL; Şükriye Beste AYDIN	
EVALUATING CASHEW NUTSHELL LIQUID AS A SUSTAINABLE COLLECTOR FOR COPPER-MOLYBDENUM ORE FLOTATION	315
Justin PARIS; Ebuka CHUKWUMA; Helmi F. KALAHARI; Alex KELISKY; James FINET; Ozan KÖKKILIÇ; Shiva MOHAMMADI-JAM; Kristian E. WATERS	

FROM ELECTRICAL SIGNATURES TO FLOTATION: A MULTI-PARAMETER ANALYSIS OF COPPER RECOVERY Ünzile YENIAL ARSLAN; Elizaveta FORBES	325
GAS DISPERSION CHARACTERISTICS OF THE CONCORDE CELL Berivan TUNÇ; Toni MATTSSON; Alejandro YANEZ; Gülay BULUT	333
GREEN EMULSION STRATEGIES FOR GRAPHITE FLOTATION: BIOSURFACTANT-COLLECTOR INTERACTIONS IN LIB BLACK MASS RECYCLING Chiedza NZUMA; Przemyslaw B. KOWALCZUK	341
INFLUENCE OF GLYCOL AND ALCOHOL TYPE FROTHER ON CRITICAL COALESCENCE CONCENTRATION AND BUBBLE SIZE Gülşah GÜVEN; Şükriye Beste AYDIN; Ferihan GÖKTEPE; Gülay BULUT	349
INVESTIGATION ON LEAD DEPRESSION IN ANTIMONY FLOTATION CIRCUIT Begüm YÜCEL; İbrahim GÖKTAŞ	356
REAGENT OPTIMIZATION IN THE FLOTATION BENEFICIATION OF SILICA SAND USED IN GLASS PRODUCTION Selen ULUSKAN; Gülay BULUT	365
RECENT ADVANCES IN FLOTATION TECHNOLOGIES FOR COARSE AND FINE PARTICLE RECOVERY Ceyda GÜRKAN; Hüseyin BAŞTÜRKCÜ	372
SPHALERITE FLOTATION USING A NEW CHELATING COLLECTOR N-HEXYLAMINOETHANETHIOL Badr-Elboudour BENAÏSSA; Mohamed CHETTIBI; Ramanathan NATARAJAN; Salima SALHI	380
STUDY OF COPPER ORE FLOTATION REAGENTS APPLICATION Vladimir PEZA	386
SULFIDE GOLD ORE FLOTATION RICH IN FINE PARTICLES Elenice Maria Schons SILVA; Antônio de Pádua Arlindo DANTAS; Jaciany Mayara Batista SOARES; Poliana Felipe PACHECO; Kascielle Braga AMORIM; Luiz Henrique Coelho Pessoa SANTOS; Bruno Gomes da MOTA; Vinicius Curcino de Carvalho VIEIRA; André Carlos SILVA	395
TESTING THE SELECTIVE SEPARATION OF LIMONITE-BARITE ORE FROM THE 'VIDRENJAK' DEPOSIT Ljiljana TANKOSIĆ; Branka ŠOLAJA	403
THE CONTRIBUTION OF ROUGHNESS PARAMETER ON COAGULATION AND FLOCCULATION CHARACTERISTICS OF FINE CHROMITE Onur GÜVEN	411
THE EFFECT OF SODIUM HEXAMETAPHOSPHATE AS A DISPERSANT AND ANIONIC POLYACRYLAMIDE-BASED FLOCCULANT ON THE ZETA POTENTIAL OF NATURAL GOETHITE, QUARTZ, AND CLAY MINERALS Ljiljana TANKOSIĆ; Svjetlana SREDIĆ	422
THE EFFECT OF WATER TYPE ON FLOTATION PERFORMANCE AND FROTH CHARACTERISTICS IN COPPER SLAG FLOTATION Ulaş USLU; Zeynep ÜÇERLER ÇAMUR; Yunus Emre ÇAVDAR; Şükriye Beste AYDIN; Gülay BULUT	430
A COMPREHENSIVE PILOT-SCALE STUDY ON PNEUMATIC IMHOFLOT FLOTATION PERFORMANCE AT THE ÇAYELİ BAKIR Atif DEMİRCAN; Ekin GÜNGÖR; Ahmad HASSANZADEH; Dilay HACIOSMANOĞLU; Aytekin TIRNAKÇIOĞLU	437
OPTIMIZATION OF APATITE DEPRESSION USING K-NA TARTRATE / AL ₂ (SO ₄) ₃ IN PHOSPHATE SLIMES FROM DJEBEL ONK (ALGERIA) Djamel NETTOUR; Yousra BOUKHAMLA; Rachid CHAIB; Mohamed CHETTIBI; Nesrine DERRADIJA	445
GEOLOGICAL STUDIES	
ASSESSMENT AND CALCULATION OF HYDROGEOLOGICAL PARAMETERS OF THE AQUIFER IN THE SOUTHERN PART OF THE KOSOVO COAL BASIN Sabri AVDULLAHI	450

CHARACTERIZATION AND PROCESSING OF VOLCANIC ROCKS FROM MONTENEGRO FOR USE AS INDUSTRIAL RAW MATERIALS Ljiljana TANKOSIĆ; Alen ŠTULIĆ	457
DETECTION OF ORE DEPOSITS USING IMAGE PROCESSING TECHNIQUES, WEST OF ELAZIĞ (TURKEY) İmren Sumru TOSUN; Melek URAL; Mustafa EĞRİ	463
GEOLOGICAL – MINERALOGICAL CHARACTERISTICS OF POLYMETALLIC ORES AND THEIR BENEFICIATION POTENTIAL IN THE MUSHTE – GURTH SPAC – LETITEN REGION, MIRDITA, ALBANIA Asllan DACI; Agim SINOJMERI; Cem Koray YAGCI; Mehmet YAVUZ; Hasan USTUNDAG	469
IMAGE PROCESSING STUDIES IN THE AKDAĞ REGION (ELAZIĞ, TURKEY)	482
IMAGING ANALYSIS OF ORE OCCURRENCES WITHIN UPPER CRETACEOUS LAVA SEQUENCES (KOÇKALE, ELAZIĞ-TURKEY) Melek URAL; Mustafa EĞRİ	487
MINERALOGICAL CONTROLS AND BENEFICIATION ASSESSMENT OF VANADIUM (V) ENRICHED META-GABBROIC ROCKS FROM THE AZITEPE–ALAŞEHİR N. Merve SÜTÇÜ; Zeynep DÖNER; Mustafa KUMRAL; Tülay TÜRK; Gülşah GÜVEN	493
HYDROMETALLURGY, PYROMETALLURGY AND BIO-PROCESSING	
A BRIEF HISTORICAL DEVELOPMENT OF REFRACTORIES Arman EHSANI; İlhan EHSANI	502
A NEW APPROACH TO STUDYING THE EFFECTS OF CYANIDE DOSAGE ON SILVER METAL THROUGH A QCM SENSOR Ömer CANIEREN; Cengiz KARAGÜZEL; Oktay ŞAHBAZ	512
A REVIEW ON FILTRATION PERFORMANCE EVALUATION AND OPERATIONAL OPTIMIZATION IN CCD-MERRILL CROWE PROCESSING Semih ERZENOĞLU; Hüseyin BAŞTÜRKÇÜ	519
ACID LEACHING OF MECHANICALLY ACTIVATED BENTONITE CLAY FOR ALUMINUM EXTRACTION Mustafa BİRİNCİ; Kader ŞENTÜRK	525
DIAGNOSTIC LEACHING OF A DOUBLE REFRACTORY GOLD ORE Deus Albert MSUMANGE; Hacı DEVECİ; Ersin Yener YAZICI; Oktay CELEP; J. Albert MSUMANGE	531
ELECTROWINNING OF ZINC FROM AMMONIACAL LEACH SOLUTIONS OBTAINED FROM CARBONATE-CONTAINING SMITHSONITE ORE Fatih ÇAVUŞLU; Arman EHSANI; İlhan EHSANI	539
EVALUATION OF ALTERNATIVE SULFATION AGENTS FOR RARE EARTH ELEMENT PRETREATMENT-A COMPARATIVE STUDY Esra BAŞTÜRKÇÜ	549
FLASH FURNACE DUST PROCESSING VIA ROASTING AND ACID LEACHING OPERATION Melikenur AYCAN; Merve DOĞAN; Abdullah Erdem YILDIZHAN; Fatih ÖZEL; İbrahim GÖKTAŞ; Mehmet CANBAZOĞLU	555
HYDROMETALLURGICAL PROCESSING AND SUSTAINABLE VALORIZATION OF BRUCITIC DOLOMITES FOR HIGH-PURITY MAGNESIUM OXIDE PRODUCTION Camelia BĂDULESCU; Camelia TRAIȘTĂ	561
HYDROMETALLURGICAL RECOVERY OF HIGH-PURITY MANGANESE DIOXIDE AND ASSOCIATED COMPOUNDS FROM SILICO-MANGANESE PRODUCTION DUSTS Mariana DUMITRACHE; Maria LAZAR; Camelia TRAIȘTĂ	570
INVESTIGATION OF THE BENEFICIATION OF MANGANESE ORE IN THE KARABURUN REGION BY LEACHING Yaşar Hakan GÜRİSOY; Koray Emre AKGÖÇMEN	580
ORP MODULATION IN HCL- AND H2SO4-BASED LEACHING SYSTEMS THROUGH SYNERGISTIC NA CL EFFECTS Kobra REZAEI; Claudio ACUNA	591

PYROMETALLURGICAL AND HYDROMETALLURGICAL VALORIZATION OF BLAST FURNACE SLUDGE FROM THE MĂLINA SETTLING POND (GALATI, ROMANIA) Camelia TRAIȘTĂ; Tiberiu RUS; Eugen TRAIȘTĂ	602
RECOVERY OF METALLIC VALUES FROM COPPER SLAGS Fatma ARSLAN; Gülay BULUT; Cüneyt ARSLAN	610
RESEARCH ON FACTORS INFLUENCING HIGH FUEL CONSUMPTION IN ROTARY KILNS Zarife BAJRAKTARI GASHI; Mimoza KOVAÇI AZEMI	617
SELECTIVE EXTRACTION OF LANTHANUM, NEODYMIUM AND PRASEODYMIUM FROM SYNTHETIC LEACH SOLUTION USING PC-88A-TBP SYSTEM Esra BAŞTÜRKÇÜ; Norman KELLY; A. Ekrem YÜCE; Servet İ. TİMUR	623
SELECTIVE METAL LEACHING FROM SmCo PERMANENT MAGNETS Mert SARIKAYA; Fatma Elif GENÇELİ GÜNER; Şükriye Beste AYDIN	629
STRIPPING PRECIPITATION OF CALCIUM VANADATES FROM ORGANIC V(V) EXTRACTS María Guadalupe SÁNCHEZ-LOREDO; Salvador Antonio PALOMARES-SÁNCHEZ; Paul CHEKHONIN; Doreen EBERT; Robert MÖCKEL; Norman KELLY; Ajay Bhagwan PATIL	635
SUSTAINABLE SYNTHESIS AND CHARACTERIZATION OF NANO ZINC BORATE FROM METALLURGICAL WASTE Gülnehal AYGÜN; Hüseyin BAŞTÜRKÇÜ; Bihter ZEYTUNCU GÖKOĞLU	643
THE POTENTIAL OF MINING AND PROCESSING OF ALBANIAN NICKEL LATERITIC RAW ORES Genc DEMI; Fatos AHMATAJ	648
SYNTHESIS OF PSEUDOBROOKITE POWDER VIA OXIDATIVE CALCINATION OF ILMENITE FOR PHOTOCATALYTIC APPLICATIONS Yahya SORKHE; Onur OZTÜRK; Pegah BAVAFA; Fatma ARSLAN; Cüneyt ARSLAN	657
THE LEACHING KINETICS OF HIGH-GRADE ZINC SILICATE ORE IN SULFURIC ACID Moloud NAZERI; Claudio ACUNA; Emad ABKHOSHK; Zahra RAZI	672
MANAGEMENT OF MINERAL PROCESSING TAILINGS	
EVALUATION OF MINERAL PROCESSING AND HYDROMETALLURGICAL PLANT WASTES A COMPREHENSIVE ASSESSMENT WITH CASE STUDIES FROM TURKIYE Gülay BULUT; Nursun ŞİRVANCI; Fatma ARSLAN	680
EVALUATION OF WASTE AND BY-PRODUCTS FROM THE ZONGULDAK HARD COAL BASIN WITHIN THE FRAMEWORK OF THE ZERO-WASTE APPROACH Mehmet BİLEN; Hayri VELİOĞLU; Haşim DURU; İhsan TOROĞLU	688
INVESTIGATION OF THE PERMITTING PROCESSES FOR ORE DRESSING AND WASTE STORAGE FACILITIES OF TÜRKİYE Ali Koray ÖZDOĞAN; Hakan AKINCI; Gizem ÖZDOĞAN	705
MINING WASTE AND CRITICAL RAW MATERIALS RECOVERY POTENTIAL FROM THE KURBNESH COPPER TAILINGS, ALBANIA Shahin BARAMAJ; Kristo RODI; Mimoza SIMIXHIU; Ledi MOISIU; Ana FOCIRO	712
PRODUCTION OF MAGNETITE CONCENTRATE FROM COPPER CONCENTRATOR PLANT TAILINGS Alperen KÖLE; Ahmet YAKAR; Yağız Kerem YALÇIN; Abdullah Erdem YILDIZHAN; Mustafa ÖZTÜRK; İbrahim GÖKTAŞ	719
SELECTIVE ACTIVATION OF COAL MINE TAILINGS AS SUPPLEMENTARY CEMENTITIOUS MATERIALS FOR SUSTAINABLE CONSTRUCTION Serkan TUYLU; Deniz ADIGÜZEL; İsmail DEMİR; Mehmet Selçuk AVDAN	726
SPATIAL DISTRIBUTION OF SELECTED VARIABLES IN ARTANA TAILINGS FOR SUSTAINABLE MANAGEMENT Naser PEÇİ; Kemajl ZEQRİ; Berat SINANI; Nazmije SEJDIU	742
THE EFFECTS OF THE CHEMICAL STRUCTURE OF FLOCCULANTS ON FLOCCULATION IN MURGUL FLOTATION PLANT TAILINGS Yağız ŞEN; Zafer GÖLLER; Gülay BULUT	752
BACKFILLING OF UNDERGROUND EXCAVATIONS WITH CEMENTED PASTE IN MODERN UNDERGROUND MINING Sanja BAJIC; Rudolf TOMANEC; Ljiljana TANKOSIĆ; Dragoljub BAJIC; Josip ISEK	758

MATERIAL ANALYSIS AND MINERAL CHARACTERIZATION

ANALYSIS OF ACCIDENTS IN UNDERGROUND MINES IN ALBANIA	764
Shahin BARAMAJ; Lavdie MOISIU; Mimoza SIMIXHIU; Dhurim KURTI	
ANTHROPOGENIC RAW MATERIALS PROCESSING APPLICATION EXAMPLES FOR THE	771
CONSERVATION OF NATURAL RESOURCES	
József FAITLI	
BEHAVIOR OF ULTRA-HIGH PERFORMANCE FIBER CONCRETE BASED ON RECYCLED GRANITE	778
WASTE FILLERS	
Houria HEBHOUB; Said BERDOUDI; Nouha REZAIGUIA; Nedjma MEZIANI; Mohammed I. BENHALILOU; Bilal BOULKENAFET	
CEMENT MAKING BY USING THE GEOCEMENTING CONCEPT	784
Hakan ARDEN KAHRAMAN; Hakan BENZER	
CHARACTERIZATION AND PROPOSED MINERALURGICAL PURIFICATION METHODS FOR	797
FELDSPAR FROM AÏN BARBAR, EASTERN ALGERIA	
Assia BOUTEMEDJET; Zohir MEKTI; Ghofrane BOUDRAA; Fatima Zohra BOUGHABA	
CHARACTERIZATION OF CONSTRUCTION AND DEMOLITION WASTES FOR VALORIZATION AS RAW	802
MATERIALS RESOURCE	
Hikmet SİS; Murat ERDEMOĞLU; Tufan KIYAK; M. Kürşat AYDEMİR; Kader ŞENTÜRK; Mustafa BİRİNCİ; İsmail BENTLİ; Didem EREN SARICI; Sema ERDEMOĞLU	
CHARACTERIZATION OF MANGANOFERROUS (Fe-Mn) OXIDE ORE FROM TURKIYE-SJRNAK	810
REGION	
A. Ufuk DENİZ; Arman EHSANI; Fatih ÇAVUŞLU; İlhan EHSANI	
DIRECT RECYCLING OF GRAPHITE LINKING MINERAL PROCESSING WITH NANOSTRUCTURAL	818
RESTORATION	
Eray TABAK; Recep BAKAR; Sadullah ÖZTÜRK; Şahika Sena BAYAZİT; Birgül BENLİ	
INFLUENCE OF ROCK WEATHERING DEGREE ON PROCESSING EFFICIENCY AND PRODUCT	830
QUALITY IN AGGREGATE QUARRIES	
Danciu CIPRIAN; Camelia TRAIŞTĂ	
PROCESS MINERALOGY INSIGHTS INTO BENEFICIATION OF RARE EARTH CARBONATITE ORES	838
Ezgi AKYILDIZ; Camilo M. SILVA; Stefanie LODE; Kornel TOBICZYK; Przemyslaw B. KOWALCZUK	
PROFESSIONAL RISK ASSESSMENT IN MINERAL PROCESSING	848
Marija HADZI-NIKOLOVA; Dejan MIRAKOVSKI; Afrodita ZENDELSKA; Nikolinka DONEVA	
SELECTION OF AN APPROPRIATE TECHNOLOGY FOR FLOTATION TAILINGS DISPOSAL USING THE	854
SAW METHOD	
Afrodita ZENDELSKA; Nikolinka DONEVA; Marija HADZI-NIKOLOVA; Dejan MIRAKOVSKI; Blagoj GOLOMEOV	
SOME CHARACTERISTICS OF CHROMITES IN THE TROPOJE – HAS – GJAKOVE MASSIF AND	862
THEIR FEATURES FOR ENRICHMENT	
Ibrahim MILUSHI; Genc DEMI; Edmond PLLANA	
STATISTICAL AND GEOSTATISTICAL ANALYSIS OF SELECTED TECHNOLOGY-CRITICAL ELEMENTS	871
IN THE TREPÇA MINE AND THEIR CORRELATION WITH Pb-Zn MINERALIZATION	
Berat SINANI; Milazim DEMAKU; Naser PEÇI; Bahri SINANI; Mehmet BİLEN	
STRUCTURAL DATA AND CHROMITE ENRICHMENT CHARACTERISTICS IN THE ULTRABASIC	881
MASSIF OF LUBOTEN, KOSOVO	
Edmond PLLANA; Ibrahim MILUSHI; Genc DEMI	
TECHNICAL EVALUATION OF AN ADDITIONAL GOLD EXTRACTION TECHNOLOGY	889
Nikolay NESTOROV; Irena GRIGOROVA; Teodora YANKOVA; Mihail PETROV	
THE IMPORTANCE OF ZETA POTENTIAL MEASUREMENT IN THE FLOTATION OF DIASPORA AND	897
CALCIUM MINERALS	
Yaşar Hakan GÜRSOY; Abdullah FİLAR; Yakup UMUCU	
THE PETROGRAPHIC CHARACTERIZATION OF THE URANIUM ORE OF TAHAGGART, EL-HOGGAR,	913
SOUTHEAST OF ALGERIA	
Zohir MEKTI; Fatima Zohra BELAID; Assia BOUTEMEDJET; Said BERDOUDI	

MINING OPERATIONS (OPEN-PIT, UNDERGROUND, SOLUTION MINING) RELATED TO MINERAL PROCESSING

- NATURAL SODA ASH PRODUCTION THROUGH IN-SITU LEACHING: OPERATIONAL FRAMEWORK . . . **926**
FROM KAZAN SODA PLANT
Erdem KUMRUOĞLU; Engin OCALAN; Barış KANDEMİR
- STUDY AND EVALUATION OF CURRENT PILLAR DESIGN USING DIFFERENT APPROACHES **939**
–ALGERIA
Said BERDOUDI; Houria HEBHOUB; Nouha REZAIGUIA

MODELING, SIMULATION, CONTROL AND AUTOMATION IN MINERAL PROCESSING

- APPLICATION OF DATA ANALYTICS IN MINERAL PROCESSING TOWARDS DIGITAL PERFORMANCE **949**
PREDICTION AND PROCESS OPTIMIZATION
Oğuzhan Mert GÜRKAN; Hüseyin BAŞTÜRKÇÜ
- APPLICATION OF THE RESPONSE SURFACE METHODOLOGY (RSM) TO THE ENRICHMENT OF . . . **959**
ESPEY COLEMANITE WASTES BY MICROWAVE
Arzu KAHVECİOĞLU; Kirali MÜRTEZAOĞLU; Zehra ZEYBEK; Ahmet AYDIN
- DIGITAL APPROACHES TO SUSTAINABLE MINERAL PROCESSING MATLAB-BASED SIMULATION OF **969**
SENSOR-ASSISTED ORE SORTING
Ali Cemal TANRIKULU; Birgül BENLİ
- MODELLING OF MULTI GRAVITY SEPARATOR (MGS) FOR FINE LIGNITE CLEANING BY CENTRAL . . **976**
COMPOSITE DESIGN (CCD) METHOD
Derya OZ AKSOY; Sabiha KOCA; Hüseyin KOCA
- NUMERICAL PREDICTION OF IMPACT AND SHEAR ENERGY PROFILES ON MILL LIFTERS **983**
Hüseyin Efe SELVI; Tahir Abbas JAUHAR; Yusuf Enes PURAL
- PHYSICAL AND PHYSICO-CHEMICAL PROCESS SIMULATION AND MODELLING TO BENEFICIATE . . **989**
LITHIUM FROM NEPHELINE SYENITE ROCKS
Zeynep ÜÇERLER ÇAMUR; Ozgul KELES; Murat Olgaç KANGAL; Marie-Véronique DURANCE; Stephane BROCHOT; Manuel GONZALEZ; Lucas REGNAULT
- REALISING THE SMART GRINDING MILL OPTIMISING MILL PERFORMANCE THROUGH REAL-TIME **1000**
LIFTER BAR WEAR MONITORING AND PREDICTIVE MAINTENANCE PLANNING
Ahmet ALTUNCU; Büşra ÇALIŞKAN; Ufuk KOÇBIYIK; Oğuzhan ÇAKIR; Ayhan YAZGAN; Uğur ŞEVİK; Tolga BERBER; Oğuzhan BAŞER; Ersin Yener YAZICI; Oktay CELEP
- TONNEX A CONTRACT-DRIVEN DIGITAL ECOSYSTEM FOR MINERAL PROCESSING OPERATIONS . **1007**
Hasan Berke AKKÖSE; Hayri Atalay KUL
- TOWARD AUTONOMOUS MINERAL SORTING INTEGRATING MACHINE LEARNING AND ROBOTICS **1014**
IN ORE PROCESSING
Alexandru MIHAI; Mihai CULEA; Adriana BURLIBASA; Gabriela IORGA; Victor MIHAI

PHYSICAL CONCENTRATION METHODS

- ANALYSIS OF SETTLING MACHINE PERFORMANCE AS A FUNCTION OF PARTICLE SIZE AT RMU . . **1028**
“BANOVİĆI” D.D. BANOVİĆI
Nedžad ALIĆ; Admir SOFTIĆ; Semir MEHIC
- BENEFICIATION OF A HIGH-GRADE LATERITIC NICKEL ORE BY PHYSICAL SEPARATION **1046**
METHODS
Yunus Emre ÇAVDAR; Hüseyin BAŞTÜRKÇÜ
- CASSITERITE FINES RECOVERY FROM JIGGING TAILINGS USING SHAKING TABLES **1053**
Cirila Raquel de Araújo Gomes e SILVA; Igo Marinho Serafim BORGES; Jaquelynnne Cassia de AMORIM; Wesley Oliveira LEMOS; Luís Felipe Schons SILVA; Elenice Maria Schons SILVA; André Carlos SILVA
- COMPARISON OF WET AND DRY MAGNETIC SEPARATION IN THE BENEFICIATION OF QUARTZ . . **1064**
ORES
Arda ARAPOĞLU; Oğuzhan Mert GÜRKAN; Ali Kaan ACAR; Emre UĞURLAR; Hüseyin BAŞTÜRKÇÜ

DESCRIPTION AND ANALYSIS OF THE TECHNOLOGICAL PROCESS OF THE KALIMASH IMI CHROMIUM ENRICHMENT PLANT Ferhat AKINOGLU; Genc DEMI	1071
DRY BENEFICIATION OF MINERAL ORES USING TRIBO-ELECTROSTATIC BELT SEPARATION Abhishek GUPTA; Tom NEWMAN; Frank HRACH	1077
EFFECT OF GRAVITY CONCENTRATOR PERFORMANCE ON CIL EFFICIENCY AND OVERALL GOLD RECOVERY Cumhur Erdem KARAHAN; Fehmi Can SUTER; Durmuş Ali KIZILCADAM; Kasım MEYDANAL	1088
EVALUATION FOR THE PROFITABILITY OF A CHROMIUM ENRICHMENT PLANT CONSTRUCTION Genc DEMI; Aida BODE	1094
PROCESS IMPROVEMENT OF A CHROMIUM ENRICHMENT PLANT Genc DEMI; Safet BOCI	1103
RESEARCH ON THE RECOVERY OF LEAD AND IRON FROM THE SLAG OF A LEAD-ACID BATTERY RECYCLING PLANT USING PHYSICAL METHODS Tülin ULUCAN; Nazlım İlkyaz DİNÇ; Şevval YILDIRIM; Kerem BÖLÜKBAŞ; Fırat BURAT	1111
UPGRADING OF LOW-GRADE TITANIUM ORES BY HIGH-INTENSITY MAGNETIC SEPARATION: A CASE STUDY FROM ESKİŞEHİR, TÜRKİYE Ulaş USLU; Yusuf Enes PURAL; Mustafa ÖZER	1121
THE ROLE OF TOMRA'S XRT-BASED ORE SORTING IN METALLIC ORE PROCESSING Carolina VARGAS	1129
PLANT AND PROCESS DESIGN AND OPERATING PRACTICE	
APPLICATION OF NEW TECHNOLOGIES - A NECESSITY FOR BENEFICIATION OF ALBANIAN CHROMITE ORES Kimet FETAHU; Bukurosh KOÇI; Ekita TOSKA	1130
BULK SOLIDS HANDLING THE OVERLOOKED DRIVER OF PLANT PERFORMANCE Enes KAYA	1136
DIGITAL PROTOTYPING AND SEQUENTIAL ASSEMBLY SIMULATION FOR A RAYMOND MILL INSTALLATION Doğan DEMİROK; Ahmet TANRIKULU	1144
REAGENT OPTIMIZATION FOR COST-EFFECTIVE AND SUSTAINABLE GOLD PROCESSING AT GOLD FIELDS GHANA, TARKWA MINE Michael Mawuenyega Kwame KUATSIENU; Maria SINCHE-GONZALEZ; Prince Pappoe AWOTWE; Eric ANDERSON	1150
UPGRADING ULTRA-LOW-QUALITY LIGNITE THROUGH WASTE HEAT-DRIVEN FLUIDIZED BED DRYING AND DENSITY-BASED SEGREGATION Harun BILIRGEN; Fatma BILIRGEN	1156
VALIDATION OF PROCESS SIMULATION THROUGH LOCKED CYCLE TEST AND PILOT FOR NORDIC TALC PLANT DESIGN Erdem ÖZDEMİR; Erkki KURONEN; Heikki VAUHKONEN; Vesa-Pekka TAKALO; Juha SAARI; Mikko RANTAMAKI	1166
PROCESSING OF INDUSTRIAL MINERALS	
A HYBRID MICROWAVE-THERMAL METHOD TO OPTIMIZE THE GRINDING OF MOIST CLAY MINERALS Doğan DEMİROK	1175
A REVIEW ON THE RECOVERY OF RARE EARTH ELEMENT (REE) RESOURCES OF TURKIYE İlgin KURŞUN; Mert TERZİ; Can GUNGOREN; İsmail DEMİR; Osman YAVUZ	1181
A STUDY ON UNDERSTANDING OF THE BEHAVIOR OF CALCIUM AND MAGNESIUM IMPURITIES ON THE BORAX PENTAHYDRATE CRYSTALLIZATION Şahan GÜL; Haldun KURAMA	1195
ENRICHED HUNTITE AS A GREEN FLAME RETARDANT THERMAL AND PHYSICAL BEHAVIORS IN POLYURETHANE MATRICES Tülay TÜRK; Birgül BENLİ; Murat Olgaç KANGAL	1202

STRUCTURAL AND MORPHOLOGICAL ROLES OF CLAY-BASED CATALYSTS FOR GREEN **1209**
HYDROGEN GENERATION

Helin HAZAR; Zeynep Burçak ŞAHİN; Birgül BENLİ

SOIL REMEDIATION

SOIL CONTAMINATION FROM THE IMPACT OF THE PIM INDUSTRIAL LANDFILL, MITROVICA **1217**

Elona IDRIZI

PROFESSIONAL RISK ASSESSMENT IN MINERAL PROCESSING

Marija HADZI-NIKOLOVA*, Dejan MIRAKOVSKI, Afrodita ZENDELSKA, Nikolinka DONEVA

Faculty of Natural and Technical Sciences, Goce Delcev University, Stip, North Macedonia

**Corresponding author: marija.hadzi-nikolova@ugd.edu.mk*

ABSTRACT

Risk assessment constitutes a fundamental element in establishing a safe and healthy working environment. The responsibility for conducting the risk assessment process lies with employees, as their active involvement promotes workplace safety, motivation, and organizational trust. Furthermore, risk assessment serves as an indicator of a company's sustainability trajectory by contributing to enhanced capacity development, productivity, and profitability.

In the mineral processing industry, workers are routinely exposed to a wide range of occupational hazards and harmful substances. Accordingly, a qualitative/semi-quantitative risk assessment was conducted using the 5×5 risk assessment matrix across four workstations within a mineral processing plant: flotation operator, filter press operator, mill operator, and flotation shift engineer. The findings indicated that all four positions were classified as high-risk workplaces, leading to the proposal of appropriate control measures aimed at hazard elimination and risk reduction.

Key words: *Flotation, hazards, workplace, safety*

1. INTRODUCTION

The rapid development of technology, accompanied by a constant increase in the power and productivity of machines, contributes to changing working conditions in workplaces in industrial enterprises. Therefore, ensuring safe and hygienic working conditions in production is a serious scientific problem that engineers of literally all specialties have to face, especially at mining (Nuruldaeva et al., 2025). Mining and mineral processing, are with the highest rate of occupational diseases and accidents (Parker et al., 2017), where workers are exposed to the worst and most dangerous working conditions (Marimuthu et al., 2023). Mining can be singled out as an industry with high occupational risk indicators, many works (Gyekye, 2003, Milošević et al., 2025) have singled them out as the most dangerous production environments due to the large number of injuries that occur in them.

Mining has always constituted one of the most dangerous industries. This is confirmed by data published in Eurostat, OECD, or by national organizations, such as, in Poland, the State Mining Authority. The reports presented by these organizations indicate the main risk groups and the effects of their occurrence in mining plants. Prepared reports on accidents in mining indicate their causes and circumstances of occurrence (Tubis et al., 2020).

Many processes in the mining are characterized by specific working conditions, and high occupational health risks for workers. Mining have the highest levels of occupational morbidity - up to 24.3 per 10 thousand workers (Preobrazhenskaya et al., 2016). Increased occupational risk has a negative impact on the health of workers, worsens the indicators of general and occupational morbidity, increases mortality from chronic non-infectious diseases (Mandal et al., 2022; Freeh and Iles, 1985; Chebotarev and Sementsova, 2021; Kiryakov and Sukhova, 2015).

Mineral processing plants are an important element of the overall process of extraction and processing of mineral raw materials. They combine different technologies, various types of

production equipment, operate with high capacities and generally observe a rather complex technological process (Kostadinova and Vladkova, 2025).

Technological processes of mineral processing can be conditionally divided into three main stages: operations of preparation for enrichment - crushing, screening and transportation of raw materials, enrichment processes and operations to obtain concentrates (drying, packaging, loading).

The key occupational hazards associated with mineral processing plants are dust, noise, vibration and mechanical injuries (Nuruldaeva et al., 2025).

Risk assessment is a proven technique for improving the quality of input to safety management, aiming to prevent accidents by “debugging” designs and operating methods etc. before accidents occur, rather than responding to accidents which have happened and aiming to prevent recurrence (Guide to Reviewing a Mine Risk Assessment of mine equipment and operations, 1997).

2. MATERIAL AND METHODS

Risk is defined as hazard or danger having adverse consequences for individuals. The U.S. Atomic Energy Commission in 1975 has identified risk as 'the probability of occurrence of particular consequences over a specific period of time' (Risk assessment and its management in mining industry, 2012). Risk assessment is process for estimate of the likelihood of getting injury or adverse health condition.

The structured process associated with risk assessment helps to characterize the major hazards and evaluate engineering, management and work process factors that impact how a mine mitigates its highest risk.

Although there is a spread range of approaches and risk assessment techniques, in essence, they all contain the same fundamental steps (Risk assessment and its management in mining industry, 2012). These are:

- Identify hazards—something with the potential to cause harm;
- Assess the likelihood, or probability, of harm arising from the hazard;
- Assess the severity of harm resulting from realization of the hazard;
- Combine assessments of likelihood and severity to produce an assessment of risk;
- Use the assessment of risk as an aid to decision making.

A 5x5 matrix to risk assessment of four workplaces (flotation operator, filter press operator, mill operator, and flotation shift engineer) in the mineral processing have been used (Table 1).

Table 1. Particle size distribution of representative ore sample

		Consequence				
		1	2	3	4	5
Likelihood		Minor	Low	Medium	High	Major
Almost certain	5	2	3	4	4	4
Likely	4	2	3	3	4	4
Possible	3	1	2	3	3	4
Unlikely	2	1	2	2	3	4
Rare	1	1	1	1	2	3

Some risks may be higher but will be well managed and therefore acceptable. An example of the actions taken based on the risk rating is shown in Table 2.

Table 2. Risk measures (Risk assessment education resource, Mining Safety and Health Advisory Committee, 2023)

Risk level	Risk measures
4– Major	Immediate action required Identify and implement controls to manage risks Highest level of management needs to be involved
3 – Significant	Immediate action required Identify and implement controls to manage risks Senior site management needs to be involved
2 – Medium	Implement control to manage risks Responsibility must be defined
1– Low	Implement controls as required Manage by routine processes

Risk assessment of four workplaces (flotation operator, filter press operator, mill operator, and flotation shift engineer) in the mineral processing is given in Table 3.

3. RESULTS AND DISCUSSION

Professional risk assessment in mineral processing plant on four workplaces have been conducted based on the findings of more researches study, as well as routine measurements of physical and chemical occupational hazards conducted by the accredited AMBICON Laboratory within the Faculty of Natural and Technical Sciences across numerous mines in North Macedonia. It was determined that operators in mineral processing plant are exposed to a complex combination of adverse working environment and labor process factors. These include industrial noise and vibration, unfavorable microclimatic conditions, elevated airborne dust concentrations in the working zone—predominantly consisting of aerosols with fibro genic effects, as well as increased physical workload and work intensity.

Occupational exposure assessments indicate that noise levels at crushing, grinding, and ore transportation workstations range between 85 and 100 dB, exceeding the maximum permissible limits in nearly 85–90% of the studies reviewed, with some reports documenting exceedances in all observed cases. Airborne dust concentrations at these workplaces vary depending on the type of mineral raw material processed and the effectiveness of ventilation systems, ranging from 3.8 to 5.8 mg/m³ and containing more than 10% free silicon dioxide. Another consistently present occupational hazard is whole-body vibration. The reviewed literature demonstrates that vibration levels in both coarse and fine crushing facilities surpass the maximum permissible values by more than 50%.

Consequently, varying intensities of production-related factors result in different levels of risk for the development of occupational pathologies among workers. Occupational diseases most commonly arise in employees exposed to multiple harmful factors simultaneously. Risk assessment findings and the reviewed literature indicate that dust-related diseases, such as pneumoconiosis, are prevalent among crusher operators. Furthermore, prolonged exposure to whole-body vibration is associated with musculoskeletal disorders, including pain in the lower back, limbs, and joints, while sustained exposure to noise levels exceeding maximum permissible limits is a well-established cause of occupational hearing loss.

Although all four positions in mineral processing plant (flotation operator, filter press operator, mill operator, and flotation shift engineer) were classified as high-risk, the role of the mill

operator was identified as the most hazardous due to additional occupational exposures encountered during routine tasks, including work in confined space and the operation of cranes and elevators.

4. CONCLUSION

The synthesized findings demonstrate a high prevalence of occupational hazards in mineral processing plant, with a strong association between multifactorial exposures and the development of chronic health conditions. These results emphasize the need for integrated protective strategies and further targeted research.

Nevertheless, despite the research conducted to date, numerous unresolved issues and challenges remain regarding the occupational health and safety of workers in mineral processing plants. Evolving working conditions and the introduction of new technologies necessitate continuous monitoring and ongoing adaptation of occupational health and safety management systems.

Future research outcomes may contribute to the enhancement of existing safety practices, including the formulation of policy recommendations, the implementation of innovative technologies, and the development of improved risk assessment tools. Ultimately, ensuring safe and healthy working conditions requires the continuous updating of knowledge and the systematic refinement of occupational health and safety management frameworks.

Table 3. Professional risk assessment in mineral processing plant (MPP). L is Likelihood, C is Consequence and R is Risk

Danger or harmful	Shift engineer in MPP			Floater			Filter press operator			Mill operator		
	L	C	R	L	C	R	L	C	R	L	C	R
Insufficient safety due to rotating and moving parts	2	3	2	3	3	3	3	3	3	3	3	3
Internal transport and movement of working machines or vehicles	3	4	3	2	4	3	2	4	3	2	4	3
Exposure to mechanical blow	2	3	2	3	3	3	3	3	3	3	3	3
Hand tools				3	3	3	3	3	3	3	3	3
Crane and elevators	2	3	2							3	4	3
Possibility of slipping, falling (wet or slippery surfaces)	2	3	3	3	3	3	2	3	3	3	3	3
Working at height	2	4	3	3	4	3	2	4	3	3	4	3
Confined space										3	4	3
Electrical hazards	2	4	3	2	4	3	2	4	3	2	4	3
Dust (inhalation, skin absorption)	3	2	2	3	2	2	4	2	3	4	2	3
Hazardous chemical substances (inhalation)	2	4	3	3	4	3	2	4	3	3	4	3
Noise	3	2	2	3	2	2	3	2	2	3	2	2
Vibration	3	2	2	3	2	2	3	2	2	3	2	2
Unfavourable microclimatic conditions (low temperature, humidity, air flow speed)	2	3	3	3	3	3	3	3	3	3	3	3
Harmfuls arising from mental and psychophysiological efforts												
Strains when performing certain tasks that cause psychological strain - stress	4	2	3	3	2	2	3	2	2	3	2	2
Non-physiological body position: prolonged standing, bending.	4	2	3	4	2	3	4	2	3	4	2	3
Need for decision-making	4	1	2									
Using appropriate knowledge and skills	4	1	2	4	1	2	4	1	2	4	1	2
Responsibility in the conducting rules	4	1	2	4	1	2	4	1	2	4	1	2
Conflict situations	3	2	2	3	2	2	3	2	2	3	2	2
Harmfuls related to the organization of work												
Shift working	4	2	3	4	2	3	4	2	3	4	2	3
Night working	4	2	3	4	2	3	4	2	3	4	2	3

REFERENCES

- Chebotarev, A. G., Sementsova, D. D., (2021), "Comprehensive assessment of working conditions and occupational disease rates at mining and metallurgical enterprises", *Russian Mining Industry*, (1), 114–119. <https://doi.org/10.30686/1609-9192-2021-1-114-119>
- Freeh, E. J., Iles, C. D., (1985), "Experience with operating and controlling an in-pit portable crushing and conveying system", *IFAC Proceedings*, 18(6), 153–158. [https://doi.org/10.1016/S1474-6670\(17\)60502-0](https://doi.org/10.1016/S1474-6670(17)60502-0)
- Gyekye, S. A., (2003), "Causal attributions of Ghanaian industrial workers for accident occurrence: Miners and non-miners perspective", *Journal of Safety Research*, 34(5), 533–538. <https://doi.org/10.1016/j.jsr.2003.03.002>
- Mude, M. A., (2016), "Guide to reviewing a mine risk assessment: Comparison of SAW and TOPSIS methods in the case of MSMEs", *Ilk. J. Ilm.* <https://doi.org/10.33096/ilkom.v8i2.49.76-81>
- Foster, P. J., Rose, H. J. M., Talbot, C. F., (1998), "Risk assessment: An opportunity to change health and safety performance", *The Journal of the South African Institute of Mining and Metallurgy*.
- Marimuthu, R., Sankaranarayanan, B., Karuppia, K., (2023), "Prioritizing the factors affecting the occupational health and safety of workers in the mining industry using the SWARA technique", *Journal of Current Science and Technology*, 13(1), 59–73. <https://doi.org/10.14456/jcst.2023.6>
- Milošević, I., Stojanović, A., Nikolić, Đ., Mihajlović, I., Brkić, A., Perišić, M., Spasojević-Brkić, V., (2025), "Occupational health and safety performance in a changing mining environment: Identification of critical factors", *Safety Science*, 184, 106745. <https://doi.org/10.1016/j.ssci.2024.106745>
- Mandal, B. B., Bhattacharya, S., Munawar, V. D., Hussain, S. A., (2022), "Health risk of exposure to noise in coal preparation and mineral processing plants", in: Moitra, A. K., Kayal, J. R., Mukherjee, B., Bhattacharya, J., Das, A. K. (eds.), *Innovative Exploration Methods for Minerals, Oil, Gas, and Groundwater for Sustainable Development*, Elsevier, pp. 139–157. <https://doi.org/10.1016/B978-0-12-823998-8.00062-4>
- Nuruldaeva, G., Isakhanova, A., Kumar, D., Kumar, B., (2025), "Occupational hazards in mineral ore crushing and grinding: A literature review", *International Journal of Safety and Security Engineering*, 15(3), 415–426. <http://iieta.org/journals/ijssse>
- Parker, A. W., Tones, M. J., Ritchie, G. E., (2017), "Development of a multilevel health and safety climate survey tool within a mining setting", *Journal of Safety Research*, 62, 173–180. <https://doi.org/10.1016/j.jsr.2017.06.007>
- Preobrazhenskaya, E. A., Sukhova, A. V., Zorkina, L. A., Bondareva, M. V., (2016), "Hygienic assessment of working conditions and health of the workers of mining and processing enterprises", *Hygiene and Sanitation*, 95(11), 1065–1070. <https://doi.org/10.18821/0016-9900-2016-95-11-1065-107>
- Tubis, A., Werbinska-Wojciechowska, S., Wroblewski, A., (2020), "Risk assessment methods in mining industry — a systematic review", *Applied Sciences*, 10, 5172.