University of Belgrade,
Technical Faculty in Bor

Chamber of Commerce
and Industry of Serbia

XVI International Mineral Processing & Recycling Conference

2025 IMPRO
INTERNATIONAL MINERAL PROCESSING & RECYCLING CONFERENCE

Proceedings

Editors:
Zoran ŠTIRBANOVIĆ
Milan TRUMIĆ

28-30 May 2025
Belgrade, Serbia

University of Belgrade,
Technical Faculty in Bor

Chamber of Commerce
and Industry of Serbia

XVI International Mineral Processing & Recycling Conference

Proceedings

Editors:
Zoran ŠTIRBANOVIĆ
Milan TRUMIĆ

28 – 30 May 2025, Belgrade, Serbia

XVI International Mineral Processing & Recycling Conference

PUBLISHER:
University of Belgrade, Technical Faculty in Bor

FOR THE PUBLISHER:
Dean: Prof. Dr Dejan Tanikić, University of Belgrade, Technical Faculty in Bor

EDITORS:
Prof. Dr Zoran Štirbanović, University of Belgrade, Technical Faculty in Bor
Prof. Dr Milan Trumić, University of Belgrade, Technical Faculty in Bor

TECHNICAL EDITORS:
Dr Vladimir Nikolić, University of Belgrade, Technical Faculty in Bor
MSc Dragana Marilović, University of Belgrade, Technical Faculty in Bor
MSc Katarina Balanović, University of Belgrade, Technical Faculty in Bor

PROCEEDINGS COVER DESIGN:
MSc Aleksandar Cvetković, University of Belgrade, Technical Faculty in Bor

PRINTED BY:
Grafika Galeb, Niš, Serbia
Printed: 200 copies

PUBLISHING LICENCE:
All papers in the Proceedings are published under CC-BY licence.

PUBLICATION YEAR:
2025

============================
CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

622.7(082)
502.131.1:628.477.6(082)
628.477.6(082)

INTERNATIONAL Mineral Processing and Recycling Conference (16 ; 2025 ; Belgrade)
Proceedings / XVI International Mineral Processing and Recycling Conference, IMPRC, 28 – 30 May 2025, Belgrade, Serbia ; editors Zoran Štirbanović, Milan Trumić. - Bor : University of Belgrade, Technical Faculty, 2025 (Niš : Grafika Galeb). - XIX, 706 str. : ilustr. ; 25 cm

Na vrhu nasl. str.: Chamber of Commerce and Industry of Serbia. - Tiraž 200. -
Bibliografija uz svaki rad.

ISBN 978-86-6305-158-4

а) Руде -- Припрема -- Зборници б) Отпадне материје -- Одрживи развој –
Зборници в) Отпадне материје -- Рециклажа -- Зборници

COBISS.SR-ID 168462601 -ID 114566153
===========================

GENERAL SPONSOR

Conference is financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia

GOLD SPONSORS

ZiJin
SERBIA ZIJIN COPPER DOO BOR

ZiJin
SERBIA ZIJIN MINING

SILVER SPONSORS

EMJM PROMISE
Erasmus Mundus Joint Master
in Sustainable Mineral and
Metal Processing Engineering

minerals

metals
an Open Access Journal by MDPI

HBIS SERBIA

RUDNIK

EXHIBITORS

BSI BALTIC SCIENTIFIC INSTRUMENTS

GLOBAL MET TECH

KRUG
KRUG INTERNATIONAL LTD.

novos
partnership through science

FRIENDS OF THE CONFERENCE

PRO FORCE
SERBIA

SCIENTIFIC COMMITTEE

Prof. Dr Milan Trumić, University of Belgrade, Technical Faculty in Bor (Serbia) President
Prof. Dr Grozdanka Bogdanović, University of Belgrade, Technical Faculty in Bor (Serbia) Vice President
Prof. Dr Jovica Sokolović, University of Belgrade, Technical Faculty in Bor (Serbia) Vice President
Prof. Dr Zoran Štirbanović, University of Belgrade, Technical Faculty in Bor (Serbia) Vice President
Prof. Dr Corby Anderson, Colorado School of Mines (USA)
Prof. Dr Zhiyong Gao, Central South University (China)
Prof. Dr Pablo Brito-Parada, Imperial College London (United Kingdom)
Prof. Dr Junbeum Kim, University of Technology of Troyes (France)
Prof. Dr Srećko Stopić, RWTH Aachen University (Germany)
Prof. Dr Lijie Guo, Beijing General Research Institute of Mining and Metallurgy (China)
Prof. Dr Mauricio Torem, Pontifical Catholic University of Rio de Janeiro (Brazil)
Prof. Dr Georgios Anastassakis, National Technical University of Athens (Greece)
Prof. Dr Przemyslaw Kowalczuk, Norwegian University of Science and Technology (Norway)
Prof. Dr Kerstin Forsberg, KTH Royal Institute of Technology (Sweden)
Prof. Dr Alexandre Chagnes, Université de Lorraine (France)
Prof. Dr Erin Bobicki, University of Alberta (Canada)
Prof. Dr Kazutoshi Haga, Akita University (Japan)
Prof. Dr Quentin Campbell, North-West University (South Africa)
Dr Fardis Nakhaei, Missouri University of Science and Technology (USA)
Dr Aleksandar Janković, Kresnik Pty Ltd (Australia)
Prof. Dr Rraghupatruni Bhima Rao, Aryan Institute of Engineering and Technology (India)
Prof. Dr Magdalena Regel-Rosocka, Poznan University of Technology (Poland)
Prof. Dr Juan M. Menéndez Aguado, University of Oviedo (Spain)
Prof. Dr Efrén Garcia Ordiales, University of Oviedo (Spain)
Prof. Dr Alejandro Rodriguez Pascual, University of Cordoba (Spain)
Prof. Dr Antonis Peppas, National Technical University of Athens (Greece)
Prof. Dr Komnitsas Konstantinos, Technical University of Crete (Greece)
Prof. Dr Semra Kurama, Eskisehir Technical University (Turkey)
Prof. Dr Mehmet Polat, Izmir Institute of Technology (Turkey)
Prof. Dr Valery Morozov, National University of Science and Technology MISiS (Russian Federation)
Dr Kadriann Tamm, Tallinn University of Technology (Estonia)
Prof. Dr Maria Sinche Gonzalez, University of Oulu (Finland)
Prof. Dr Sônia Denise Rocha, Federal University of Minas Gerais (Brazil)
Prof. Dr Rodrigo Souza, Pontifical Catholic University of Rio de Janeiro (Brazil)
Prof. Dr Frederico Marques Penha, KTH Royal Institute of Technology (Sweden)
Prof. Dr Silvie Heviánková, VSB – Technical University of Ostrava (Czech Republic)
Dr Hector Muñiz Sierra, Institute of Chemical Process Fundamentals of the Czech Academy of Sciences (Czech Republic)
Dr Slavomir Hredzak, Institute of Geotechnics of the Slovak Academy of Science (Slovakia)
Dr Vladimir Joković, University of Queensland (Australia)
Prof. Dr Gabor Musci, University of Miskolc (Hungary)
Prof. Dr Francisc Popescu, University Politehnica Timisoara (Romania)

Prof. Dr Adian Cioabla, University Politehnica Timisoara (Romania)
Prof. Dr Irena Grigorova, University of Mining and Geology "St. Ivan Rilski" (Bulgaria)
Prof. Dr Jakob Lamut, University of Ljubljana (Slovenia)
Prof. Dr Filip Kokalj, University of Maribor (Slovenia)
Prof. Dr Aleksandra Anić Vučinić, University of Zagreb (Croatia)
Asst. Prof. Dr Branimir Farkaš, University of Zagreb (Croatia)
Prof. Dr Ilhan Bušatlić, University of Zenica (Bosnia & Herzegovina)
Prof. Dr Svjetlana Sredić, University of Banja Luka (Republic of Srpska, Bosnia & Herzegovina)
Prof. Dr Afrodita Zendelska, University "Goce Delchev " (North Macedonia)
Prof. Dr Aleksandar Jovović, University of Belgrade, Faculty of Mechanical Engineering (Serbia)
Prof. Dr Milena Kostović, University of Belgrade, Faculty of Mining and Geology (Serbia)
Prof. Dr Predrag Lazić, University of Belgrade, Faculty of Mining and Geology (Serbia)
Prof. Dr Željko Kamberović, University of Belgrade, Faculty of Technology and Metallurgy (Serbia)
Prof. Dr Vlada Veljković, University of Nis, Faculty of Technology (Serbia)
Prof. Dr Goran Vujić, University of Novi Sad, Faculty of Technical Sciences (Serbia)
Prof. Dr Srđan Rončević, University of Novi Sad, Faculty of Sciences (Serbia)
Prof. Dr Bogdana Vujić, University of Novi Sad, Technical Faculty "Mihajlo Pupin" (Serbia)
Prof. Dr Marina Stamenović, The Academy of Applied Technical Studies Belgrade (Serbia)
Prof. Dr Dimitrije Zakić, University of Belgrade, Faculty of Civil Engineering (Serbia)
Prof. Dr Vladimir Pavićević, University of Belgrade, Faculty of Technology and Metallurgy (Serbia)
Prof. Dr Nada Štrbac, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Milan Antonijević, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Zoran Stević, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Dejan Tanikić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Ljubiša Andrić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Snežana Šerbula, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Snežana Milić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Mira Cocić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Maja Trumić, University of Belgrade, Technical Faculty in Bor (Serbia)
Asst. Prof. Dr Vladan Milošević, University of Belgrade, Technical Faculty in Bor (Serbia)
Asst. Prof. Dr Vladimir Nikolić, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Mile Bugarin, Mining and Metallurgy Institute Bor (Serbia)
Dr Zoran Stevanović, Mining and Metallurgy Institute Bor (Serbia)
Dr Radmila Marković, Mining and Metallurgy Institute Bor (Serbia)
Dr Jelena Petrović, Mining and Metallurgy Institute Bor (Serbia)
Dr Ivana Smičklas, Vinča Institute of Nuclear Sciences (Serbia)
Dr Ivana Jelić, Vinča Institute of Nuclear Sciences (Serbia)
Dr Miroslav Sokić, Institute for Technology of Nuclear and Other Mineral Raw Materials (Serbia)
Dr Dragan Radulović, Institute for Technology of Nuclear and Other Mineral Raw Materials (Serbia)
Dr Sonja Milićević, Institute for Technology of Nuclear and Other Mineral Raw Materials (Serbia)
Dr Milinko Radosavljević, Mining Institute (Serbia)
Dr Svetlana Polavder, Mining Institute (Serbia)
Dr Miroslav Ignjatović, Chamber of Commerce and Industry of Serbia (Serbia)

ORGANIZING COMMITTEE

Prof. Dr Zoran Štirbanović, University of Belgrade, Technical Faculty in Bor, President
Prof. Dr Milan Trumić, University of Belgrade, Technical Faculty in Bor
Prof. Dr Grozdanka Bogdanović, University of Belgrade, Technical Faculty in Bor
Prof. Dr Jovica Sokolović, University of Belgrade, Technical Faculty in Bor
Prof. Dr Maja Trumić, University of Belgrade, Technical Faculty in Bor
Dr Vladimir Nikolić, University of Belgrade, Technical Faculty in Bor Secretary
Dr Miroslav Ignjatović, Chamber of Commerce and Industry of Serbia
MSc Dragana Marilović, University of Belgrade, Technical Faculty in Bor
MSc Katarina Balanović, University of Belgrade, Technical Faculty in Bor
MSc Ivana Ilić, University of Belgrade, Technical Faculty in Bor
MSc Tamara Gavrilović, University of Priština – Kosovska Mitrovica
MSc Oliver Marković, University of Belgrade, Technical Faculty in Bor
MSc Dragan Milenković, University of Belgrade, Technical Faculty in Bor
MSc Sandra Vasković, University of Belgrade, Technical Faculty in Bor
BSc Vera Ražnatović, Chamber of Commerce and Industry of Serbia
Dobrinka Trujić, University of Belgrade, Technical Faculty in Bor

LIST OF REVIEWERS

Prof. Dr Georgios Anastassakis, National Technical University of Athens (Greece)
Prof. Dr Pablo Brito-Parada, Imperial College London (United Kingdom)
Prof. Dr Milan Trumić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Srećko Stopić, RWTH Aachen University (Germany)
Prof. Dr Grozdanka Bogdanović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Ljubiša Andrić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Jovica Sokolović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Zoran Štirbanović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Maja Trumić, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Radmila Marković, Mining and Metallurgy Institute Bor (Serbia)
Dr Jelena Petrović, Mining and Metallurgy Institute Bor (Serbia)
Dr Stefan Đorđijevski, Mining and Metallurgy Institute Bor (Serbia)
Dr Vesna Conić, Mining and Metallurgy Institute Bor (Serbia)
Dr Ivana Jelić, Vinča Institute of Nuclear Sciences (Serbia)
Prof. Dr Maja Nujkić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Ivana Marković, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Marija Petrović-Mihajlović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Žaklina Tasić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Radoje Pantović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Snežana Milić, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Ljiljana Avramović, Mining and Metallurgy Institute Bor (Serbia)
Prof. Dr Przemyslaw Kowalczuk, Norwegian University of Science and Technology (Norway)
Prof. Dr Alexandre Chagnes, Université de Lorraine (France)
Prof. Dr Aleksandar Nikoloski, Murdoch University (Australia)
Dr Dragana Medić, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Ljubiša Balanović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Juan M. Menéndez Aguado, University of Oviedo (Spain)
Dr Hector Muñiz Sierra, Institute of Chemical Process Fundamentals of the Czech Academy of Sciences (Czech Republic)
Dr Vladimir Nikolić, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Dragana Božić, Mining and Metallurgy Institute Bor (Serbia)
Dr Marija Šljivić-Ivanović, Vinča Institute of Nuclear Sciences (Serbia)
Dr Dragan Radulović, Institute for Technology of Nuclear and Other Mineral Raw Materials (Serbia)
Prof. Dr Maria Sinche Gonzalez, University of Oulu (Finland)
Prof. Dr Kerstin Forsberg, KTH Royal Institute of Technology (Sweden)
Dr Srđan Stanković, University of Belgrade, Faculty of Biology (Serbia)
Prof. Dr Igor Miljanović, University of Belgrade, Faculty of Mining and Geology (Serbia)
Prof. Dr Milena Kostović, University of Belgrade, Faculty of Mining and Geology (Serbia)
Dr. Yu Yuexian, Xi'an University of Science and Technology (China)
Dr. Yunfeng Song, Central South University (China)
Prof. Bojan Marinkovic, Pontifical Catholic University of Rio de Janeiro (Brazil)

Prof. Dr Aleksadra Fedajev, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Ljiljana Tolić Stojadinović, Innovation Center of the Faculty of Technology and Metallurgy (Serbia)
Dr. Vasily Timofeevich Lebedev, Petersburg Nuclear Physics Insttitute (Russian Federation)
Prof. Maurício Leonardo Torem, Pontifical Catholic University of Rio de Janeiro (Brazil)
Prof. Dr Vesna Alivojvodić, The Academy of Applied Studies Polytechnic, Belgrade (Serbia)
Dr Saied Karimi, Hamedan University of Technology (Iran)
Dr Mathilde Perrin, University of Grenoble Alpes, CEA-Liten (France)
Dr Aleksandar Janković, Hatch (Australia)
Dr Vladan Milošević, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Milan Antonijević, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Sonja Milićević, Institute for Technology of Nuclear and Other Mineral Raw Materials (Serbia)
Prof. Dr Milan Gorgievski, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Dragan Manasijević, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Semra Kurama, Eskişehir Technical University (Turkey)
Dr Aleksandra Mitovski, Engineering Dobersek GmbH (Germany)
Prof. Dr Carmen Mihaela Neculita, Research Institute on Mines and Environment, University of Québec in Abitibi-Témiscamingue (Canada)
Dr Janine Rodrigues Figueiredo, Federal University of Ouro Preto, (Brazil)
Prof. Dr Ana Radojević, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Jelena Jordanović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Komnitsas Konstantinos, Technical University of Crete (Greece)
Dr Jelena Avdalović, Institute of Chemistry, Technology and Metallurgy (Serbia)
Dr Milica Mladenović, Vinča Institute of Nuclear Sciences (Serbia)
Prof. Dr Xiaomin Ma, Taiyuan University of Technology (China)
Prof. Dr Snežana Urošević, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Milan Radovanović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Ana Simonović, University of Belgrade, Technical Faculty in Bor (Serbia)
Prof. Dr Francesco Ferella, University of L'Aquila (Italy)
Prof. Dr Fatma Arslan, Istanbul Technical University (Turkey)
Prof. Dr Gülay Bulut, Istanbul Technical University (Turkey)
Dr Samah S. Abdallah, Central Metallurgical Research and Development Institute (Egypt)
Prof. Dr. Vesna Grekulović, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr. Vandana Kumari Jha, KTH Royal Institute of Technology (Sweden)
Dr Vesna Krstić, Mining and Metallurgy Institute Bor (Serbia)
Dr Sanja Petrović, Mining and Metallurgy Institute Bor (Serbia)
Dr Goran Pačkovski, Mining and Metallurgy Institute Bor (Serbia)
Dr Ivana Jovanović, Mining and Metallurgy Institute Bor (Serbia)
Prof. Dr Tanja Kalinović, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Jelena Kalinović, University of Belgrade, Technical Faculty in Bor (Serbia)
Dr Predrag Stolić, University of Belgrade, Technical Faculty in Bor (Serbia)

TABLE OF CONTENTS

PLENARY LECTURES 1

Pablo R. Brito-Parada 3
A MINERAL'S JOURNEY – UNRAVELLING FLOTATION PHENOMENA THROUGH PARTICLE TRACKING

Srecko Stopic, Duško Kostić, Mitar Perušić, Richard Schneider, Bernd Friedrich 9
RECOVERY OF VALUABLE METALS FROM BAUXITE RESIDUE (BR) USING DECARBONIZING TECHNOLOGIES

Corby G. Anderson 19
HOW THE RARE EARTHS BECAME THE LANTHANIDES AGAIN

Junbeum Kim 21
EMERGING TECHNOLOGIES AND EMERGING WASTES: CHALLENGES AND OPPORTUNITIES

INVITED LECTURES 23

Aleksandar Nikoloski, Pritam Singh, Tina Chanda Phiri 25
AN OVERVIEW OF GLOBAL COPPER SMELTING SLAG PRODUCTION AND REPROCESSING APPROACHES

Maria Sinche-Gonzalez 37
EDUCATION IN MINERAL PROCESSING AND FILLING THE GAP OF TALENTED MINERAL PROCESSING ENGINEERS

Predrag Umičević, Ivica Karoglan, Gregor Radišić, Viktor Simončič 44
INNOVATIVE BIODEGRADABLE WASTE TREATMENT AS A POSSIBLE SOLUTION FOR RECULTIVATION OF TAILINGS AND SLAG LANDFILLS

Kerstin Forsberg 50
CRYSTALLIZATION CHALLENGES IN HYDROMETALLURGY

Belinda McFadzean, Avuyile Wali, Megan Becker, Stefan Geldenhuys 55
CRITICAL MINERALS: CHALLENGES AND OPPORTUNITIES IN PLATINUM GROUP MINERAL FLOTATION

Alexandre Chagnes, Pierric Hubert, Safi Jradi 62
INNOVATIVE STRATEGIES FOR METAL RECOVERY FROM LFP-NMC LITHIUM-ION BATTERY BLENDS

Michal Šyc, Jiří Hykš 66
FROM LINEAR TO CIRCULAR ECONOMY – STORY OF THE BOTTOM ASH

Przemyslaw B. Kowalczuk 70
CRITICAL RAW MATERIALS (CRM) RECOVERY FROM NORWEGIAN DEPOSITS: CHALLENGES AND OPPORTUNITIES

SESSION LECTURES **73**

Massoud Aghamirian Vu Truong, Kristina Muntu, Jean-Gabriel Fraboulet, Sean Salour, Brian Kawenski Cook 75
INVESTIGATIONS INTO LITHIUM MINERALS PROCESSING

Héctor Muñiz Sierra, Michal Šyc, Ayse Asya Arslanturk 86
THE APPLICATION OF PHYSICAL CONCENTRATION TECHNOLOGIES IN THE RECYCLING OF NEW WASTE STREAMS

METALS YOUNG RESEARCHER AWARD **89**

Diego Poblete, Claudio Leiva, Maria Sinche-Gonzales, Claudio Acuña 91
HOLLOW DROP BUBBLES A PROPOSED NEW TECHNOLOGY FOR OPTIMIZED METAL EXTRACTION VALIDATED IN THE LABORATORY

Wanjia Zhang, Zhitao Feng, Zhiyong Gao 98
PREDICTION OF COLLECTOR FLOTATION PERFORMANCE BASED ON MACHINE LEARNING AND QUANTUM CHEMISTRY: A CASE OF SULFIDE MINERALS

Helir Muñoz, Sophia Korili, Antonio Gil 106
SYNTHESIS OF MOF@ALUMINUM SALINE SLAG COMPOSITES FOR CO_2 CAPTURE AS A NEW STRATEGY OF VALORIZATION OF SECONDARY ALUMINUM WASTES

Jernej Imperl, Mitja Kolar, Vilma Ducman, Gorazd Žibret, Lea Žibret 113
SELECTIVE SEPERATION OF MAGNESIUM FROM SLOVENIAN DOLOMITES

Vladan Nedelkovski, Dragana Medić, Aleksandar Cvetković, Sonja Stanković, Žaklina Tasić, Milan Radovanović, Snežana Milić 119
ANODE NANOMATERIAL RECOVERED FROM SPENT BATTERIES FOR PEROXIDE-ASSISTED CRYSTAL VIOLET PHOTOCATALYTIC DEGRADATION

Dragana Marilović, Sonja Stanković, Grozdanka Bogdanović 125
EFFECT OF TEMPERATURE ON THE LEACHING COPPER FROM FLOTATION TAILINGS WITH IONIC LIQUID

PAPERS **131**

Iyiola Olatunji Otunniyi, Oluwayimika Olasunkanmi Oluokun 133
CLEAN GOLD SOLUTION FROM PRINTED CIRCUIT BOARD PHYSICAL PROCESSING DUST BY SELECTIVE COMPLEXATION

Ugur Ulusoy Fırat Burat, Guler Bayar, Behrad Mojtahedi, Gulsah Guven 142
CHARACTERIZATION AND COMPARISON OF THE PARTICLE SHAPE OF MICRONIZED GRAPHITE GROUND IN DIFFERENT MILLS USING DIA

Aleksander Sokolov, Edvins Letko, Vitalijs Kuzmovs, Ulises Miranda Ordonez 148
ON-LINE XRF ANALYSIS OF ELEMENTS IN MINERALS ON A CONVEYOR BELT

Aleksandra Mitrovic, Jelena Vucicevic 154
LABORATORY-SCALE REACTORS EMPLOYING MOVING BED BIOFILM REACTOR (MBBR) TECHNOLOGY: A COMPREHENSIVE REVIEW

Vesna Marjanović, Emina Požega, Miomir Mikić, Milutin Stojadinović 160
INCREASING RECYCLING RATES IN THE FIELD OF CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT BY IMPLEMENTING THE LEGAL ACT OF THE REPUBLIC OF SERBIA AND THE EUROPEAN UNION

Radmila Marković, Vesna Marjanović, Aleksandra Ivanović, Milutin Stojadinović 166
CHARACTERISTICS OF COPPER POWDER OBTAINED AT LOWER VALUES OF CATHODE CURRENT DENSITY

Messai Ali, Berrekbia Linda, Meramria Ikram, Juan M. Menéndez-Aguado, Begoña Fernández Pérez, Vladimir Nikolić, Milan Trumić, Boustila Amir 171
POTENTIAL OF USING ZINC PROCESSING TAILINGS (ZPT's) IN THE PRODUCTION OF BURNT CLAY BRICKS

Aleksandra Božić, Dominik Brkić, Marina Stamenović, Marija Miletić 179
DETERMINATION OF PCB CONCENTRATION IN SOIL

Stefan Milanović, Nikola Simić, Lazar Kričak, Milanka Negovanović, Miljan Gomilanović, Nikola Đokić 184
ENVIRONMENTAL IMPACT WITH THE GREENHOUSE GASES AND AIR POLLUTANT PREDICTION BY DRILLING AND BLASTING WORKS

Dragan Milošević, Jasmina Nešković, Pavle Stjepanović, Svetlana Polavder 190
LANDFILL FOR COMBUSTION PRODUCTS FROM THE KOSTOLAC THERMOELECTRON

Fatma Arslan, Gülay Bulut 196
EVALUATION OF MINERAL PROCESSING AND METALLURGICAL PLANTS WASTES

Abhishek Gupta, Tom Newman, Frank Hrach 202
BENEFICIATION OF MINERAL ORES USING TRIBO-ELECTROSTATIC SEPARATOR

Valentin Alexeyevich Chanturia, Valeriy Valentinovich Morozov, Galina Petrovna Dvoichenkova, Elena Leonidovna Chanturia 208
THE SELECTION OF APPLICATION MODES OF AGENTS MODIFYING DIAMOND SPECTRAL CHARACTERISTICS IN THE PROCESS OF X-RAY LUMINESCENCE SEPARATION

Valeriy Valentinovich Morozov, Galina Petrovna Dvoichenkova, Irina Vasilyevna Pestryak, Valentina Anatolyevna Chut-Dy 214
UP-TO-DATE METHODS AND TECHNOLOGIES FOR IMPROVING THE PERFORMANCE OF FOAM SEPARATION OF DIAMOND-BEARING KIMBERLITES

Plamen Georgiev, Marina Nicolova, Irena Spasova, Mihail Iliev, Ralitsa Ilieva 220
NON-FERROUS METALS BIOLEACHING FROM PYROMETALLURGY COPPER SLAG USING SPENT MEDIUM OF DIFFERENT FUNGAL SPECIES

Milica Zdravković, Vesna Grekulović, Edina Huseinović, Robert Vianello, Nada Štrbac, Melita Huremović, Milan Gorgievski 226
UV-VIS IDENTIFICATION OF COPPER COMPLEXES WITH INHIBITOR ORGANIC COMPONENTS IN THE ELECTROLYTE

Moloud Nazeri, Maria Sinche-Gonzalez, Emad Abkhoshk 232
DISSOLUTION KINETICS OF LOW-GRADE ZINC SILICATE ORE IN HYDROXIDE SOLUTION

Ivana Smičiklas, Mihajlo Jović, Jelena Amidžić, Snežana Dragović 238
EVALUATION OF WASTE MATERIALS FOR CADMIUM REMOVAL: COMPARATIVE STUDY OF SORPTION CAPACITY AND STABILITY

Tanja Kalinović, Ana Radojević, Jelena Kalinović, Jelena Jordanović, Snežana Šerbula 244
CASE STUDY ON METAL(LOID)S DISTRIBUTION IN LINDEN TREE PARTS, IN AREAS WITH HIGHT ENVIRONMENTAL POLLUTION

Branimir Farkaš, Ana Hrastov, Iva Štefičar 250
POSSIBILITY OF INSTALLATION OF SOLAR POWER PLANTS IN EXPLOITATION SITES

Marija Simić, Marija Kovačević, Katarina Stojanović, Branislava Savić Rosić, Dragana Vasić Anićijević, Tanja Brdarić, Danka Aćimović 256
ELECTROCHEMICAL OXIDATION OF BISPHENOL S WITH SnO_2-MWCNT ELECTRODES

Marija Simić, Marija Kovačević, Katarina Stojanović, Marija Ječmenica Dučić, Dragana Vasić Anićijević, Danka Aćimović, Tanja Brdarić 261
COMPARATIVE STUDY OF ELECTROCHEMICAL DEGRADATION OF RHODAMINE B USING GLASSY CARBON, STAINLESS STEEL, AND NICKEL ELECTRODES

Marija Kovačević, Marija Simić, Katarina Stojanović, Danka Aćimović, Sanja Živković, Tanja Brdarić, Dragana Vasić Anićijević 267
PHOTODEGRADATION OF CIPROFLOXACIN WITH COPER-MODIFIED TITANIUM(IV)-OXIDE

Francielle Câmara Nogueira, Carlos Alberto Pereira, Leandro Vinícius Alves Gurgel, Stephânia da Consolação Silva Nogueira, Iranildes Daniel Santos 273
PROCESS WATER REUSE IN IRON ORE FLOTATION: REDUCING AMINE CONSUMPTION

Jovica Sokolović, Ivana Đolović, Dejan Tanikić, Zoran Štirbanović, Ivana Ilić 279
THE EFFECT OF PARTICLE SIZE ON THE FLOTATION KINETICS OF RAW AND WASTE COAL

Zuzana Danková, Alexandra Bekényiová, Zuzana Kollová, Erika Fedorová, Pavel Bačo, Jaroslav Briančin 286
SLOVAK DOLOMITE AS A RAW MATERIAL SOURCE FOR METAL MAGNESIUM PRODUCTION

Fatma Arslan, Cüneyt Arslan 292
RECYCLING OF WASTE CELL PHONES

Fulya Mennik, Nazlım İlkyaz Dinç, Beril Tanç Kaya, Fırat Burat 298
THE RECYCLING OF PLASTICS AND METALS FROM END-OF-LIFE NMC-TYPE ELECTRIC VEHICLE LITHIUM-ION BATTERIES USING SELECTIVE FROTH FLOTATION

Paul Delaney 306
PERFORMANCE OF IRON ALUMINIUM AND COPPER IRON BIMETALLIC PARTICLES IN REMOVAL OF HEAVY METALS AND METALLOIDS

Samah S. Abdallah, Samah M. El-Sayed, Mohamed A. Abdel-Khalek 313
SELECTIVE BIO-FLOCCULATION OF HEMATITE MINERAL USING BACILLUS SUBTILIS FOR PHOSPHOROUS REMOVAL FROM IRON ORES

Patrycja S. Bednarek, Nima Razavi, Przemyslaw B. Kowalczuk 320
THE ROLE OF ADDITIVE MANUFACTURING IN MINERAL AND METAL EXTRACTION

Zeynep Üçerler Çamur, Tülay Türk, Murat Olgaç Kangal 327
INVESTIGATION OF SURFACE PROPERTIES OF PVC FOR SELECTIVE RECOVERY

Martin Straka 333
ELECTROCHEMISTRY OF INDIUM IN METHYL-TRIOCTYLAMMONIUM BIS(TRIFLUOROMETHYLSULFONYL)IMIDE IONIC LIQUID

Seyed Hamzeh Amiri, Maria Sinche-Gonzalez 340
GRADE IMPROVEMENT OF IRON ORE CONCENTRATE BY APPLYING PLANT AUDITS, STANDARDIZATION AND PROCESS OPTIMIZATION

Henrique Dias Gatti Turrer, Josue Mesquita De Souza Junior, Gillian Nikka Omaga, Juliette Laine, Marcello Rodrigues Cruz, Nubia Bottosso, Vinicius Seerig 347
ADVANCEMENTS IN MINERAL PROCESSING: COLLABORATIVE EFFORTS AND TECHNOLOGICAL INNOVATIONS AT ARCELORMITTAL

Zuzana Kollová, Pavel Bačo, Zuzana Danková, Zoltán Németh 353
THE POTENTIAL SOURCES OF CRITICAL RAW MATERIALS IN SLOVAKIA

Amalia Andreas, Titus Nghipulile, Godfrey Dzinomwa 359
SELF-FLOTATION OF GALENA IN A COMPLEX SULPHIDE ORE FROM A COPPER MINE IN NAMIBIA

Janine Rodrigues Figueiredo, Érica Linhares Reis, Arthur Silva de Oliveira 368
PROCESSING OF FINE LITHIUM MINERAL TAILINGS

Theodor Steller, Stefan Eisert, Bernd G. Lottermoser 375
EXPLORING ELECTROHYDRAULIC FRAGMENTATION FOR PROCESSING ELECTRIC ARC FURNACE SLAGS

Yergeshev Akim Ruslanovich, Tokpayev Rustam Rishatovich, Khavaza Tamina Narimanovna, Karmeyeva Marina, Nauryzbayev Mikhail Kasymovich, Ignatkina Vladislava Anatolyevna 381
REFRACTORY POLYMETALLIC ORES BY FLOTATION. DIRECTIONS FOR IMPROVING METALLURGICAL BALANCE

Valentine A. Chanturia, Igor Zh. Bunin, Maria Ryazantseva 389
THE USE OF DIELECTRIC BARRIER DISCHARGE TO REGULATE THE TECHNOLOGICAL PROPERTIES OF CHALCOPYRITE AND SPHALERITE

Luis Verdugo, Barbara Etschmann, Maryam Abdus-Salam, Andrew Hoadley, Jorge Menacho, Joel Brugger 395
MECHANOCHEMICAL LEACHING OF CHALCOPYRITE IN LOW MOISTURE CONDITIONS

Miomir Mikić, Milenko Jovanović, Radmilo Rajković, Daniel Kržanović, Sandra Milutinović 401
RECULTIVATION PROCEDURE OF FLOTATION TAILINGS AT THE LOCATION OF RTH IN BOR

Vandana Kumari Jha, Christophe Duwig, Samaneh Teimouri, Kerstin Forsberg 407
METAL RECOVERY FROM SPENT BATTERIES THROUGH ANTISOLVENT CRYSTALLIZATION IN A T-MIXER USING A COUPLED CFD-PBE APPROACH

Luka Ceyssens, Nina Miladinović, Giuseppe Granata, Tom Van Gerven 413
MECHANOCHEMICAL ACTIVATION OF ARGON OXYGEN DECARBURIZATION SLAGS FOR IMPROVED MINERAL CARBONATION

Miomir Mikić, Vesna Marjanović, Emina Požega, Radmilo Rajković 416
TREATMENT OF ACIDIC MINE WATERS BY THE NEUTRALIZATION PROCESS

Julio Valenzuela Elgueta, Silvia Ahualli Yapur, Angel Vicente Delgado Mora 422
INFLUENCE OF CATIONIC SURFACTANTS ON THE ELECTROKINETIC PROPERTIES AND STABILITY OF SILICA-KAOLINITE SUSPENSIONS UNDER COPPER HYDROMETALLURGY CONDITIONS

Dragana Medić, Maja Nujkić, Žaklina Tasić, Vladan Nedelkovski, Stefan Đorđievski, Slađana Alagić, Snežana Milić 429
CHARACTERIZATION OF ELECTRODE MATERIALS FROM SPENT BATTERIES IN THE PROCESS OF RECOVERING VALUABLE METALS

Stefan Đorđievski, Dragana Adamović, Miloš Đukić, Ana Petrović, Jelena Petrović, Zoran Štirbanović 435
IMPROVEMENT OF BOR RIVER WATER QUALITY THROUGH TREATMENT AND RECIRCULATION OF MINING AND METALLURGICAL WASTEWATER

Kristina Pavićević, Danica Jovašević, Maja Rajković, Ivana Jelić, Marija Janković, Marija Šljivić-Ivanović 441
BIOCHAR IN WASTEWATER REMEDIATION: A BRIEF REVIEW OF CHARACTERISTICS AND PREPARATION MATERIALS

Semra Kurama, Hüseyin Boğaç Poyraz, Zahide Bayer Öztürk 449
A PROPOSAL FOR ZERO WASTE IN THE IRON AND STEEL INDUSTRY: ZIRCONIA NOZZLE WASTE EVALUATION

Boris Borche Fidanchev, Afrodita Zendelska 457
NEW SAG-BALL MILL AND FLOTATION LINE FOR RECONSTRUCTING OF “ZLETOVO” FLOTATION PLANT-PROBISHTIP, NORTH MACEDONIA

Nela Vujović, Vesna Alivojvodić, Dragana Radovanović, Marija Štulović, Miroslav Sokić, Filip Kokalj 463
POTENTIAL OF RECYCLING AND REUSE MINING WASTE IN SERBIA: CHALLENGES AND PROSPECTS

Haldun Kurama 469
DISSOLVED AIR FLOTATION: IS IT REALLY A SUITABLE SOLUTION FOR INDUSTRIAL PURIFICATION PROCESSES?

Carmen M. Neculita, Flavia L. Braghiroli 476
VALORIZATION OF RESIDUAL MATERIALS IN THE PREVENTION AND TREATMENT OF CONTAMINATED MINE WATER AND AIR

Vladimir Topalović, Ana Vujošević, Anja Antanasković, Veljko Savić, Marija Djošić, Zorica Lopičić, Jelena Nikolić 483
CHEMICAL STABILITY AND FERTILIZER EFFICIENCY OF BIOGLASS AND BIOCHAR ON ROSE PLANTINGS

Vladimir Topalović, Veljko Savić, Marija Djošić, Danijela Smiljanić, Snežana Zildžović, Snežana Grujić, Jelena Nikolić 490
THE EFFECT OF FLUXING AGENT CATIONS IN FLY ASH-BASED GLASS ON CHEMICAL STABILITY

Aleksandar Cvetković, Marija Petrović Mihajlović, Žaklina Tasić, Milan Radovanović, Ana Simonović, Vladan Nedelkovski 497
INFLUENCE OF ORGANIC COMPOUND STRUCTURE ON BRASS CORROSION INHIBITION EFFICIENCY

Aleksandar Cvetković, Vladan Nedelkovski, Dragana Medić, Sonja Stanković, Žaklina Tasić, Milan Radovanović, Snežana Milić 503
WASTE TO RESOURCE TRANSFORMATION: INNOVATIVE APPROACHES TO RECYCLING CATHODE MATERIALS FROM LITHIUM-ION BATTERIES

Gašper Tavčar, Davide Mombelli, Carlo Mapelli, Gianluca Dall'Osto, Dragan Radulović, Ivica Ristović, Mateusz Ciszewski, Jasna Kastivnik, Ana Mladenovič, Alenka Mauko Pranjič 509
OPTIMIZING METAL RECOVERY FROM EAF DUST: A COMPREHENSIVE APPROACH BEYOND THE WAELZ KILN PROCESS

Amir Mohammad Bidmeshki, Mahmoud Abdollahy 515
SOLVENT EXTRACTION OF La, Ce, AND Nd ELEMENTS FROM THE NiMH BATTERIES LEACH SOLUTION

Igor Zh. Bunin 522
LOW-TEMPERATURE ATMOSPHERIC PLASMA IN THE COMPLEX PROCESSING OF HARD-BENEFICIATION MINERAL RAW MATERIALS

Xiaopeng Peng, Lijie Guo, Xingshan Jin 529
THE STUDY ON THE STRESS CHARACTERISTICS OF BACKFILL BARRICADE IN UNDERGROUND METAL MINES BASED ON SIMULATION EXPERIMENTS

Sonja Stanković, Vladan Nedelkovski, Milan Radovanović, Stefan Đorđievski, Dragana Medić, Snežana Milić 537
SUSTAINABLE PRODUCTION OF GRAPHENE OXIDE AND ZINC OXIDE NANOPARTICLES FROM SPENT Zn-C BATTERIES

Jasna Kastivnik, Gašper Tavčar, Dragan Radulović 543
ENHANCING EU ECONOMIC RESILIENCE: EXPLORING NEW SOURCES AND BENEFICIATION OF CRITICAL RAW MATERIALS NIOBIUM AND TANTALUM FROM CENTRAL AFRICA

Džafer Dautbegović, Mirsada Hasanbašić 549
THE IMPACT OF THE TRANSFER STATION ON THE ORGANIZATION OF MUNICIPAL WASTE COLLECTION

Genc Demi, Bukurosh Koci, Islam Nika 556
RECYCLING OF CHROMIUM TAILINGS IN BULQIZA PLANT

Mafeni Samuel Ramatsoma, Veruska Govender, Deshenthree Chetty, Olga Bazhko 562
KINETIC AMD PREDICTION FOR A MINE TAILINGS DUMP: A SOUTHERN AFRICAN MINE CASE STUDY

Dragan S. Radulović, Jovica Stojanović, Gašper Tavčar, Vladimir Jovanović, Dejan Todorović, Branislav Ivošević, Sonja Milićević 568
CHARACTERIZATION OF AN ORE SAMPLE FROM CONGO BASED ON TANTALUM AND NIOBIUM FOR POSSIBLE FURTHER TECHNOLOGICAL TESTS

Dragan S. Radulović, Jovica Stojanović, Grozdanka Bogdanović, Vladimir Jovanović, Dejan Todorović, Branislav Ivošević, Vladimir Simić 575
STUDY OF MINERALOGICAL AND PHYSICOCHEMICAL PROPERTIES OF SAMPLES OF FLOTATION TAILINGS "RUDNIK“ MINE

Sara Živojinović, Živko Đorović, Miloš Vuleta 581
OPTIMIZATION RECYCLING IN IRON AND STEEL METALLURGY: UTILIZATION OF BY-PRODUCTS FOR EFFICIENCY AND SUSTAINABILITY

Aleksandra Milosavljević, Marijana Pavlov - Kagadejev, Ana Kostov 587
IR CAMERA APPLICATION IN CONTROL OF THE CURRENT STATE OF AN INDUCTION FURNACE IN LABORATORY CONDITIONS

Kostović Milena, Bajić Sanja 592
WASTE FOUNDRY SAND REGENERATION

Ilhan Bušatlić, Nadira Bušatlić, Nevzet Merdić, Nedžad Haračić, Lejla Mujezinović 598
GEOPOLYMERS BASED ON FLY ASH WITH THE ADDITION OF GRANULATED BLAST FURNACED SLAG

Sadaf Samadi-Tavanaa, Saeid Karimi, Mehdi Pourabdoli, Zoran Štirbanović 605
RECYCLING OF PRINTED CIRCUIT BOARDS (PCBS) USING VARIOUS DEEP EUTECTIC SOLVENTS (DESS) AND INSIGHTS FROM DFT SIMULATIONS

Kristina Muntu, Jean-Gabriel Fraboulet, Sean Salour, Christine Bonnet, Enkhzul Bayarmagnai, Brian K. Cook, Massoud Aghamirian 613
VARIABILITY IN FLOTATION PERFORMANCE OF LEPIDOLITE SAMPLES FROM THE EMILI DEPOSIT, FRANCE

Titus Nghipulile, Theophile Mwaku, Godfrey Dzinomwa, Benjamin Mapani, Jaquiline Tatenda Kurasha 620
REPROCESSING OLD MINE TAILINGS TO RECOVER COPPER AND PRECIOUS METALS USING FROTH FLOTATION

Sonja Milićević, Jovica Stojanović, Ivana Jelić, Snežana Zildžović, Vladimir Jovanović, Dejan Todorović 626
ZEOLITE ACID (UN)STABILITY AS MAJOR DISANDVANTAGE FOR ITS HUMAN CONSUMPTION

Paweł Tomach, Jacek Feliks, Marta Łuczak, Grzegorz Fabijański 632
INVESTIGATION OF ULTRA-FINE GRINDING OF AGGLOMERATED BASALT DUST

Francesco Ferella, Svetlana B. Zueva, Ionela P. Birloaga, Valentina Innocenzi, Nicolò M. Ippolito, Francesco Vegliò 639
PRODUCTION OF HIGH-PURITY QUARTZ FOR OPTICAL APPLICATIONS

Roshanak Adavodi, Adriana Zuffranieri, Soroush Rahmati, Pietro Romano, Francesco Ferella, Francesco Veglio' 646
SELECTIVE EXTRACTION OF MOLYBDENUM, NICKEL, AND COBALT FROM SECONDARY RESOURCES USING BIFUNCTIONAL IONIC LIQUIDS

Predrag Stolić, Zoran Jovanović, Željko Mravik, Marko Jelić, Sonja Jovanović 652
SELECTED ASPECTS OF SENSOR APPLICATION IN THE DESIGN AND IMPLEMENTATION OF INTELLIGENT INSTRUMENTATION FOR RECYCLING SYSTEMS

Maja Trumić, Katarina Balanović, Tamara Gavrilović 659
PREDICTION OF RESULTS OF FLOATATION PROCESS USING ARTIFICIAL NEURAL NETWORKS

Tomasz Suponik, Paweł Friebe, Umut Kar, Dawid Franke, Pengbo Chu 665
FINANCIAL AND TECHNOLOGICAL POTENTIAL OF ECO-EFFICIENT RECYCLING OF WASTE ELECTRONIC EQUIPMENT

David Oluwasegun Afolayan, Adamu Hassan Abubakar, Samuel Olumide Ogunmodimu 674
GRAVITY CONCENTRATION OF FINE PARTICLES COMPLEX ORES-CONTAINING BARYTE USING LABORATORY-BUILT MINERAL JIG

Olajuyi Seun Isaiah, Afolayan David Oluwasegun, Ogunmodimu Samuel Olumide 681
PRELIMINARY INVESTIGATION ON NIGERIAN LITHIUM ORES FOR EFFICIENT LITHIUM OXIDE EXTRACTION

Anđelija Bogdanović, Hassene Affouri, Ivan Kojić, Ksenija Stojanović 690
ORIGIN, DEPOSITIONAL ENVIRONMENT AND MATURITY OF ORGANIC MATTER IN EOCENE COALS FROM TUNISIA

Andriela Dutra Norberto de Oliveira, Luis Gonzaga Santos Sobral, Armando Lucas Cherem da Cunha 696
THE INFLUENCE OF DIFFERENT FORMS OF MINERAL PROCESSING ON THE BIO-OXIDATION OF SULPHIDE MINERALS BEARING GOLD

Andriela Dutra Norberto de Oliveira, Luis Gonzaga Santos Sobral, Armando Lucas Cherem da Cunha 702
BIODESULPHURISING HIGH SULPHUR CONTENT TAILINGS FROM COAL MINING IN BRAZIL

ABSTRACTS 707

Maria Cristina Vila, Maria Lurdes Dinis, Laura Ferrando-Climent, Nirosham Gajendra, Deniz Avsar, Duygu Yilmaz, Erika Levei, Iulia Török 709
INNOVATIVE PRE-FEASIBILITY STUDIES TOWARDS THE SUSTAINABLE PRODUCTION OF RARE EARTH CONCENTRATES FOR SELF-SUPPLY IN EUROPE

Randal Tzeou Hah Fauline, Agnès Grandjean, Antoine Leydier, Emeric Brun, Florian Herbelet, Xavier Heres, Justine Taurines 711
MODELING AND SIMULATION OF SOLID PHASE EXTRACTION FOR LEACHED ORE PURIFICATION

Michelle Airah N. Pablo, Joshua P. Pocaan, Jacob Louies Rohi W. Paulo, Piolo N. Gervacio, Arnel B. Beltran, Carla Mae J. Pausta, Aileen H. Orbecido 712
LEACHING OF CALCIUM FROM PHOSPHOGYPSUM FOR CARBON SEQUESTRATION

Michael Angelo B. Promentilla 713
A PROBLEMATIQUES APPROACH FOR UNDERSTANDING CIRCULAR ECONOMY INTEGRATION BARRIERS IN THE MINING AND MINERAL PROCESSING SECTOR

Joshua Pocaan, Brian Gerald Bueno, Jaica Mae Pagaduan, Aileen Orbecido, Carlito Tabelin, Ana Santos, Anne Jungblut, Vannie Joy Resabal, Renan Ma. Tanhueco, Michael Angelo Promentilla, Arnel Beltran 714
DEVELOPMENT OF LIMESTONE-BASED PASSIVE TREATMENT SYSTEM FOR COPPER-RICH ACID MINE DRAINAGE

Mathilde **Perrin,** Emmanuel **Billy** 715
BLACKMASS FLOTATION OF END-OF-LIFE BATTERIES: HOW TO DO WITHOUT PRE-TREATMENT?

XVI International Mineral Processing
and Recycling Conference
28-30 May 2025, Belgrade, Serbia

DOI: 10.5937/IMPRC25171A

Original research article

POTENTIAL OF USING ZINC PROCESSING TAILINGS (ZPT's) IN THE PRODUCTION OF BURNT CLAY BRICKS

Messai Ali[1#], 0000-0003-0165-5052,
Berrekbia Linda[1], 0009-0000-1669-1422,
Meramria Ikram[1], 0009-0000-1982-2774,
Juan M. Menéndez-Aguado[2], 0000-0002-6216-6984,
Begoña Fernández Pérez[2], 0000-0003-1239-4839,
Vladimir Nikolić[3], 0000-0003-1885-1156,
Milan Trumić[3], 0000-0002-4321-5218,
Boustila Amir[1], 0000-0002-1108-5105,
[1]National Higher School of Technology and Engineering, Department of Mining, Metallurgy and Materials Engineering, Annaba, Algeria
[2]University of Oviedo, Asturias Raw Materials Institute, Spain
[3]Univesity of Belgrade, Technical Faculty in Bor, Bor, Serbia

ABSTRACT – Zinc processing tailings (ZPTs) from the Kharzet Youcef processing complex (Setif- Algeria) are mainly stockpiled in tailings dumps without use, occupying a significant area with potentially influencing the environment and human health. Incorporating ZPTs in building materials manufacturing is an effective solution to meet the dual objectives of environmental protection and economic development. The study investigates the influence of integrating ZPTs to partially replace clays and firing temperature on the physic-mechanical properties of fired clay bricks (FCB). Microstructural, chemical, and mineralogical analyses of ZPT and clays were carried out by SEM-EDS, XRF and XRD, respectively. Seven mixtures were produced with various percentages of ZPTs added to clays (0%, 5%, 10%, 15%, 20%, 25% and 30%) and were fired to three different temperatures (950, 1000 and 1050 °C) at a ramp rate of 5 °C. Physic-mechanical tests were carried out on different brick specimens, and the results obtained showed the FCB incorporated with 30% of ZPTs produced the highest flexural strength of 6.24 MPa, compressive resistance of 29.78 MPa, bulk density of 1.37 g/cm^3 and water absorption of 15.1% at 900 °C. Therefore, recycling ZPTs for FCB manufacturing is a feasible alternative waste disposal solution for sustainable development while reducing negative environmental impacts.

Keywords: Zinc Processing, Fired Clay Bricks, Construction, Kharzet Youcef, Tailings Valorisation.

INTRODUCTION

Mineral resources, as non-renewable, are the basic blocks for global economic and social growth [1]. The exponential increase in mining activities has generated large amounts of waste and various types of waste. These wastes, mainly in tailings disposed of in dumps without proper management, inevitably affect the environment [2]. In this

---

[#] corresponding author: ali.messai@hotmail.com context, zinc mining and processing tailings are a primary source of toxic heavy metals to the environment [1,3].

In this regard, recycling and utilisation of mining wastes and tailings as alternative raw materials is regarded as an environmentally friendly solution to mitigate its impacts on the environment on the one hand and to maximise the returns on investments by reusing all extracted materials on the other hand [4].

Furthermore, zinc wastes have a chemical composition similar to natural raw materials used in construction industries [5]. So they can be used as partial replacements in bricks [6-8], cement [9], concrete admixture [10], mortar [11], the production of ceramics [12-14], and cementitious paste [15].

In Algeria, Chaabet El Hamra deposit is the only zinc deposit currently exploited in the country; it's operated by the National Company of Non-Ferrous Mining Products (ENOF). Raw ore is extracted using the room and pillar method and directed to the mineral processing plant to increase quality. Froth flotation is the method used to produce a final high-grade concentrate while the rejects are deposited in a dump. This dump occupies an area of 07 ha, and it has been receiving Chaabet El Hamra treatment waste of ore since 1994.

Subsequently, the authors designed a research plan focused on characterising ZPTs generated from the Kharzet Youcef mineral processing factory and evaluating its suitability as a partial replacement of clays in fired brick manufacturing. Physical-mechanical testing and the microstructure of produced brick specimens were investigated.

STUDY AREA DESCRIPTION

Geographic location

The mineral processing plant of Kherzet Youcef ore (Chaabet El Hamra Mine) is located in Eastern Algeria, 5 km northwest of Ain Azel and approximately 50 km southeast of Setif municipality (Figure 1).

MATERIALS AND METHODS

Materials

The clays used in this study were obtained from El Amel brick factory in El Taref, Algeria. The sampling is done manually from the discharge of the rolling mill (<1 mm).

The ZPT samples were obtained from five distinctive dump locations at the zinc processing plant of Kharzet Youcef. Then, the subsamples of each zone were homogenised, and five samples were finally obtained. After that, the materials (Clays and ZPTs) were dried at 105 °C for 24 h. ZPTs are ground using a planetary ball mill type Welte WTR 950 W/R-V and then sieved to select particles with an average diameter of less than 0.074 mm.

Five samples of ZPTs collected from Kharzet Youcef dumps were thoroughly mixed and prepared by conning and quartering to prepare a single representative sample.

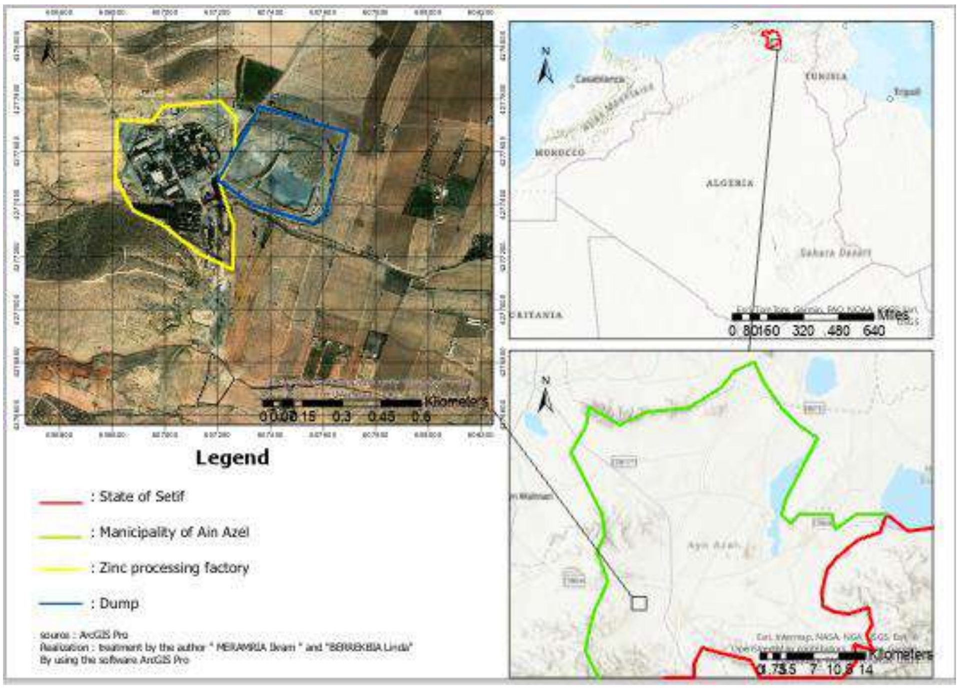

Figure 1 Geographic location of the study area

Molding and sintering of brick specimens

ZPTs were mixed with clays in varying portions to manufacture bricks (Table 1). The different mixtures were blended for 10 minutes in a blender, with 10% by mass of water, to get semi-dry homogenous mixes. Homogenised mixtures were manually pressed using a 40 × 40 × 160 mm mould to produce nine brick specimens for each combination.

Table 1 Mixtures specification

Formulations	**F0**	**F5**	**F10**	**F15**	**F20**	**F25**	**F30**
ZPT's (%)	0	5	10	15	20	25	30
ZPT's (g)	0	15	30	45	60	75	70
Clays (%)	100	95	90	85	80	75	70
Clays (g)	300	285	270	255	240	225	210

The obtained specimens were left in ambient air for 24 h, then dried in an oven at 105 °C for 24 h to decrease moisture content. The dried specimens were fired in a laboratory electrical furnace at a rate of 5 °C/min from room temperature to the desired firing temperature, where two different temperatures were targeted (900 °C and 1000 °C) and held for two hours at the desired firing temperature. After firing, natural convection inside the laboratory electrical furnace cooled bricks to room temperature.

Characterisation

The main chemical composition of the raw materials was determined by X-ray fluorescence spectroscopy (XRF PANalytical AXIOS minerals) and Inductively Coupled Plasma Optical Emission spectroscopy (Agilent Technologies 5900). The plasticity and liquidity limits of mixtures were determined according to ASTM D4318 and ASTM D4943—the sintered samples' bulk density and water absorption values. Linear shrinkage (%) was determined from the lengths of the brick specimens after drying and after sintering treatment by a calliper with a precision of ±0.01 mm according to ASTM C326-09. The compressive resistance and flexural strength were measured using a mechanical testing machine called the Bera Test.

RESULTS AND DISCUSSION

ZPTs and clay characterization

Chemical composition

Chemical analysis of the clays used in this study (Table 2) reveals a high content of SiO_2 (42.9) and Al_2O_3 (23.3), accompanied by significant levels of FeT (8.25) and CaO (8.9).

Table 2 Chemical composition of used clays

Elements	SiO_2	Al_2O_3	Fe_T	CaO	K_2O	MgO	TiO_2	Na_2O	LOI
Percentage (%)	42.9	23.3	8.25	8.9	2.8	4.1	2.7	1.1	5.95

The main components of ZPTs of composite samples are presented in Table 3. The sample is dominated by CaO (31.62%) and a high loss on ignition (LOI) of 35.46%, indicating a large amount of volatile or organic matter. SiO_2 and MgO are also in significant quantities, representing 9.45% and 10.74%, respectively.

Table 3 Chemical composition of Kharzet Youcef ZPT's

Elements	SiO_2	Al_2O_3	Fe_2O_3	CaO	K_2O	MgO	MnO	Na_2O	P_2O_5	S	LOI
Percentage (%)	9.45	2.2	5.05	31.62	0.38	10.74	0.08	0.54	0.05	3.18	35.46

In conclusion, the silica and alumina content in ZPTs can qualify them as a partial replacement for clays in brick manufacturing.

Physic-mechanical tests

The mass and volume of mixtures prepared for briquetting reveal interesting trends in density. The mass of the briquettes gradually increases with ZPT's added percentage, leading to higher material compactness. These results suggest that adding ZPTs to clays provides denser briquettes, enhancing strength.

The results of plasticity limits for mixtures illustrated in Figure 3 demonstrate the inverse correlation between adding ZPTs and plasticity. These results suggest that incorporating ZPTs affects clays' physical properties.

Figure 4 represents the results of the water absorption test in two cases: 900°C and 1000°C. At 900°C, a general increase in water absorption is evident, suggesting increased porosity of the briquettes. At 1000°C, variations in water absorption are less pronounced.

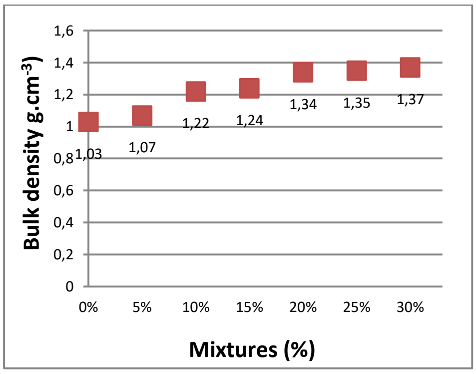

Figure 2 Variation of bulk density of different clay mixtures

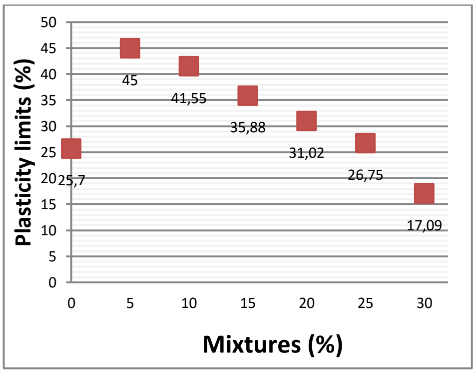

Figure 3 Results of plasticity limits

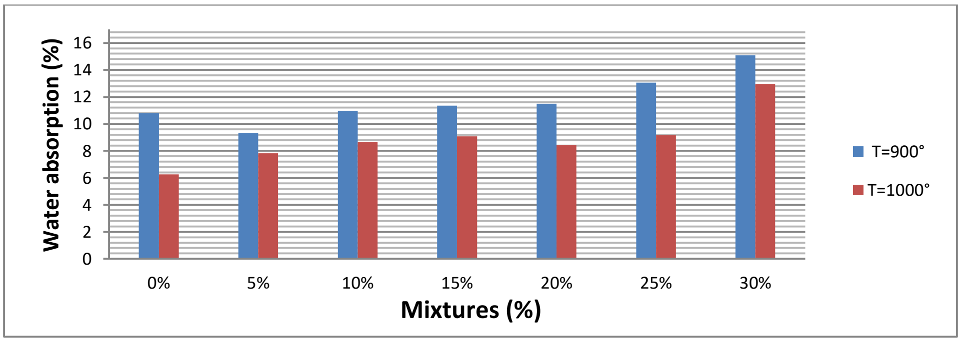

Figure 4 Water absorption as a function of mixtures fired at 900 °C and 1000 °C

Bulk density of bricks:

These results indicate that the firing temperature and the percentage of ZPTs significantly impact the compactness and density of the briquettes after firing, which can influence their mechanical properties and performance in practical applications.

The bulk density of the produced bricks for different proportions of ZPTs fired at various temperatures (900-1000 °C) was presented in Figure 5. The results reveal significant variations in the density depending on the added quantity of ZPTs and the firing temperature. As presented, the samples without ZPT's bulk density, fired at 900 °C and 1000 °C, were 1.18 and 1.40 g/cm^3, respectively. The addition of the ZPTs influences the bulk density of the bricks. At 900 °C, the density varies irregularly, with peaks at 5%

and 10% of added ZPTs. On the other hand, at 1000°C, density augmentation with the increase of ZPTs is observed, reaching maximum values at 15% and 20% added.

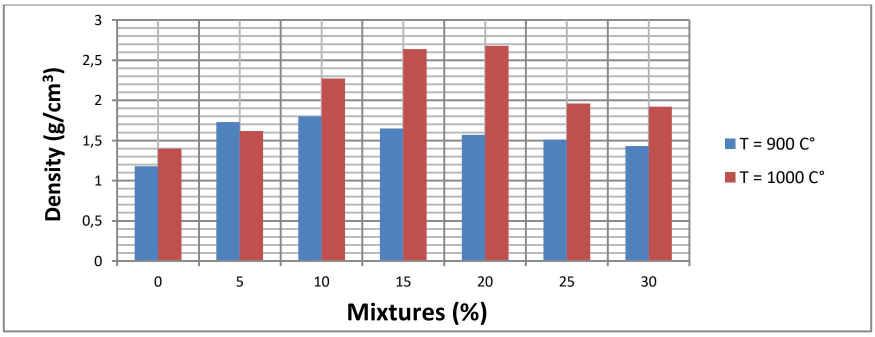

Figure 5 Density variation as a function of mixtures and firing temperature

Linear shrinkage:

Figure 6 shows a general reduction trend in linear shrinkage with increasing percentage of ZPTs, suggesting less contraction of the briquettes at higher added concentrations. This can be attributed to better adhesion and a more homogeneous structure of the materials at these concentrations, which reduces the internal tensions responsible for shrinkage. These results highlight the impact of the percentage of ZPTs on the physical properties of the briquettes, mainly their behaviour during drying, which may have implications on their final sizing and compatibility with the intended applications.

Figure 7 represents the shrinkage results obtained after the firing of bricks at 900 and 1000 °C. A significant variation in material shrinkage has been shown depending on the percentage of ZPTs and the firing temperature. At 900°C, linear shrinkage increases with the increase in the rate of ZPTs up to 15%, and then a decrease to 20% and 25% is added. In contrast, at 1000°C, linear shrinkage appears to vary irregularly, with maximum values observed at 10%, 20% and 30% of ZPTs.

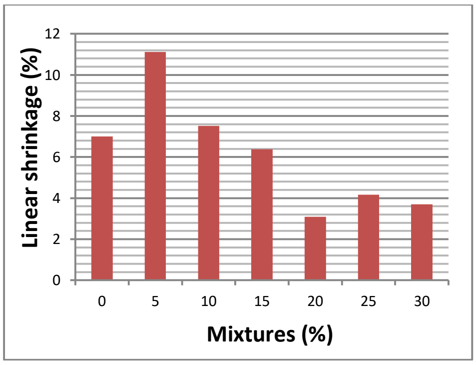

Figure 6 Linear shrinkage of bricks after drying

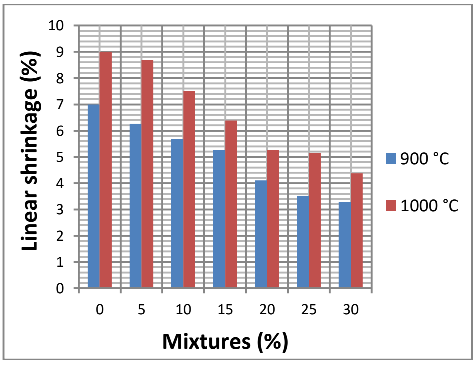

Figure 7 Linear shrinkage of bricks fired at 900 and 1000 °C

Mechanical resistance

The results of mechanical resistance tests of bricks manufactured with different mixtures of ZPTs and clays and subjected to different firing temperatures provide in-depth information on the mechanical performance of these materials. At the firing temperature of 900 °C, the flexural strength (R_F) shows an overall decrease with the increasing percentage of ZPTs, suggesting a reduction in the ability of the bricks to withstand flexural stresses.

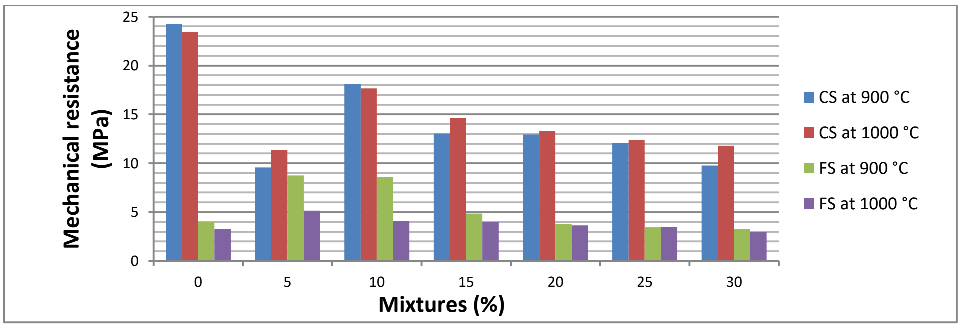

Figure 8 Mechanical resistance of fired clay bricks at 900-1000 °C with 0 to 30 wt% of ZPT's additions (CS: compressive strength; FS: flexural strength)

In contrast, the compressive strength (R_C) varies in a more complex manner, reaching maximum values at 0% and 30% ZPTs, which could indicate a better capacity of the briquettes to support axial loads at these concentrations. At a higher temperature of 1000°C, the downward trend in flexural strength is confirmed, while compressive strength shows more pronounced fluctuations, with peaks observed at 25% and 30% ZPTs. These results highlight the importance of considering both the percentage of ZPTs and the firing temperature in the design of the mixtures to obtain the desired mechanical properties because these parameters significantly influence the ability of the briquettes to resist the different forces and constraints to which they could be subjected in practical applications.

CONCLUSION

The advantage of this research is to reutilise the zinc processing tailings (ZPTs) as a partial replacement in manufacturing clay-fired bricks, an effective alternative treatment for waste resource recycling. It is possible to summarise the experimental findings that ZPTs can partially replace clays in fired clay bricks manufacturing with a percentage of 10% and a firing temperature equal to 900 °C.

ACKNOWLEDGEMENT

"The research presented in this paper was done with the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, within the funding of

the scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-137/2025-03/200131".

REFERENCES

1. Sun, R., Gao, Y., Yang, Y. (2022) Leaching of heavy metals from lead-zinc mine tailings and the subsequent migration and transformation characteristics in paddy soil. Chemosphere, 291, 132792.
2. Zhou, Y., Duan, X., Chen, T., Yan, B., Li, L. (2021) Mechanical properties and toxicity risks of lead-zinc sulfide tailing-based construction materials. Materials, 14 (11), 2940.
3. Nassiri, O., Rhoujjati, A., Moreno-Jimenez, E., Hachimi, M.L.E. (2023) Environmental and geochemical characteristics of heavy metals in soils around the former mining area of zeïda (high moulouya, Morocco). Water, Air, and Soil Pollution, 234 (2), 110.
4. Doğan-Sağlamtimur, N., Bilgil, A., Szechyńska-Hebda, M., Parzych, S., Hebda, M. (2021) Eco-friendly fired brick produced from industrial ash and natural clay: A study of waste reuse. Materials, 14 (4), 877.
5. Li, R., Yin, Z., Lin, H. (2023) Research status and prospects for the utilisation of lead–zinc tailings as building materials. Buildings, 13 (1), 150.
6. Yaras, A., Sutcu, M., Erdogmus, E., Gencel, O. (2021) Recycling and immobilisation of zinc extraction residue in clay-based brick manufacturing. Journal of Building Engineering, 41, 102421.
7. Long, Z., Sulian, Z., Huaju, M. (2022) Study on the Preparation and Performance of Lead-Zinc Mine Steam-free and Burn-free Brick. Multipurpose Utilization of Mineral Resources, 43 (3), 12-16.
8. Lin, H., Li, R., Li, S. (2024) Fabrication of Lead–Zinc Tailings Sintered Brick and Its Effect Factors Based on an Orthogonal Experiment. Materials, 17(10), 2352.
9. Zhao, T., Zhang, S., Yang, H., Ni, W., Li, J., Zhang, G., Teng, G. (2022) Influence on fine lead–zinc tailings solidified/stabilised by clinker-free slag-based binder. Journal of Environmental Chemical Engineering, 10 (6), 108692.
10. Saedi, A., Jamshidi-Zanjani, A., Darban, A.K., Mohseni, M., Nejati, H. (2022) Utilisation of lead–zinc mine tailings as cement substitutes in concrete construction: Effect of sulfide content. Journal of Building Engineering, 57, 104865.
11. Qu, G., Ge, R., Li, J., Zhang, Y. (2022) Lead-Zinc Tailings-Based Construction Mortars/Preparation, Performance and Stabilization Mechanism of Heavy Metals. Preparation, Performance and Stabilization Mechanism of Heavy Metals.
12. Li, C., Zhang, P., Li, D. (2022) Study on low-cost preparation of glass–ceramic from municipal solid waste incineration (MSWI) fly ash and lead–zinc tailings. Construction and Building Materials, 356, 129231.
13. Zhang, X., Li, L., Hassan, Q.U., Pan, D., Zhu, G. (2023) Preparation and characterisation of glass ceramics synthesised from lead slag and lead-zinc tailings. Ceramics International, 49 (10), 16164-16173.
14. Luo, Z., Guo, J., Liu, X., Mu, Y., Zhang, M., Zhang, M., Tian, C., Ou, J., Mi, J. (2023) Preparation of ceramsite from lead-zinc tailings and coal gangue: Physical properties and solidification of heavy metals. Construction and Building Materials, 368, 130426.
15. Zhang, F., Li, Y., Zhang, J., Gui, X., Zhu, X., Zhao, C. (2022) Effects of slag-based cementitious material on the mechanical behavior and heavy metal immobilisation of mine tailings based cemented paste backfill. Heliyon, 8 (9), e10695.