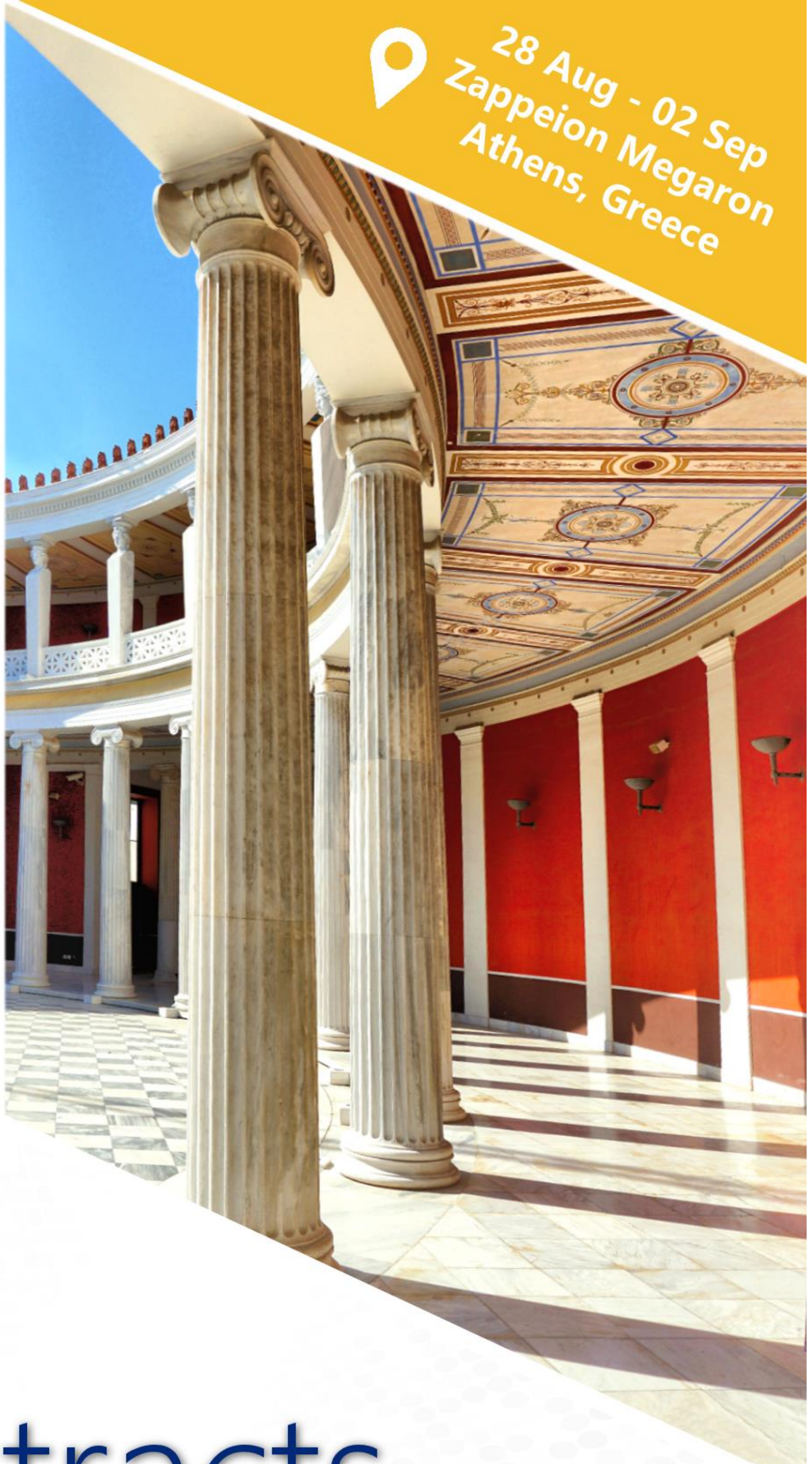
RawMat2023

2nd International Conference on Raw Materials and Circular Economy

Raw Materials: Setting the foundations for the Green Transition

28 Aug - 02 Sep
Zappeion Megaron
Athens, Greece



Book of Abstracts

Organized by

National Technical University of Athens

Technical Chamber of Greece

Contact us:

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Organized by

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σύνδεσμος επιχειρήσεων μαρμάρου μακεδονίας - θράκης

RawMat2023

2nd International Conf. on Raw Materials and Circular Economy

"*Raw Materials: setting the foundation for the Green Transition*"

Raw materials are strongly connected to human development and the prosperity of Earth's population and therefore, they are crucial to every country's economy. Raw materials form a strong industrial base, producing a broad range of goods and applications used not only in everyday life but also in new strategic and green technologies. The global population growth, the rise in the standard of living and the drive for clean energy technologies are increasing the demand of mineral resources. According to the International Energy Agency (IEA), there could be a 20-fold increase in demand for nickel and cobalt by 2040 to meet the needs of an increasingly electrified world, and the total copper demand will nearly double by 2035. Other raw materials, such as lithium, rare earth elements, vanadium, etc. are critically important for the transition to green energy, higher mobility and the digital world. At the same time, raw materials must be sourced in a sustainable and responsible way, achieving high-level environmental standards and social acceptance. All the above present both an opportunity and a challenge for the raw materials industry.

Reliable and unhindered access to certain raw materials is a growing concern across the globe. To ensure the sustainable supply of raw materials, it is crucial that the minerals sector, apart from exploring new regions and opening new projects, can also embrace the concept of a circular economy and identify opportunities for the rational use of raw materials, such as reducing and optimizing the use of materials, industrial symbiosis, recycling, reuse, remanufacturing, etc. By conserving materials embodied in high-value products, or returning waste to the economy as high-quality secondary raw materials, a circular economy could increase the efficiency of primary resource consumption. The transition from linear to circular economy is essential in achieving a resource-efficient and sustainable society.

In that respect, the 1st international conference entitled "Raw Materials and Circular Economy - Technological Developments and Future Challenges" (RawMat2021), was organized on September 2021 in Athens, Greece, which was embraced by stakeholders involved in all steps of the materials value chain. The 2nd international conference entitled "**Raw Materials and Circular Economy - *Raw Materials: setting the foundation for the Green Transition*" (RawMat2023)** is **organized** again in Athens, Greece, by the School of Mining and Metallurgical Engineering, **National Technical University of Athens** and the **Technical Chamber of Greece** under the auspices of Hellenic Ministry of Environment and Energy, Association of Mining Enterprises and Association of Marble Enterprises of

Macedonia and Thrace. It is also **co-organized** by the *Hellenic Survey of Geology and Mineral Exploration*, *Geotechnical Chamber of Greece*, *Geological Society of Greece*, School of Mineral Resources Engineering, *Technical University of Crete*, Department of Mineral Resources Engineering, *University of Western Macedonia*, Department of Geology and Department of Chemistry, *Aristotle University of Thessaloniki*, Department of Geology and Geo-environment, *National and Kapodistrian University of Athens*, Department of Geology, *University of Patras*, *Centre for Renewable Energy Sources and Saving* and *EBETAM SA - Company of Industrial Research, Technological Development and Laboratory Testing, Certification and Quality*. In addition, it is **supported** by The Metallurgy and Materials Society of Canadian Institute of Mining and Petroleum (*MetSoc/CIM*), The Minerals, Metals & Materials Society (*TMS USA*) and the Australasian Institute of Mining and Metallurgy (*AusIMM*).

RawMat2023 topics cover a wide range of raw materials related activities, including strategies on raw materials supply, exploration, mining, mineral processing, metallurgy, energy, waste valorisation, recycling, Industry 4.0 transformation with emphasis on Green Transition issues. RawMat2023 brings together industry executives and engineers, junior and senior scientists, stakeholders and policy makers, professionals and academics from the whole raw materials value chain, for a comprehensive, cross-discipline exchange of knowledge. New tools, methods, research findings, methodological frameworks and hypotheses as well as innovative ideas are going to be presented in its scientific and technical sessions.

We are looking forward to your participation and attendance at the RawMat2021 Conference!

Prof. Anthimos Xenidis
Chair RawMat2023

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CONFERENCE DETAILS

RawMat2023 is organized by the **Technical Chamber of Greece**, the **School of Mining and Metallurgical Engineering of the National Technical University of Athens** under the auspices of Hellenic Ministry of Environment and Energy, Association of Mining Enterprises and Association of Marble Enterprises of Macedonia and Thrace.

It is also **co-organized** by the *Hellenic Survey of Geology and Mineral Exploration*, *Geotechnical Chamber of Greece*, *Geological Society of Greece*, School of Mineral Resources Engineering, *Technical University of Crete*, Department of Mineral Resources Engineering, *University of Western Macedonia*, Department of Geology and Department of Chemistry, *Aristotle University of Thessaloniki*, Department of Geology and Geo-environment, *National and Kapodistrian University of Athens*, Department of Geology, *University of Patras*, *Centre for Renewable Energy Sources and Saving* and *EBETAM SA - company of Industrial Research, Technological Development and Laboratory Testing, Certification and Quality*.

In addition, it is **supported** by The Metallurgy and Materials Society of Canadian Institute of Mining and Petroleum (*MetSoc/CIM*), The Minerals, Metals & Materials Society (*TMS USA*) and the Australasian Institute of Mining and Metallurgy (*AusIMM*). Finally, RawMat2023 is co-funded by the Greek Green Fund “Extrovertial Actions, Natural Environment and Innovative Actions”

TOPICS

RawMat2023 covers a broad list of topics as follows

- EU Industrial Strategy / Circular and Resource Efficient Economy
- Minerals Exploration and Resource Characterization: securing critical and strategic raw materials supply
- Mining: Trends and Perspectives
- Advances in Mineral Processing Technologies
- Sustainable Metallurgy
- Industrial Minerals
- Environment, Energy and Sustainability
- Reuse - Recycling and Valorisation
- Education
- Occupational Health and Safety (OHS)
- Greece - Specific Issues

PRESENTATION GUIDELINES

Oral contributions

Regular oral presentations will last 15 minutes which include a 12 min speech by the presenting author and another 3 min for questions by the audience. Plenary and keynote presentations will last 30 min(25 min speech and 5 min for discussion) unless otherwise indicated in the final program. In order to keep the program on time, all authors are requested to be accurate in their timetable

Poster presentations

The presenting authors should hang their printed posters in the morning of their presentation and remove them at the end of the poster session. The preferable dimensions for posters should be 80 cm x 120 cm (width x height). All posters are required to conform to portrait orientation. Type size should be sufficiently large to allow people to read from 2-3 meters. There is no template to hold you back, so feel free to explore your artistic prowess and create a stunning poster that truly stands out.

All presentations should be prepared in English language (official language of the Conference).

AWARDS

The most outstanding presentations during RawMat2021 will receive one of the awards from the following categories:

- **Best Oral Presentation Award.** Most distinguished paper combining high scientific quality and presentation significance. The award is sponsored by the journal Minerals MDPI.
- **Best Poster Award.** Dedicated to the best presentation during the poster sessions of the conference.
- **Young Researcher Award.** For the best presentation by a young scientist.

Selected high-impact presentations will get a waiver for full paper submission in the peer-review journals collaborating with RawMat2023.

Presented papers will be evaluated by the Award Committee according to the following criteria: Significance of the paper, Originality, Presentation impact, Young researcher. The winners of RawMat2023 awards will be announced during the closing ceremony of the conference.

PROCEEDINGS

Conference participants may submit a full paper which is oriented to be published in the RawMat2023 Proceedings Volume hosted in Materials Proceedings journal. Publication in the Proceedings is free of charge for all registered participants and the paper will be available as an open access document.

PUBLICATION IN JOURNALS

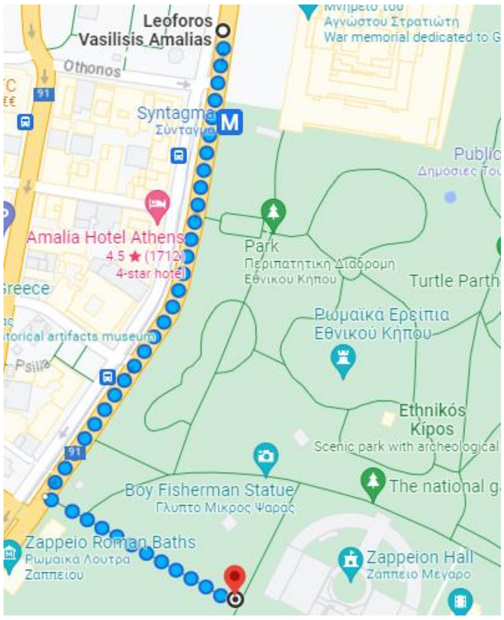
For selected papers presented RawMat2023, the opportunity to publish a full paper in one of the collaborating peer-review journals will be offered after the end of the conference. Some of the mentioned journals are open access requiring an Article processing charge from the side of the authors. RawMat2023 provides a significant discount of this amount for all participant and a number Papers related to metallurgical processes and research aiming at improving the sustainability of metals production, with an emphasis on materials recovery, reuse, and recycling, energy and environmental impacts minimization will be invited to submit in a Special Issue of the **Journal of Sustainable Metallurgy** (Springer, Impact factor 3.068 (2021)).

Papers related to minerals, minerals processing, mining and environment will have an opportunity to be submitted in the Special Issue entitled "***Exploration, Mining, and Processing of Minerals: Enabling the Clean Energy Transition***" of the journal **Minerals** (MDPI, open access, impact factor 2.818 (2021)).

Selected papers in the area of Raw Materials and Circular Economy will be also published in a Special Issue of the Open Access e-**Technical Annals** Journal. It is a relatively new international journal, formerly a national one having published engineering articles for decades, that recently started publishing high-quality original research articles, reviews, and technical notes in various fields of engineering and technology. The journal is edited by the Technical Chamber of Greece through the e-Publishing Platform.

VENUE

RawMat2023 shall take place in Athens, the historical heart of Greece known as the birthplace of democracy and home to some of the most significant philosophers. The **Zappeion Exhibition Hall** or **Zappeion Megaron**, located in the Athens city center, is the conference venue. It has been an active part of Greece's history and that of Hellenism, for the last 130 years, surrounded by some of the most important buildings in Athens, such as the Parliament building, the Tomb of the Unknown Soldier, the Maximou Palace, which is the official residence of the Prime Minister, the Foreign Ministry, and other public buildings. Nearby are the National Gardens and, opposite, on the side of the Ardittos Hill, the Panathinaic Stadium, Hadrian's Arch and the ancient Temple of the ROOM 13n Zeus. Athens International Airport Eleftherios Venizelos is about 35 km away from the venue (about 50 minutes trip by public transportation or 30 minutes' drive) and easily accessible. The Zappeion Megaron is served by a metro station (Syntagma: red and blue lines) located within walking distance (6 minutes-500m). Website: https://www.zappeion.gr/en/



EXHIBITION

In the framework of the RawMat2023, a parallel exhibition will be organized where supporting companies and organizations dealing with the raw materials sector are going to provide detailed information on their activities and future plans to the conference participants. The exhibition area is located in Room 3.

SOCIAL EVENTS / FIELD TRIPS

Opening ceremony	28-8-2023	Zappeion / Room 13		09:00
Welcome reception	28-8-2023	Zappeion / Peristilio		20:00
Gala dinner	29-8-2023	Royal Olympic Hotel-Ioannis Roof Garden		20:00
Field Trip 1 to AoG / Mytilineos and Delphi	31-8-2023	Aluminium of Greece - Delphi archeological site	Departure: Return:	08:00 19:00
Field Trip 2 to Lavrion and Sounion	1-9-2023	Lavrion Historical Mine Sounion archeological site	Departure: Return:	08:00 18:15

PARALLEL EVENTS

- **Greek specific issues** 29-8-2023 09:00-13:00

Presentations by companies and government bodies discussing current situation, problems, challenges and future trends in the field of raw materials in Greece. Event language will be Greek.

- **ERA MIN** 29-8-2023 09:00-16:30

ERA-MIN3 is a global, innovative and flexible pan-European network of 25 European and non-European research funding organisations, aiming to continue strengthening the mineral raw materials community through the coordination of research and innovation programmes on non-fuel and non-food raw materials (metallic, construction, and industrial minerals).

Attracting and promoting innovations for increased raw material efficiency and circular economy is crucial for the transition to a climate-neutral and digital economy. ERA-MIN3 organizes three sessions which address recent research results and future challenges and research needs for raw materials and the circular economy.

The first two ERA-MIN sessions (Session B2 "***Sustainable Mining, Processing and Production Processes***" and Session B5 "***Recycling of EoL products and immovable assets, e.g. batteries, magnets***" will highlight the results of the 22 out of 24 transnational research projects that have ended recently or will end soon. The transnational projects target R&I innovations that cover the entire raw materials value chain (exploration, mining, processing, production and recycling of EoL products, including batteries and magnets). Within a systemic view, research the transnational R&I projects address both technological and non-technological aspects, e.g. circular economy business models. By joining these sessions, you will learn from Europe's leading players in the research sector who will share insights into their recent research results and their plans for future exploitation. To discuss challenges and the future research and innovation needs towards a sustainable raw materials supply which should be addressed by a partnership of funding programmes is the aim of the 3rd session (Session B8 "***ERA-MIN SRIA workshop***").

- **Critical metals sourcing - Experts Panel Discussion** 30-8-2023 17:00-19:00

This session will give delegates the opportunity to learn about and discuss with industrial experts. Five experts from SME, large and small enterprises, and consultancies are invited. They represent important economic sectors, scandium and related alloys, gallium, aluminium (bauxite), titanium dioxide, and magnesium. Each metal has its specific supply and market issues, driven by the choice of technologies, related economic and financial matters.

The important titanium and aluminium industries may unlock by-products from residual waste streams or secondary products. Magnesium, and other critical metals can be recovered with innovative extraction processes reducing energy consumption, and C-footprint. Critical raw materials can and will thus be available in Europe for refiners and end-users.

What are the challenges, strength, opportunities, and threats for a European metal transformation and production? What are European solutions to be competitive with Asian produced critical metals.

PROGRAM STRUCTURE

	Monday 28 Aug. 2023	Tuesday 29 Aug. 2023	Wednesday 30 Aug. 2023
08^{00}-09^{00}	Registration	Registration	Registration
09^{00}-10^{30}	Opening speeches PLENARY LECTURES	B1 GREECE-SPECIFIC ISSUES B2 ERA-MIN3 at RawMat2023 B3 ENERGY AND CO_2 STORAGE	PLENARY LECTURES
10^{30}-11^{00}	Coffee break - Poster session I	Coffee break - Poster session II	Coffee break - Poster session III
11^{00}-13^{00}	PLENARY LECTURES Sponsors presentations	B4 GREECE-SPECIFIC ISSUES B5 ERA-MIN3 at RawMat2023 B6 ENVIRONMENT AND SUSTAINABILITY I	C1 CRITICAL METALS RECOVERY FROM WASTE C2 SUBSTITUTION & RECYCLING IN THE AUTOMOTIVE SECTOR C3 INDUSTRIAL MINERALS & WASTE REUSE - VALORIZATION I
13^{00}-14^{30}	Lunch break - Poster session I	Lunch break - Poster session II	Lunch break - Poster session III
14^{30}-16^{30}	A1 EU STRATEGY-CIRCULAR ECONOMY A2 MINERALS EXPLORATION - RESOURCE CHAR. I A3 CRITICAL ELEMENTS REC. FROM EoL PRODUCTS	B7 MINING: TRENDS AND PERSPECTIVES I B8 ERA-MIN SRIA WORKSHOP B9 ENVIRONMENT AND SUSTAINABILITY II	C4 MAGNETS AND REEs C5 ENERGY TRANSITION METALS - ENICON & EXCEED C6 REUSE-RECYCLING AND VALORISATION II
16^{30}-17^{00}	Coffee break - Poster session I	Coffee break - Poster session II	Coffee break - Poster session III
17^{00}-18^{30}	A4 ADVANCES IN MINERAL PROCESSING A5 MINERALS EXPLORATION - RESOURCE CHAR. II A6 Li-ion BATTERIES RECYCLING	B10 MINING: TRENDS AND PERSPECTIVES II B11 HYDROMETALLURGICAL PROCESSES B12 OSH and EPD REPORTING	C7 ADVANCED METALLURGICAL PROCESSES C8 CRITICAL METALS SOURCING - EXPERTS PANEL DISCUSSION C9 EDUCATION
18^{30}-19^{00}	PLENARY LECTURES		
19^{00}-19^{30}			19^{00} Closing ceremony Awards
20^{00}-22^{30}	20^{00} Welcome reception	20^{00} Gala Dinner	

PROGRAM AT A GLANCE

Monday 28 August 2023

ROOM 13	09:00-09:30	**Welcome** and brief introduction by the **organizers**
	09:30-10:00	**Welcome** speeches
	10:00-10:30	**Plenary** lectures
ROOM 3, 16	**10:30-11:00**	**Coffee break – Poster session I**
ROOM 13	11:00-12:00	**Plenary** lectures
	12:00-12:50	**Sponsors** presentations
	12:50-13:00	**Honorary Award** to Dr. Nikolaos Arvanitidis
ROOM 2, 3 Peristilio	**13:00-14:30**	**Lunch break**
ROOM 3, 16	**Poster Session I – Exhibition**	
	14:30-16:30	**Parallel sessions**
ROOM 13	A1. EU Strategy-Circular economy	
ROOM 5	A2. Minerals Exploration and Resource Characterisation I	
ROOM 6	A3. Critical elements recovery from End-of-Life products	
ROOM 3, 16	**16.30-17.00**	**Coffee break – Poster session I**
	17:00-18:45	**Parallel sessions**
ROOM 13	A4. Advances in mineral processing technologies	
ROOM 5	A5. Minerals Exploration and Resource Characterisation II	
ROOM 6	A6. Li-ion Batteries recycling	
ROOM 3, 16	**18:30-18:45**	**Coffee break – Poster session I**
ROOM 13	18:45-19:45	**Plenary** lectures
PERISTILIO (Zappeio)	20:00	**Welcome reception**

PROGRAM AT A GLANCE

Tuesday 29 August 2023

	09:00-10:30	**Parallel sessions**
ROOM 13	B1. Greek specific issues (in Greek)	
ROOM 5	B2. ERA-MIN3 at RawMat2023 *(starts at 08:30)*	
ROOM 6	B3. Energy and CO_2 storage	
ROOM 3, 16	**10:30-11:00**	**Coffee break – Poster session II**
	11:00-13:00	**Parallel sessions**
ROOM 13	B4. Greek specific issues (in Greek)	
ROOM 5	B5. ERA-MIN3 at RawMat2023	
ROOM 6	B6. Environment and Sustainability I	
ROOM 1, 2, 3	**13:00-14:30**	**Lunch break**
	Poster Session II – Exhibition	
	14:30-16:30	**Parallel sessions**
ROOM 13	B7. Mining: Trends and perspectives I	
ROOM 5	B8. ERA-MIN SRIA workshop	
ROOM 6	B9. Environment and Sustainability II	
ROOM 3, 16	**16:30-17:00**	**Coffee break – Poster session II**
	17.00-19.00	**Parallel sessions**
ROOM 13	B10. Mining: Trends and perspectives II	
ROOM 5	B11. Hydrometallurgical processes for metals recovery from EoL and ores	
ROOM 6	B12. OSH and EPD Reporting	
Royal Olympic Hotel	20:00	**Gala dinner**

PROGRAM AT A GLANCE

Wednesday 30 August 2023

ROOM 13	09:30-10:30	**Plenary** lectures
ROOM 3, 16	**10:30-11:00**	**Coffee break – Poster session III**
	11:00-13:00	**Parallel sessions**
ROOM 13	C1. Critical metals recovery from mining/metallurgical waste	
ROOM 5	C2. Substitution and Recycling of Critical Raw Materials in the Automotive Sector - The Industrial Perspective	
ROOM 6	C3. Industrial minerals & Waste reuse - valorisation I	
ROOM 1, 2, 3	**13:00-14:30**	**Lunch break**
	Poster Session III – Exhibition	
	14:30-16:30	**Parallel sessions**
ROOM 13	C4. Magnets and REEs	
ROOM 5	C5. Energy transition metals - ENICON & EXCEED HE projects	
ROOM 6	C6. Reuse-Recycling and Valorisation II	
ROOM 3, 16	**16:30-17:00**	**Coffee break – Poster session III**
	17:00-19:00	**Parallel sessions**
ROOM 13	C7. Advanced metallurgical processes	
ROOM 5	C8. Critical metals sourcing - Experts Panel Discussion	
ROOM 6	C9. Education	
ROOM 13	19:00	**Closing ceremony - Awards**

Thursday 31 August 2023

	08:00-19:00	**Field trip 1**
Aluminium of Greece / Mytilineos SA and Delphi	Tour of Aluminium of Greece/Mytilineos plant, Visit of Bauxite Residues valorisation pilots, Visit of BR disposal site and the "House of Bauxite" – the enviromental awareness pavilion in Aspra Spitia, Visit of Delphi Archaeological Site and Museum	

Friday 1 September 2023

	08:00-18:15	**Field trip 2**
Lavrion Historical Mine Site and Sounion	Visit to Lavrion Technological and Cultural Park (Mineral processing and Metallurgical plants), Mineralogical Museum, Archaeological Sites of Thorikos, Souriza and Poseidon Temple	

Monday 28 August 2023

08^{00}- 09^{00} *Registration*

OPENING SESSION

ROOM 13 *Chair: Anthimos Xenidis, Konstantinos Komnitsas, Dimitris Kaliampakos*

09^{00}-09^{30} Welcome and brief introduction by the organizers

Anthimos Xenidis, Conference Chair

Georgios Stasinos, President, Technical Chamber of Greece

Dimitris Kaliampakos, Dean, School of Mining and Metallurgical Eng., NTUA

Andreas Boudouvis, Rector, National Technical University of Athens

09^{30}-10^{00} Welcome speeches

Maximos Senetakis, Deputy Minister of Development

10^{00}-10^{15} Plenary lecture 1

PL-01 **Konstantinos Yazitzoglou**, President of Greek Mining Enterprises Association, CEO, GEOHELLAS SA
NON-critical raw materials. Can we afford to ignore them?

10^{15}-10^{35} Plenary lecture 2

PL-02 **Maria Nyberg**, European Commission, DG for Internal Market, Industry, Entrepreneurship and SMEs, unit 'Energy Intensive Industries, Raw Materials, Hydrogen'
European Critical Raw Materials Act Proposal for a Regulation-establishing a framework for ensuring a secure and sustainable supply of critical raw materials

10^{35}-11^{00} *Coffee Break – Poster session 1*

ROOM 13 *Chair: Anthimos Xenidis, Nikolaos Arvanitidis, Mark Rachovides*

11^{00}-11^{15} Plenary lecture 3

PL-03 **Anna-Michelle Asimakopoulou**, Member of European Parliament
How Europe can win the race to secure its Critical Raw Material Needs

11^{15}-11^{30} Plenary lecture 4

PL-04 **Mark Rachovides**, President Emeritus Euromines
Opportunities, challenges and paradoxes in Raw Materials for Europe today

11^{30}-12^{00} Plenary lecture 5

PL-05 **Antje Wittenberg**, Bundesanstalt für Geowissenschaften und Rohstoffe, **Daniel Oliveira**, LNEG, Chair of EuroGeoSurveys Mineral Resources Expert Group, Critical raw materials in Europe
Critical Raw Materials resource potential in Europe

12^{00}-12^{50} Sponsors presentations

12^{00}-12^{15} **Filio Lanara**, Communication & Marketing Director, Corporate Affairs & Communication General Division MYTILINEOS Energy & Metals Representative of MYTILINEOS Energy & Metals

12^{15}-12^{35} **Panos Tserolas**, Sustainability Senior Manager of ElvalHalcor's Aluminium Rolling Division
George Georgiadis, Operational Excellence Manager of ElvalHalcor's Copper and Alloys Extrusion Division
Aluminium and Copper solutions tailored for sustainable growth

12^{35}-12^{50}		**Michalis Papasotiriou**, Deputy General Manager of Operations, Hellas Gold
12^{50}-13^{00}		**Honorary Award to Dr. Nikolaos Arvanitidis for his pioneer work in the Development of Mineral Raw Materials in Europe** *Award presented by Mark Rachovides, President Emeritus Euromines, with testaments by friends and colleagues of Dr. Arvanitidis*

13^{00}-14^{30} *Lunch – Poster Session 1*

PARALLEL SESSIONS

SESSION A1
EU Strategy-Circular economy

ROOM 13 *Chair: Antje Wittenberg, Ioannis Paspaliaris*

14^{30}-15^{00}	KN-01	**Keynote presentation** **Mining wastes as potential sources for critical raw materials** **Kaj Lax**, Geological Survey of Sweden
15^{00}-15^{15}	O-01	**The Jevons Paradox and Vernon's Theory of Product Life Cycle: A Study of Copper and Aluminum Markets** <u>Antonio Alonso-Jimenez</u>, Manuel Regueiro y González-Barros, Enrique Álvarez Areces
15^{15}-15^{30}	O-02	**Characterization of waste from the dicalcium phosphate industry as a potential secondary source of YREEs** <u>Marcin Plachciak</u>, Fidel Grandia, Vladimir Roddatis, Marcin Syczewski
15^{30}-15^{45}	O-03	**CO_2 utilization in Added-Value Construction Products from Magnesia Production** <u>Guilherme Rubio</u>, David Konlechner
15^{45}-16^{00}	O-04	**A Proposal for the use of recycled aggregates in concrete in Greece** <u>Maria Nomikou</u>, Charalampos Kouris, Thalassis Karkaletsis, Vasileios Kaloidas, Efstratios Badogiannis
16^{00}-16^{15}	O-05	**Mining Wastes - An integrated thermochemical process for the conversion of multi-layer packaging waste into coal, hydrogen, and chemical flocculating agent** <u>Andrea Salimbeni</u>, Marta Di Bianca, Andrea Maria Rizzo, David Chiaramonti
16^{15}-16^{30}	O-06	**Benefits from the incorporation of ICME in the metallurgical industry** <u>Vasileios Loukadakis</u>, Spyros Papaefthymiou

SESSION A2
Minerals Exploration and Resource Characterisation I

ROOM 5 *Chair: Stefanos Kilias, Konstantinos Laskaridis*

14^{30}-15^{00}	KN-02	**Keynote presentation** **Seabed mining and blue growth: Exploring the potential of marine mineral deposits as a sustainable source of strategic and critical raw materials** **Francisco Javier Gonzalez**, Geological Survey of Spain

15^{00}-15^{15} **Magnetite-hematite characterization at micron scale with implications for metallurgical processing and decarbonisation**

O-07 Beate Orberger, Christiane Wagner Raffin, Omar Boudouma, Nicolas Rividi, Christine Bauer, Rebecca Wagner, Ghassem Nabatian, Maryam Honarmand, Iman Monsef

15^{15}-15^{30} **Battery Mineral commodities characterisation – A case study for Nickel reference material**

O-08 Lorenza Sardisco, Nikolaos Apeiranthitis, Sari Lukkari, Ester Jolis, Pasi Heikkila, Jesal Hirani, Johanna Tepsell, Tim Pearce, Alan Butcher

15^{30}-15^{45} **Application of portable spectroscopic tools in the exploration of manganese oxide minerals: the case study of Drama Mn-oxide deposits, Northern Greece**

O-09 George Soulamidis, Marjolene Jatteau, Christina Stouraiti, Panagiotis Voudouris, Constantinos Mavrogonatos, Konstantinos Soukis, Cécile Fabre, Marie-Camille Caumon, Jean Cauzid, Alexandre Tarantola

15^{45}-16^{00} **Fast and cost-effective quantitative assessment of the chemical and mineral composition of heavy mineral sands ores: an application to the Grande Cote Operation Ti-Zr mine of the new SOLSA combined XRF-XRD analytical solution.**

O-10 Maud Herbelin, Sylvain Delchini, Henry Pilliere, Luca Lutterotti, Marion Nicco, Moctar Dia, Monique Le Guen, Thomas Riegler

16^{00}-16^{15} **Exploration potential of Cu isotope fractionation in magmatic-hydrothermal Au-rich deposits in the Cyclades continental back-arc: insights from the Aegean Kolumbo submarine arc-volcano**

O-11 Nikolaos Zegkinoglou, Stephanos Kilias, Ryan Mathur, Linda Godfrey, Vasilios Pletsas, Paraskevi Nomikou, Nina Zaronikola

16^{15}-16^{30} **Assessing CRM's content of abandoned mine sites of Greece.**

O-12 Vassiliki Angelatou, Athanasios Exikis, Adamantia Hatziapostolou

SESSION A3
Critical elements recovery from End-of-Life products

ROOM 6 *Chair: Helena Soares, Paschalis Oustadakis*

14^{30}-14^{45} **End-of-life mobile phones: re-thinking its recycling based on pillars of circularity and economic and environmental sustainability**

O-13 Liliana Martelo, Márcia Silva, Cátia Graça, Marta Azevedo, Adrian Silva, Margarida Bastos, Helena Soares

14^{45}-15^{00} **Advances in the bioleaching of copper from end-of-life printed circuit boards**

O-14 Alessandro Becci, Alessia Amato, Giulia Merli, José Miguel Rodrìguez Maroto, Francesca Beolchini

15^{00}-15^{15} **Integrated production and recycling of silicon for pv application**

O-15 Gabriella Tranell, Maria Wallin, Nishan Simkhada, Mathilde Meling, Elif Emil Kaya

15^{15}-15^{30} **Indium recovery from solar cell waste by means of layer-by-layer membrane filtration**

O-16 Meret Amrein, Michael Thomann, Frank Nüesch, Markus Lenz

15^{30}-15^{45} **LCDs screens from smartphones wastes: towards a nearly circular and zero-waste process for recycling Indium plus other raw materials**

O-17 Liliana Martelo, Márcia Silva, Hugo Bacelo, Margarida Bastos, Helena Soares

15^{45}-16^{00} **Beneficiation of Critical Metals from fine fraction of End-of-Life printed circuit boards, with the use of Column Flotation Process**

O-18 Kyriakos Syrmakezis, Kostas Tsakalakis

16^{00}-16^{15} **Impact of Extractant Type and pH on Yttrium Recycling from End of Life Fluorescent Lamp**

O-19 Tülay Koç Delice, Gülşah Türker, Hüseyin Eren Obuz; Belma Soydas

16^{15}-16^{30} **Hydrometallurgical recovery of tin from waste Printed Circuit Boards**

O-20 Dimitrios Vlasopoulos, Paschalis Oustadakis, Emmanouella Remountaki, Styliani Agatzini -Leonardou

16^{30}-17^{00} ***Coffee Break - Poster session 1***

SESSION A4
Advances in mineral processing technologies

ROOM 13 *Chair: Kostas Tsakalakis, Konstantinos Betsis*

17^{00}-17^{30} **Keynote presentation**

Evaluation of the processing routes for the "hard lithium" European deposits

KN-03 Lev Filippov, Inna Filippova

17^{30}-17^{45} **Investigation of industrial residues and waste materials to expand the raw material base for the production of lightweight aggregates**

O-21 Jacob Fenner, Andrej Zeller, Steffen Liebezeit, Manuela Knorr, Alexander Schnell, Luka Mettke, Daniel Goldmann

17^{45}-18^{00} **METALLICO EU PROJECT**

O-22 María González-Moya, Ana Lara

18^{00}-18^{15} **The applicability of screening and ore sorting to the beneficiation of low-grade gold ore from Western Australia**

O-23 Bogale Tadesse, Laurence Dyer

18^{15}-18^{30} **On the flotation of sulphide minerals using organosolv lignin as collector**

O-24 Panagiotis Angelopoulos, Nikolaos Kountouris, Georgios Anastasakis, Maria Taxiarchou

SESSION A5
Minerals Exploration and Resource Characterisation II

ROOM 5 *Chair: Kaj Lax, Francisco Javier Gonzalez*

17^{00}-17^{30} **Keynote presentation**

The environmental, social and governance challenges in the Lithium Triangle supply chain

KN-04 Evi Petavratzi, Andrew Hughes, Jonathan Ford

17^{30}-17^{45} **Bauxite Residue deposition in Corinth Gulf, Greece: a potential REE resource**

O-25 Efthymios Douros, Margarita Iatrou, Nikolaos Sofis, Maria Elli Damoulianou, Georgios Papatheodorou, Stavros Kalaitzidis

17^{45}-18^{00} **Rare earth and trace element behaviour in different size fraction in an old uranium mine (centre-north of Portugal)**

O-26 Andres Cardenas Nino, Maria Dias, Rosa Marques, Dulce Russo, Catarina Diamantino, Edgar Carvalho, Fernando Rocha, Maria Cristina Sequeira

18^{00}-18^{15}	**Mineral exploration at the Kimmeria Fe-skarn deposit, N. Greece: Reassessment and new perspectives focusing on the CRMs**
O-27	Michalis Fitros, Constantinos Mavrogonatos, Marianthi Anastasatou, Adamantia Chatziapostolou, Konstantinos Laskaridis, Petros Karmis, Magdalini Aggeli, Dimitrios Tsouvalas, Alexandros Liakopoulos, Dimitrios Tarenidis and Vasiliki Angelatou
18^{15}-18^{30}	**Mine and mineral exploration projects within the Natura 2000 areas: Case studies from northern Finland**
O-28	Toni Eerola, Nike Luodes, Hannu Panttila

SESSION A6
Li-ion Batteries recycling

ROOM 6 — *Chair: Panagiotis Xanthopoulos*

17^{00}-17^{30}	**Keynote presentation** **The COOL-Process – a holistic recycling approach for lithium recovery**
KN-05	Sandra Pavon Regana, Alexander Nickol, Sebastian Hippmann, Mareike Partsch, Alexander Michaelis
17^{30}-17^{45}	**Development of a process for low-cost LFP batteries treatment**
O-29	Rafaella - Aikaterini Megaloudi, Alexandros Galanes, Paschalis Oustadakis, Anthimos Xenidis
17^{45}-18^{00}	**Closed-loop Recycling of Li, Ni, Co, and Mn From Spent NMC Batteries**
O-30	Fırat Tekmanlı, Hüseyin Eren Obuz, Bengi Yağmurlu
18^{00}-18^{15}	**Removal of metal contaminants from LFP black mass leachates**
O-31	Ilias Lampropoulos, Daniel Reyes Martinez, Alexandra Thiere, Panagiotis Xanthopoulos, Anthimos Xenidis, Alexandros Charitos
18^{15}-18^{30}	**Investigation of recycling behaviour of lithium iron phosphate battery batteries with different thermal pre-treatments**
O-32	Hüseyin Eren Obuz, Fırat Tekmanlı, Luka Nils Mettke, Marius Müller, Bengi Yagmurlu

18^{30}-18^{45} *Coffee Break - Poster session 1*

PLENARY LECTURES – Funding Opportunities for Research and Innovation Projects

ROOM 13 — *Chair: Maria Taxiarchou, Vitor Correia*

18^{45}-19^{05}	**Plenary lecture 6**
PL-06	**Dimitrios Biliouris**, Project Adviser for the Health and Digital Executive Agency (HaDEA), European Commission ***Horizon Europe raw materials funding opportunities***
19^{05}-19^{20}	**Plenary lecture 7**
PL-07	**Antonis Politis,** EIT Raw Materials ***EIT RawMaterials. World largest innovation community in the Raw Materials sector***
19^{25}-19^{45}	**Plenary lecture 8**
PL-08	**Dina Carrilho**, Senior Science Officer, ERA-MIN3 Project Coordinator ***Advances and contributions to the EU Raw Materials policies via Pan-European coordinated funding***

20^{00} *Welcome reception – Zappeion (Peristilio)*

Tuesday 29 August 2023

PARALLEL EVENT - Greece specific issues *(in Greek)*

Greece-specific issues (*in Greek*)

SESSION B1
New raw materials/energy projects in Greece I

ROOM 13 — *Chair: Anthimos Xenidis, Peter Tzeferis*

09^{00}-09^{15} **Αλεξάνδρα Σδούκου,** Υφυπουργός Περιβάλλοντος και Ενέργειας
Κρίσιμες πρώτες ύλες: Η στρατηγική αυτονομία της χώρας

09^{15}-09^{30} **Λάμπρος Μπίσαλας,** Διευθύνων Σύμβουλος της Sunlight Group Energy Storage Systems
Παραγωγή και ανακύκλωση μπαταριών LFP

09^{30}-09^{50} **Μιχάλης Παπασωτηρίου,** Αναπληρωτής Γενικός Διευθυντής Λειτουργιών, Ελληνικός Χρυσός
Υπό εξέλιξη μεταλλευτικά έργα της Ελληνικός Χρυσός

09^{50}-10^{10} **Δημήτριος Κούτρας, Βασίλειος Λάμπος,** ΕΛΛΗΜΕΤ ΑΕ
Μονάδα παραγωγής μεταλλουργικού πυριτίου
Μονάδα παραγωγής σιδηροχρωμίου υψηλής περιεκτικότητας άνθρακα

10^{10}-10^{30} **Κώστας Γάτος**, Διευθυντής QHSE και R&D, ΤΕΡΝΑ ΛΕΥΚΟΛΙΘΟΙ Α.Ε.
Εξόρυξη και βιομηχανική επεξεργασία μαγνησίτη στη Βόρεια Εύβοια)

10^{30}-11^{00} ***Coffee Break – Poster session 2***

SESSION B4
New raw materials/energy projects in Greece II

ROOM 13 — *Chair: Anthimos Xenidis, Peter Tzeferis*

11^{00}-11^{15} **Παναγιώτης Δάβρης**, MYTILHNAIOS SA **/**Αλουμίνιο της Ελλάδος
Δυνατότητες για παραγωγή γαλλίου στην Ελλάδα

11^{15}-11^{30} **Χρήστος Σκεύας,** Διευθυντής Ελλάδος, ΕΛΛΗΝΙΚΑ ΟΡΥΚΤΑ ΑΕ
Το Νέο Έργο μεταλλευτικής έρευνας και εκμετάλλευσης βασικών και κρίσιμων μετάλλων Μολάων Λακωνίας

11^{30}-11^{45} **Κωνσταντίνο Λασκαρίδη,** Διευθ. Ορυκτών Πόρων και Μεταλλευτικής-Εθνικό Εκπρόσωπο της Ε.Α.Γ.Μ.Ε. στα EuroGeoSurveys
Η συμβολή της Ε.Α.Γ.Μ.Ε. στην έρευνα των στρατηγικών και κρίσιμων Ορυκτών Πρώτων Υλών και την εφαρμογή της κυκλικής οικονομίας

11^{45}-12^{00} **Ηλιόπουλος Παναγιώτης,** Αντιπρόεδρος ΣΕΜΜΘ, Γεν. Διευθυντής ΜΑΡΜΥΚ ΗΛΙΟΠΟΥΛΟΣ ΑΕ
Το ελληνικό μάρμαρο στο μέλλον

12^{00}-12^{15} **Πελοπίδας Καλλίρης**, Διοικητής της Ειδικής Υπηρεσίας Δίκαιης Αναπτυξιακής Μετάβασης
Πορεία σχεδίου δίκαιης αναπτυξιακής μετάβασης για τη Δ. Μακεδονία και Μεγαλόπολη

12^{15}-12^{30} **Γεώργιος Τσιφουτίδης**, Διεύθ. Ορυκτών Πρώτων Υλών, Υπουργείο Περιβάλλοντος και Ενέργειας,
Νέος διεθνής διαγωνισμός εκμίσθωσης δικαιωμάτων έρευνας γεωθερμικού δυναμικού

12^{30}-13^{00} **Ερωτήσεις -- Συζήτηση**

13^{00}-14^{30} ***Lunch – Poster Session 2***

PARALLEL SESSIONS

SESSION B2
ERA-MIN3 at RawMat2023

ROOM 5 — *Chair: Francesca Beolchini*

08:30-10:30 Sustainable Mining, Processing & Production Processes

Exploration

	Critical metals and environmental risks: better understanding to better predict
O-33	Eric Gloaguen, Giada Iacono-Marziano, Pablo Higueras, Alexandre Lima, Fabienne Battaglia, Charles Gumiaux, Axel Aurouet, Daniel Pierre, Romain Augier, Laurent Guillou-Frottier, Johann Tuduri, Anthony Pochon
	Multi-scale and interdisciplinary approaches to the granite-related ore-forming systems in the Segura-Argemela-Panasqueira-Góis belt (Portugal); insights for innovative exploration surveys
O-34	Antonio Mateus, Michel Cathelineau, Colombo Tassinari, Marie-Christine Boiron, Maria Helena Hollanda, Rute Salgueiro, Alexandra Guedes, Patrícia Moita, Alcides Pereira *(online)*
	Regional to Deposit scale exploration (D-Rex) project
O-35	Maxim Smirnov, Jochen Kamm, Graham Hill, Jan Vozar

Sustainable Mining Operations

	The cuttability of carbonate rocks using a new microwave-assisted laboratory cutting machine
O-36	Sair Kahraman, Ramazan Çomakli, Masoud Rostami
	Use of nanobubble technology in the development of next-gen sustainable liquid mining and phytoextraction processes for the recovery critical and strategic metals
O-37	Georgios Kolliopoulos, Nicolas Kalogerakis, Kostas Komnitsas, Quartus Paulus Botha
	Project REVIVING – Bio- Remining mine tailings to the production of critical metals
O-38	Paula Morais, Rita Branco *(online)*

Ore Processing

	The MiCCuR project for improved copper recovery from chalcopyrite
O-39	Mark Dopson
	RETECH - Recovery of rare earth elements from complex ores in Turkey and their potential use in high tech industrial applications
O-40	Belma Soydaş Sözer, Gülşah Türker, Tülay Koç Delic, Arda Temizkalb, Fazlı Cabbar Metin, Halil Yalcın Elerman, Radu-Robert Piticescu, Marius Zlagnean
	Electro-electrodialysis technology on the copper electrorefining operation for the recovery of antimony and recycling of the solution media
O-41	Manuel César Martí-Calatayud, Lorena Hernández-Pérez, Andréa Bernardes, Marco Antonio Rodrigues, Gerardo Cifuentes, Gabriel Riveros, Valentín Pérez-Herranz

Closing cycles in mining and production

	MINECO – New eco-innovative materials for mining infrastructures
O-42	Tiago Miranda, Nuno Cristelo

Tuesday 29 August 2023

	REEScue-An Integrated process for the recovery of Rare Earth Elements and Scandium from Bauxite Residues
O-43	Paschalis Oustadakis, Panagiotis Angelopoulos, Maria Georgiou, Ioannis Paspaliaris, Murat Kabataş, Tuğba Selcen Atalay Kalsen, Hakan Burak Karadağ, Yasin Ramazan Eke, Bayram Ünal, Meral Baygül, Gökhan Demir, Sedat Arslan, Panagiotis Davris, Efthymios Balomenos, Gheorghe Dobra, Alina Boiangiu
	SMART Geopolymers
O-44	Dinos Sakkas, Silviana Onisei, Hubert Rahier

SESSION B3
Energy and CO_2 storage

ROOM 6 — *Chair: Vassilis Gaganis, Charis Vasilatos*

09^{00}-09^{15}	**Carbon dioxide storage in depleted oil fields**
O-45	Georgios Avraam, Konstantinos Vatalis
09^{15}-09^{30}	**A unified approach to describe flow dynamics in geothermal energy production systems**
O-46	Stefanos Lempesis, Sofianos Panagiotis Fotias, Vassilis Gaganis
09^{30}-09^{45}	**Energy Transition and Evaporitic formations utilization as potential subsurface storage for H_2 and CO_2**
O-47	Spyridon Bellas, Emmanuel Stamatakis, Ioannis Vakalas
09^{45}-10^{00}	**Sensitivity of CO_2 flow in production/injection wells in CPG (CO_2 Plume Geothermal) systems**
O-48	Sofianos Panagiotis Fotias, Sofia Stamataki, Vassilis Gaganis
10^{00}-10^{15}	**Optimizing Geothermal Energy Extraction in CPG (CO_2 Plume Geothermal) systems**
O-49	Sofianos Panagiotis Fotias, Spyridon Bellas, Vassilis Gaganis
10^{15}-10^{30}	**Well Control Strategies for Effective CO_2 Subsurface Storage: Optimization & Policies**
O-50	Ismail Ismail, Vassilis Gaganis

10^{30}-11^{00} ***Coffee Break – Poster session 2***

PARALLEL SESSIONS

SESSION B5
ERA-MIN3 at RawMat2023

ROOM 5 — *Chair: Francesca Beolchini*

11^{00}-13^{00} Recycling of EoL products and immovable assets e.g. batteries, magnets

Battery recycling

	Challenges and opportunities for recycling of spent lithium ion batteries – a summary of results of the NEXT-LIB project
O-51	Guozhu Ye
	Biotechnological recycling and recovery of metals from waste printed circuit boards & spent Li ion batteries- ERAMIN EU BaCLEM Project
O-53	Sandeep Panda, Ata Akcil, Stoyan Gaydardzhiev, Eric van Hullebusch (*online*)

Tuesday 29 August 2023

Magnets and E-Waste

Recovery of valuable metals from Nd-Fe-B magnet leach liquor using antisolvent crystallization and non-aqueous ion exchange

O-54 Brecht Dewulf, Dženita Avdibegović, Kerstin Forsberg, Srečo Škapin, Koen Binnemans

Siderophores assisted recovery of Ga, In from the end-of-the life product

O-56 Rohan Jain, Christian Hintersatz, Kun Zheng, Katrin Pollmann, Eric van Hullebusch, Luis Rojas

Minerals Material Cycles

Evaluation of EOL Materials as SCMs for OPC

O-57 Mehmet Ali GULGUN, Mirijam Vrabec, Saso Sturm, Bogdan Stefan VASILE, Cleva Ow-Yang , Zeynep Başaran Bundur, Adrian Ionut NICOARA, Sorour Samsari Parapari, Yasemin Akyol, Kosar Hassan Nezhad, Otilia Ruxandra VASILE

ReFina - Novel methods for enhanced recovery of metals and minerals from fine incineration ash

O-58 Héctor Muñiz Sierra, Michal Šyc

PROPER: New sustainability metrics to improve refractories recycling performances regarding resource use, environmental impacts and economic benefits

O-59 Stephanie Muller, Frédéric Lai, Antoine Beylot, Ambroise Lachat, Tom Huppertz, Elisabeth van Overbeke, Quentin Ricoux

Enabling circular economy

RedOx Recycling - A new approach for the recovery of gold from E-waste

O-60 Claudio Baldizzone

LiCoBAT - LIthium and Cobalt recovery from batteries coming from the reverse logistics chain of WEEE

O-61 José Rocha Andrade da Silva

End-of-life Li-ion Battery Management Integration and Technology Evaluation

O-62 Rudolph van Schalkwyk, Ersin Yazici, Jan Ots, Erik Emilsson, Martina Petranikova, Esra Eken Torunoglu, Alexandra Wu, Hacı Deveci, Guven Akdogan, Louis Louw, Nilay Elginöz Kanat, Roelof Maritz, Dominic Vooght, Theuns Kuhn, Ayse Nur Ozturk, Henric Lassesson, Christie Dorfling

SESSION B6
Environment and Sustainability I

ROOM 6 — *Chair: Ariadne Argyraki, Vasilis Loukadakis*

11:00-11:15 **Immobilization of Rare Earth Elements and Yttrium (REY) by iron (bio)precipitation in sulphated acid waters from El Bierzo (Spain)**

O-63 Blanca Rincón-Tomás, Francisco Javier Gonzalez, Enrique López-Pamo, Esther Santofimia

11:15-11:30 **First study of microbial diversity living at Nisyros volcano extreme environment - Future applications**

O-64 Vassiliki Angelatou, Stefano Fazi, Franco Tassi, Orlando Vaselli, Georges Vougioukalakis

11:30-11:45 **Grain size distribution of rare earth elements in a passive treatment system installed in a legacy polymetallic sulfide mine in Portugal**

O-65 Cynthia Obregón Castro, Isabel Prudêncio, João Carlos Waerenborgh, Bruno Vieira, Dulce Russo, Catarina Diamantino, Edgar Carvalho, Rosa Marques

11^{45}-12^{00} **Long-term assessment of surface cover geochemical characteristics of a treated sulfidic mining waste pile in Lavrion, Greece**

O-66 Ariadne Argyraki, Zacharenia Kypritidou, Khaled Imbrahim

12^{00}-12^{15} **Risk assessment of Metal transportation mechanism from mining source by rainfall runoff as a contribution to the bioaccumulation in seafood**

O-67 Rafi Ullah, Shaikh Mohiuddin

12^{15}-12^{30} **Environmental assessment of replacing fossil fuels with hydrogen for motorized equipment in the mining sector**

O-68 Antonis Peppas, Sotiris Kottaridis, Chrysa Politi, Paschalis Oustadakis

12^{30}-12^{45} **A scenario-based analysis for the selection of post-mining land uses applying a cellular automata model**

O-69 Konstantinos Karalidis, Christos Roumpos, Aikaterini Servou, Nikolaos Paraskevis, Francis Pavloudakis

12^{45}-13^{00} **Towards the exploitation of unconventional heavy oils: Electrostatic technologies for the minimization of dehydration cost**

O-70 Christina Argyropoulou, Vassilis Gaganis, Dimitris Marinakis

13^{00}-14^{30} *Lunch – Poster Session 2*

PARALLEL SESSIONS

SESSION B7

Mining: Trends and perspectives I

ROOM 13 *Chair: Ioannis Kapageridis, Christos Roumpos*

14^{30}-15^{00} **Keynote presentation**

Mining and Challenges for the Transformation in Energy Sector

KN-06 Carsten Drebenstedt

15^{00}-15^{15} **Evaluation methodology of open pit mine overall slope failure risks**

O-71 Natalija Pavlovic, Branko Petrovic, Tomislav Subaranovic

15^{15}-15^{30} **A Glimpse to a Holistic Approach to Environmental Monitoring of the Kolumbo Submarine Volcano with Implications for Deep Seafloor Mining, Ocean Governance and Policy**

O-72 Stephanos Kilias, Vasilios Pletsas, Nikolaos Zegkinoglou, Paraskevi Nomikou, Theodoros Mertzimekis, Paraskevi Polymenakou, Andreas Gondikas

15^{30}-15^{45} **Narrow Reef Mining (NRE) – innovative mining technology for narrow, sub-horizontal PGE ore bodies**

O-73 Vječislav Bohanek, Luka Petro, Sibila Borojević Šoštarić

15^{45}-16^{00} **Using force field analysis for examining and managing the stakeholders' perceptions in mining projects**

O-74 Francis Pavloudakis, Philip-Mark Spanidis, Christos Roumpos

16^{00}-16^{15} **Application of International Standards to Evaluate the Potential of Sustainable Secondary Production of Tin and Tungsten in Portugal**

O-75 Md Ariful Islam, José Brito Iria, Georg Meißner, George Barakos, Helmut Mischo

16^{15}-16^{30} **Machine Learning Techniques to model and predict airflow requirements in underground mining**

O-76 Maria Karagianni, Andreas Benardos

SESSION B8
ERA-MIN3 at RawMat2023

ROOM 5 — *Chair: Pontus Westrin*

14^{30}-16^{30} ERA-MIN SRIA workshop

This workshop aims to collect feedback and expert opinions on the new Strategic Research and Innovation Agenda (SRIA) on raw materials supply for the green and digital transition. The SRIA will serve as a basis for a future international research and innovation partnership within the field of non-energy, non-food raw materials. The workshop discussion will be based on the current draft agenda structure, and focus on identifying technological and structural challenges, as well as research and innovation needs, in six thematic areas:

- *Resilient primary and secondary raw materials supply*
- *Efficient use of raw materials in design and production*
- *Sustainable use and reuse of products*
- *Effective policy development and governance*
- *Maximizing societal benefits*
- *World-class innovation capacity*

See the ERA-MIN website (https://www.era-min.eu/sria) for more information.

SESSION B9
Environment and Sustainability II

ROOM 6 — *Chair: Toni Eerola, Antonis Peppas*

14^{30}-14^{45} **Reconciliation conflicting societal objectives: Nature protection vs. raw materials supply resilience**

O-77 Vitor Correia, Eberhard Falck

14^{45}-15^{00} **Assessment of the environmental behavior of phosphogypsum with the application of lab-scale experimentation**

O-78 Georgios Gaidajis, Maria Pliaka

15^{00}-15^{15} **Can We Alleviate the NIMBY Effect?**

O-79 Demetrios Constantinides

15^{15}-15^{30} **Remote Sensing Analysis for Flood Detection in Complex Surface Mining Areas Using Satellite Data**

O-80 Konstantinos Karalidis, Georgios Louloudis, Christos Roumpos, Eleni Mertiri, Francis Pavloudakis

15^{30}-15^{45} **Durability of red-mud concrete pavement slabs**

O-81 Aggeliki Skaropoulou, Konstantinos Tsivolas, Ioanna Angelou, Konstantinos Sakkas, Christos Georgopoulos, Maria Taxiarchou, Efstratios Badogiannis

15^{45}-16^{00} **Investigation of thermal behavior of cementitious pastes, mortars and concrete- Effect of Closed Structured Expanded Perlite addition**
O-82 Chrysanthi Panagiotopoulou, Maria Taxiarchou, Iliana Douni, Katerina Maliachova, Aggeliki Skaropoulou, Ioanna Angelou, Stratis Badogiannis

16^{00}-16^{15} **Integrated mine water management system in mixed sulphide mines – case study: Kassandra mines**
O-83 Vithleem Gazea

16^{30}-17^{00} ***Coffee Break – Poster session 2***

SESSION B10
Mining: Trends and perspectives II

ROOM 13 *Chair: Michail Galetakis, Ioannis Kapageridis*

17^{00}-17^{15} **Artificial Intelligence Engineering System for a Tailings Storage Facility**
O-84 Bartłomiej Bursa, Paweł Stefanek, Paweł Stefaniak, Bartosz Świderski

17^{15}-17^{30} **Onsite characterisation of magnesite and laterite mining blocks by using novel sensing technologies – An experimental approach**
O-85 Basileios Deligiorgis, Declan Vogt, Ferenc Mádai, Michail Galetakis

17^{30}-17^{45} **Risk analysis in underground marble quarries using geotechnical data from monitoring equipment**
O-86 Christos Gravalos, Lampros Lamprinidis, Ioannis Kapageridis

17^{45}-18^{00} **Applying Model-Based Systems Engineering to Tailings Storage Facility Structures**
O-87 Bartłomiej Bursa, Paweł Stefaniak, Ioannis Kakogiannos

18^{00}-18^{15} **Industry 4.0 roadmap for the mining industry**
O-88 Doris Skenderas, Chrysa Politi

18^{15}-18^{30} **Machine Learning Based Domaining of a Porphyry Copper-Gold Deposit**
O-89 Ioannis Kapageridis, Agni Patra, Argyro Asvesta, Ioannis Sinatkas

18^{30}-18^{45} **Transforming decommissioned mines to gravity energy storage system**
O-90 Michail Galetakis, Georgios Biotakis, Basileios Deligiorgis, Emmanouil Varouchakis

18^{45}-19^{00} **Multi-risk assessment in post-mining lignite areas**
O-91 Dafni Nalmpant-Sarikaki, Alexandros Theocharis, Nikolaos Koukouzas, Andreas Benardos, Ioannis Zevgolis

SESSION B11
Hydrometallurgical processes for metals recovery from EoL and ores

ROOM 5 *Chair: Panagiotis Davris*

17^{00}-17^{15} **Recycling platinum and palladium from autocatalysts: searching for alternative processes combining efficiency with environmental sustainability**
O-92 Hugo Bacelo, Michiel de Brauwer, Liliana Martelo, Helena Soares

17^{15}-17^{30} **Gold recovery from integrated circuits: proposal of an innovative and greener hybrid process**
O-93 Márcia Silva, Liliana Martelo, Margarida Bastos, Helena Soares

17^{30}-17^{45} Leaching and recovery of gold from ores using alternative lixiviants to cyanide
O-94 Maria Taxiarchou, Ioannis Paspaliaris, Nymphodora Papassiopi, Katerina Adam

17^{45}-18^{00} Solvent extraction for iron removal and HCl recovery from Ni/Co pregnant leach solutions: flowsheet optimization and thermodynamic modelling
O-95 Brecht Dewulf, Rayco Lommelen, Koen Binnemans, Sofía Riaño

18^{00}-18^{15} Gold recovery from refractory auriferous sulphides applying the Platsol Process
O-96 Nymphodora Papassiopi, Paschalis Oustadakis, Panagiota Georgopoulou, Evangelia Mylona, Maria Taxiarchou, Ioannis Paspaliaris, Katerina Adam

18^{15}-18^{30} An innovative approach for the crystallization of battery grade cobalt sulfate
O-97 Luka Nils Mettke, Marius Müller, Bengi Yağmurlu

18^{30}-18^{45} Recovery of antimony from alkaline sulphide leaching solutions
O-98 Marianna Stathogianni, Rafaella - Aikaterini Megaloudi, Paschalis Oustadakis, Anthimos Xenidis

SESSION B12
OSH and EPD Reporting

ROOM 6 *Chair: George Barakos, Katerina Adam*

17^{00}-17^{30} Keynote presentation
Occupational Health and Safety in industry-improvements and perspectives
KN-07 Rena Bardani

17^{30}-17^{45} The experience on the implementation of Risk Management in OSH and environmental issues in the extractive companies
O-99 Petros Maraboutis, Niki Iliana Poulimenou, Elena Nikolaou

17^{45}-18^{00} Piloting the establishment of soil geochemical baselines for Potentially Toxic Elements (PTEs) in Greece- Preliminary results from Attica and Boeotia
O-100 Artemis Kontomichalou, Alexandros Liakopoulos, Ariadne Argyraki, Zacharenia Kypritidou, Fotini Botsou, Antonis Vlastos

18^{00}-18^{15} Evaluation of occupational health and safety issues in coal mining Industry
O-101 Petkani Zoi, Vatalis Konstantinos

18^{15}-18^{30} Understanding the Social License to Operate from a Cultural Perspective: The case studies of Australia, Greece, and India
O-102 Chrysanthi Rodolaki, George Barakos

18^{30}-18^{45} EPD reporting in the metal and mineral sector
O-103 Maria Vastardi, Eugenia Filtikaki, George Mavraganis, Katerina Adam

18^{45}-19^{00} Sustainability Reporting in the Raw Materials Industry
O-104 Eugenia Filtikaki, Maria Vastardi, Katerina Adam

20^{00} *Gala dinner*

Wednesday 30 August 2023

PLENARY LECTURES

ROOM 13 — *Chair: Anthimos Xenidis, Petros Koutsovitis, Stavros Kalaitzidis*

09^{30}-10^{00}	**Plenary lecture 9**
	Gian Andrea Blengini, Politecnico di Torino
PL-09	***From List of Critical Raw Materials to List of critical projects***
10^{00}-10^{30}	**Plenary lecture 10**
	Slavko Solar, United Nations Economic Commission for Europe (UNECE) Sustainable Energy Division
PL-10	***The Application of United Nations Framework Classification for Resources (UNFC) to European Mineral Deposits***

10^{30}-11^{00} ***Coffee Break – Poster session 3***

PARALLEL SESSIONS

SESSION C1
Critical metals recovery from mining/metallurgical waste

ROOM 13 — *Chair: Angel Lopez-Buendia, Dimitris Panias*

11^{00}-11^{05}	**PROMETIA: innovation and sustainability in mineral processing, extractive metallurgy & recycling**
	Patrick d'Hugues, PROMETIA chairman & Director of the Mineral Resources and Circular Economy Programme at BRGM
11^{05}-11^{30}	**Keynote presentation**
	Holistic valorisation of bauxite residue: Results from pilots demonstrations
KN-08	**Efthymios Balomenos**, Mytilineos SA
11^{30}-11^{45}	**Efficient Use of Sulfuric Acid in Bauxite Residue Leaching**
O-105	Aikaterini Toli, Danai Marinos, Maria Psoma, Dimitrios Kotsanis, Panagiotis Davris, Efthymios Balomenos, Dimitrios Panias
11^{45}-12^{00}	**HCl- based leaching method for extracting Ni/Co from ore deposits and tailings**
O-106	Seyedehmaryam Sadeghi, Sofía Riaño, Koen Binnemans, Stylianos Tampouris, Vitalis Chipakwe
12^{00}-12^{15}	**Microwave roasting of bauxite residues**
O-107	Angel Lopez-Buendia, Eduardo Brau, Efthymios Balomenos
12^{15}-12^{30}	**Alumina and iron recovery from the BR-Ca reduced pellets by simultaneous magnetic separation and alkali leaching**
O-108	Manish Kumar Kar, Jafar Safarian, Casper van der Eijk
12^{30}-12^{45}	**Recovery of copper and zinc from ash from incinerated municipal waste**
O-109	Ragnhild Dirdal, Aslak Skåra, Erik Nedkvitne, Jon Omtvedt, Dag Ø Eriksen
12^{45}-13^{00}	**Unlocking the Potential of Bauxite Residue: A Comparative Exergy Analysis of Emerging Valorisation Techniques**
O-110	Eleni Mikeli, Efthymios Balomenos, Dimitrios Panias

SESSION C2
Substitution and Recycling of Critical Raw Materials in the Automotive Sector - The Industrial Perspective

ROOM 5 *Chair: Iakovos Yakoumis*

11^{00}-11^{15}	**Raw Materials Act - opportunities in recycling and substitution for Industry, from Innosup Mine The Gap, to I3 and Regional Innovation Valleys**
O-111	Santiago Cuesta Lopez, Icamcyl, Spain
11^{15}-11^{30}	**Promoting Sustainable Value Chains: Ford Otosan's Approach to Critical Raw Materials Recovery**
O-112	Mehmet Celik, Ford Otosan, Turkey
11^{30}-11^{45}	**Recycling of lithium ferrophosphate (LFP) batteries in Greece**
O-113	Panagiotis Xanthopoulos, Sunlight Energy Group, Greece
11^{45}-12^{00}	**Recovering and Substituting of Noble Metals from Fuel Cells and Electrolyzers**
O-114	Christos Chochos, Advent Technologies, Greece
12^{00}-12^{15}	**Recovering and Substituting of Rare Earth Elements from Permanent Magnets**
O-115	Milana Karajic, Magneti, Slovenia
12^{15}-12^{30}	**Recovering of Critical Raw Materials from Electric and Electronic Devices**
O-116	Teresa Sessa, TREEE, Italy
12^{30}-12^{45}	**Universal Hydrometallurgical Up-Scaled Process for Recovering Critical and Strategic Materials from Automotive EoL Streams**
O-117	Anastasia-Maria Moschovi, Monolithos Catalysts & Recycling Ltd., Greece
12^{45}-13^{00}	**Roundtable discussion**

SESSION C3
Industrial minerals and Waste reuse - valorisation I

ROOM 6 *Chair: Charis Vasilatos, Kostas Komnitsas*

11^{00}-11^{30}	**Keynote presentation** **Pathways towards Sustainability and Decarbonisation in the Construction Industry: The Role of Industrial Minerals and Geopolymers**
KN-09	Maria Taxiarchou, National Technical University of Athens
11^{30}-11^{45}	**Factors affecting the properties of slag-based alkali activated materials**
O-118	<u>Kostas Komnitsas</u>, Vasiliki Karmali, Dimitra Vathi, Lefteris Kaklamanos
11^{45}-12^{00}	**Composite lightweight materials with upgraded physicochemical functionality and improved economic feasibility**
O-119	<u>Antonia Ekonomakou</u>, Xenofon Simos, Ioanna Kitsou, Michaela Papageorgiou, Maria Eleni Mamassi, Theodoros Gikarakis, Achilleas Amanatidis, Georgios Anastasakis, Athena Tsetsekou
12^{00}-12^{15}	**Creating public acceptance in building products made from metallurgical wastes**
O-120	<u>Efthymios Balomenos</u>, Nikolaos Patsavos, Alexandros Peteinarelis, Panagiotis Davris, Grigorios Paschalis
12^{15}-12^{30}	**Li extraction from a-spodumene concentrate by carbonizing calcination**
O-121	<u>Katerina Maliachova</u>, Nikos Doukas, Danai Tsakiri, Michail Samouhos, Lefkothea Sakellariou, Iliana Douni, Maria Taxiarchou, Ioannis Paspaliaris

12^{30}-12^{45} **Crystalline and Amorphous Phases in Fe-Rich Slags: Implications for As and Sb leaching Behaviour**
O-122 Konstantina Koukouza, Glenn Beersaerts, Valérie Cappuyns, Yiannis Pontikes

12^{45}-13^{00} **Eco-friendly composites – environmental assessment of mine tailings based geopolymers**
O-123 Kinga Korniejenko, Beata Figiela, Michał Łach, Barbara Kozub

13^{00}-14^{30} ***Lunch – Poster Session 3***

PARALLEL SESSIONS

SESSION C4
Magnets and REEs

ROOM 13 *Chair: Efthymios Balomenos, Stavros Kalaitzidis*

14^{30}-14^{45} **High-performance solid phase extraction chromatography for recycling of NdFeB magnet waste.**
O-124 Tiaan Punt, Kerstin Forsberg, Michael Svärd

14^{45}-15^{00} **Advancing sustainable magnets for electric mobility and renewable energy: Innovating processing and recycling routes for Nd-Fe-B permanent magnets**
O-125 Kristina Žužek, Tomaž Tomše, Mihaela Rebernik, Sina Khoshsima, Amit Mishra, Sorour Semsari Parapari, Spomenka Kobe, Laurence Schieren, Carlo Burkhardt, Sašo Šturm

15^{00}-15^{15} **Process mineralogy applied to mineral processing for the development of REE deposits**
O-126 Tassos Grammatikopoulos, Stavros Kalaitzidis

15^{15}-15^{30} **Investigation and Optimization of the Chemical and Operational Parameters of the Stripping Process Using Oxalic Acid to Recycle REEs from Permanent Magnets**
O-127 Soroush Rahmati, Ionela Birloaga, Francesco Vegliò

15^{30}-15^{45} **Potential application of modified diglycolamide resin For Rare Earth Element extraction**
O-128 Junnile Romero, Carlito Tabelin, Ilhwan Park, Richard Alorro, Leaniel Silva, Joshua Zoleta, Takunda Mandu, Kosei Aikawa, Mayumi Ito, Steffen Happel, Naoki Hiroyoshi, Vannie Joy Resabal

15^{45}-16^{00} **Recovery of Scandium from industrial acidic solutions through ion-exchange**
O-129 Eleni Mikeli, Aikaterini Toli, Danai Marinos, Efthymios Balomenos, Dimitrios Panias

16^{00}-16^{15} **Utilization of graphite industrial wastes for the sustainable production of silicon carbide**
O-130 Charikleia Vourgidi, Ioanna Giannopoulou, Apostolos Kourtis, Maria Magganiari, Anthimos Xenidis

16^{15}-16^{30} **Securing the supply chain for rare earth polymer-bonded magnets by recycling**
O-131 Iliya Radulov, Eva Brouwer, Jan Leitloff, Jürgen Gassmann, Cyril Aymonier, Guido Sonnemann, Benjamin Balke, Anke Weidenkaf

SESSION C5
Energy transition metals - ENICON & EXCEED HE projects

ROOM 5 — *Chair: Kostas Komnitsas*

14:30-14:40 **Energy transition metals: Future demand and low carbon processing technologies**
O-132 Kostas A Komnitsas, Ilias Lazos, Toni Eerola

14:40-14:55 **Challenges in Li minerals recovery from different deposits**
O-133 Lev Filippov

14:55-15:10 **Exploring barriers to the implementation of circular economy processes for batteries**
O-134 Vasileios Rizos, Patricia Urban

15:10-15:25 **Preliminary assessment of the social license to operate in four European lithium projects**
O-135 Toni Eerola, Kostas Komnitsas

15:25-15:40 **Strategic and critical raw materials in the battery supply chain - skills, education and training**
O-136 Kulczycka Joanna

15:40-15:50 **Round table discussion including representatives from Larco, Euronickel and Sunlight**

15:50-16:00 **Q and A**

SESSION C6
Reuse-Recycling and Valorisation II

ROOM 6 — *Chair: Clive Mitchell, Vasilis Melfos*

14:30-14:45 **Fuelling the Foundation Industries: discovering the hidden value of mineral waste in the UK**
O-137 Clive Mitchell

14:45-15:00 **EcoGlassFab: Eco-Glass-Fabrication from the assembly of secondary precursors**
O-138 Sophie Schuller, Kahina Hamadache, Frédéric Angeli, Frederic Goettmann, Benoit Darbouret, Frédéric Boisumeau

15:00-15:15 **Valorizing mineral wool ash as a supplementary cementitious materials**
O-139 Tolga Aydin, Zeynep Başaran Bundur, Kaan Aksoy, Turker Ince, Ezgi Perin, Baris Karabiyik, Mihriban Sari

15:15-15:30 **Microwave chemistry for enhanced carbon capture by serpentine quarry waste**
O-140 Marcello Campione

15:30-15:45 **Effect of by-pass filter dust on durability of self-compacting concrete**
O-141 Andreas Kounadis, Konstantinos Tsivolas, Efstratios Badogiannis

15:45-16:00 **How to convert your waste into a resource?**
O-142 Duane Runciman, Matt Dey

16:00-16:15 **Valorisation of aplite in alkali-activated materials**
O-143 Georgia Maria Tsaousi, Georgia Flessoura, Dimitrios Panias

16:15-16:30 **Optimization of the demolition waste incorporation to cement mortar by response surface methodology**
O-144 Ikbel Bejaoui, Halim Hammi, Khaoula Mkadmini, Rym Abidi

16:30-17:00 ***Coffee Break – Poster session 3***

PARALLEL SESSIONS

SESSION C7
Advanced metallurgical processes

ROOM 13 — *Chair: Casper van der Eijk, Dimitris Panias*

17:00-17:30 **Keynote presentation**
The possibilities and limitations of the use of hydrogen in different metallurgical sectors
KN-10 Casper van der Eijk, Jafar Safarian, Halvor Dalaker

17:30-17:45 **Isothermal Pre-reduction behaviour of Nchwaning Manganese Ore in H_2 atmosphere**
O-145 Alok Sarkar, Trygve Lindahl Schanche, Jafar Safarian

17:45-18:00 **Optimization of Fe, Al, and Na recovery from H_2 Reduced Bauxite Residue (Red mud) using Response surface methodology (RSM)**
O-146 Ganesh Pilla, Tobias Hertel, Bart Blanpain, Yiannis Pontikes

18:00-18:15 **Contribution to the optimization of the smelting reduction of nickeliferous laterites, based on the recent industrial experience.**
O-147 Charalabos Zografidis, Konstantinos Betsis

18:15-18:30 **Exploring the leaching potential of lemonitic laterites with nitrate solutions**
O-148 Iraklis Varsamos, Paschalis Oustadakis, Konstantinos Betsis, Anthimos Xenidis

18:30-18:45 **Aluminothermic reduction of iron and titanium from metallurgical wastes**
O-149 Dimitris Sparis, Efthymios Balomenos, Dimitrios Panias

18:45-19:00 **Wastes from olive oil production as a perspective component for biocoke production**
O-150 Małgorzata Wojtaszek-Kalaitzidi, Michał Rejdak, Michał Książek, Sten Yngve Larsen, Stavros Kalaitzidis

SESSION C8
Critical metals sourcing - Experts Panel Discussion

ROOM 5 — *Moderators: Thymis Balomenos, Beate Orberger*

17:00-19:00 **How can EU Critical Raw Materials extraction from waste or low-grade ore compete with Asian production?**

Industrial Minerals: The sleeping giant of European CRM resources?
O-152 Anastasios Kladis, AdMiRIS

Waste to resource - secondary resourcing from waste
O-153 Duane Runciman, Mures Magnesium Srl.

Gallium Supply Chain - EU Resilience
O-154 Stefan Eichler, Freiberger Compound Materials

A European Stockpile Organization is a must have for Europe to reduce its supply disruptions for Critical Materials
O-155 Henk Van der Laan, VIC

SESSION C9

Education

ROOM 6 — *Chair: George Barakos, Maria Menegaki*

17^{00}-17^{30}	**Keynote presentation**
	European Universities and New Tools in the Raw Materials Education
KN-11	**Katerina Adam,** National Technical University of Athens
17^{30}-17^{45}	**TIMREX – an EIT labelled master programme in innovative mineral exploration**
O-156	Sibila Borojević Šoštarić, Ferenc Madai, Gabriela Paszkowska, Nils Jansson
17^{45}-18^{00}	**Integrated Mine Planning Education for the Modern Engineer**
O-157	Ioannis Kapageridis, Kyros Koios
18^{00}-18^{15}	**The interactive advancement of the Australian Mining Industry and Academia toward the sustainable supply of critical raw materials**
O-158	George Barakos, Danielle Thompson, Michael Hitch
18^{15}-18^{30}	**Program for achieving progress in transfer the science to business developed within teaching project for staff at Eastern and Southeastern European universities**
O-159	Malwina Kobylańska, Agnieszka Urbańska-Ciszek
18^{30}-18^{45}	**Discussion on Knowledge Gaps in Mining Operations: Empirical Evidence from the Greek Mining Industry**
O-160	Philip-Mark Spanidis, Francis Pavloudakis, Christos Roumpos
18^{45}-19^{00}	**EIT Deep Tech Talent Initiative**
O-161	Francesca Barisani, Cross-KIC Outreach and Stakeholder Manager, EIT RawMaterials

19^{00} Closing ceremony-Awards

POSTER SESSION 1

EU Strategy on Circular economy / Mineral exploration and characterization / Mineral Processing / EoL products / LiBs

Monday 28 August 2023 *ROOM 16*

P1-01 **Effect of thermal treatment on flotation and leaching in EV lithium-ion battery recycling**
Marius Müller, Luka Nils Mettke, Bengi Yagmurlu

P1-02 **Effect of freeze-thaw cycles on the flexural strength of Greek natural stones**
Konstantinos N Laskaridis, Angeliki Arapakou

P1-03 **Structural and electrochemical characterization of Natural Manganese Oxides from Drama Mn-oxide Deposits of Greece**
George Soulamidis, Christina Stouraiti, Harilaos Tsikos, Maria Kourmousi, Eleni Charalampous, Christiana Mitsopoulou

P1-04 **Mineralogical and geochemical constrains of the critical and rare metals in the vein-type mineralization at the Vertiskos unit, northern Greece**
Christos Stergiou, Grigorios Aarne Sakellaris, Vasilios Melfos, Panagiotis Voudouris

P1-05 **Sustainable blue economy as a supplier of Strategic and Critical Raw Materials**
Fani Sakellariadou, Francisco Javier Gonzalez, James Hein, Blanca Rincón-Tomás, Nikolaos Arvanitidis, Thomas Kuhn

P1-06 **The suitability of mafic volcanics from the island of Patmos for acidic water purification applications: Report on initial experimental results**
Efi Kosti, Natalia Aggelopoulou, Petros Koutsovitis, Christina Lazaratou, Alkiviadis Sideridis, Petros Petrounias, Dimitrios Papoulis

P1-07 **The Hydrogeological Conditions as a Crucial Factor for Creating Pit Lakes. The Case of Kyparissia Mine in Megalopolis, Greece.**
Georgios Louloudis, Christos Roumpos, Eleni Mertiri, Georgios Kasfikis, Eleni Vasileiou

P1-09 **Magmatic controls on Zr-Ti-U-Th-REE enrichment in potassic mafic-intermediate rocks and evaluation of their economic significance**
Charalampos Vasilatos, Angeliki Papoutsa

P1-10 **Application of magnetic geophysical survey for the identification of buried bauxite deposits in Fokis, Central Greece.**
Panagiotis Zachariadis, Armand Dubus, Emmanuel Pizzo

P1-11 **Application of MCDM methods in mineral processing – a review**
Zoran Štirbanović, Dragiša Stanujkić, Jovica Sokolovic, Ivana Ilić

P1-12 **Mineral characterization of Ni-Co sulphide ores and tailings from Kevitsa Mine, Finland**
Nivea Magalhaes, Hannah Hughes, Jens Andersen, Richard Crane, Fernando Prado Araújo, Philippe Muchez

P1-13 **Mapping the soil chemical properties of the Sarigkiol Basin, Western Macedonia, Greece, in the view of the transition to the post-lignite era**
Despoina Psarraki, Panagiotis Papazotos, Eleni Vasileiou, Maria Perraki

P1-14	**The Controlled-source Audio-frequency Magnetotellurics (CSAMT/AMT) method tested in the search for deep Fe-Skarn mineralization at Kimmeria, Xanthi, N. Greece** Petros Karmis, Magdalini Angeli, Dimitrios Tsouvalas, Constantinos Mavrogonatos, Michalis Fitros, Marianthi Anastasatou, Adamantia Chatziapostolou, Konstantinos Laskaridis
P1-15	**Recycling concrete to aggregates. Implications on CO_2 footprint** Ioannis Bampanis, Charalampos Vasilatos
P1-16	**Circular Economy for Critical Raw Materials in India** Anjali Singh
P1-17	**Investigating the recovery of noble metals from single-use medical technology specific waste streams** Kokkinos Evgenios, Merachtsaki Domna, Lampou Angeliki, Prochaska Charikleia, Peleka Efrosyni, Konstantinos Simeonidis, George Vourlias, Zouboulis Anastasios
P1-18	**Granulometric, chemical, and mineralogical evaluation of Greek lignite bottom ash for potential utilization in the concrete manufacturing** Argyro Asvesta, Ioannis Kapageridis, Agapi Vasileiadou, Kyros Koios, Nikolaos Kantiranis
P1-19	**A comparative study on the properties of volcanic rocks from Aegean islands, Greece, for utilization as pozzolanic additives in cement** Theodoros Sainis, Glikeria Kakali, Panagiotis Pomonis, Charalampos Vasilatos
P1-20	**Hydrometallurgical pilot plant reconfiguration for the recycling of automotive waste for the recovery of precious and critical metals: H2020 Treasure project** Nicolò Maria Ippolito, Soroush Rahmati, Pietro Romano*, Marco Passadoro, Valentina Innocenzi, Hossein Shalchian, Giorgio Pellei, Ionela P. Birloaga, Francesco Ferella, Svetlana B. Zueva, Francesco Vegliò
P1-21	**SEMACRET-Geophysical exploration of magmatic ore deposits** Isla Fernández, Andrea Viezzoli, Elena Kozlovskaya, Shenghong Yang, Vojtěch Wertich, Ana Patricia Jesus, Olga Rosowiecka

POSTER SESSION 2

Mining, Energy Environment and Sustainability, Hydrometallurgical Processes

Tuesday 29 August 2023 *ROOM 16*

P2-01	**Geochemical and limnological characterization of the Corta Atalaya pit lake (Riotinto mines, Spain)** Esther Santofimia, Blanca Rincón-Tomás, Enrique López-Pamo, Francisco Javier Gonzalez, Ricardo Amils
P2-02	**Preliminary Environmental Assessment of Carbonated Slags as a CCUS in Agricultural Applications** Ponnapat Watjanatepin, Laura Steinwidder, Anthony de Schutter, Giuseppe Granata, Sara Vicca, Tom Van Gerven, Karel Van Acker
P2-03	**Evolution of alluvial gold mining technologies** Spyridon Mathioudakis, George Xiroudakis, Evangelos Petrakis, Emmanouil Manoutsoglou

P2-04	**Capacity of Nerium oleander to phytoremediate mining spoils assisted by air nanobubbles and biochar** Petroula Seridou, Vasiliki Karmali, Evdokia Syranidou, Anna Kritikaki, Kostas Komnitsas, Georgios Kolliopoulos, Nicolas Kalogerakis
P2-05	**Extractive waste management in coal surface mining projects - A circular economy approach** Ariadni Sokratidou, Christos Roumpos, Nikolaos Paraskevis, Aikaterini Servou, Francis Pavloudakis
P2-06	**Dynamic adsorption of Pb by Fe-Mg clay–quartz beds using micro-columns** Zacharenia Kypritidou, Maria-Anna Gatou, Ariadne Argyraki, Vasileios Zotiadis
P2-07	**Potential use of leaching gravel as a raw material to the preparation of geopolymeric material as an alternative to conventional cement materials** Arturo Reyes Roman, Francisca Balarezo Olivares, Daniza Castillo, Francisco Arriagada, Miguel Maulen Tapia
P2-08	**Alluvial gold mining from Argonauts to Agricola** Spyridon Mathioudakis, George Xiroudakis, Evangelos Petrakis, Emmanouil Manoutsoglou
P2-09	**A Review about the methods and techniques for evaluating the waters and soils in mining regions.** Ioanna Petropoulou, Maria-Sotiria Frousiou, Eleni Vasileiou
P2-10	**Groundwater monitoring system based on Arduino platform and IIoT platform** Marcin Paterek
P2-11	**Face Mapping in Open Pit Mines-A new approach** Agni Patra, Konstantinos Pilalidis, Francis Pavloudakis, Ioannis Kapageridis
P2-12	**Potential benefits from Carbon Capture Utilisation and methanol production in magnesite processing line** Antonis Peppas, Doris Skenderas, Chrysa Politi, Dimitris Sparis
P2-13	**Potential application of RES and underground $_{H2}$ storage in abandoned mines** Antonis Peppas, Sotiris Kottaridis, Chrysa Politi
P2-14	**Prediction of hydrate dissociation conditions in natural/acid/flue gas streams in the presence and absence of inhibitors** Ismail Ismail, Vassilis Gaganis
P2-15	**Evaluation of an iron nanocomposite material for heavy metals removal under flow conditions** Christiana Mystrioti, Nymphodora Papassiopi, Anthimos Xenidis
P2-16	**Manganese Recovery from Nickel and Cobalt Production Facility MHP Leach Waste** Fırat Tekmanlı, Bengi Yağmurlu, Hüseyin Eren Obuz
P2-17	**An innovative approach for the recovery of cobalt sulfate from battery leach solutions by anti solvent crystallization** Luka Nils Mettke, Marius Müller, Bengi Yagmurlu
P2-18	**Raw materials and circular economy: bioelectrochemical copper removal and recovery from wastewater** Hyusein Yemendzhiev, Valentin Nenov
P2-19	**Evaluation of thiosulphate for gold recovery from pressure oxidation residues** Christiana Mystrioti, Konstantina Kousta, Nymphodora Papassiopi, Katerina Adam, Maria

	Taxiarchou, Ioannis Paspaliaris
P2-20	**Hydrometallurgical recovery of EoL LFP batteries using oxalic acid as lixivient** Rafaella - Aikaterini Megaloudi, Nikos Konsolas, Paschalis Oustadakis, Anthimos Xenidis
P2-21	**Leaching of Bauxite Residues from Turkish, Greek and Romanian Plants Using Concentrated Sulphuric and Hydrochloric Acids for Potential Application in an Industrial Recovery Plant** Murat Kabataş, Tuğba Selcen Atalay Kalsen, Hakan Burak Karadağ, Yasin Ramazan Eker, Bayram Ünal, Panagiotis Angelopoulos, Paschalis Oustadakis, Ioannis Paspaliaris, Meral Baygül, Gökhan Demir, Sedat Arslan, Panagiotis Davris, Efthymios Balomenos, Gheorghe Dobra, Alina Boiangiu
P2-22	**Unlocking the potential of intermediate type C2 laterites through nitrate leaching: Investigating leaching behavior for efficient metal recovery** Ioannis Varsamos, Paschalis Oustadakis, Rafaella - Aikaterini Megaloudi, Anthimos Xenidis
P2-23	**Acid Leaching of Cu/Fe polymetallic alloy: Process alternatives & Challenges** Michail Vafeias, Amalia Bempelou, Dimitrios Panias
P2-24	**Novel GO/ceramic composite membranes for environmental applications** Evdokia Galata, Mohammed Subrati, George Petrou, Petros Magkaniaris, George Romanos, Zili Sideratou, Fotis Katsaros

POSTER SESSION 3

Industrial Minerals, Reuse and Valorisation, Advances in Metallurgy, Education

Wednesday 30 August 2023 *ROOM 16*

P3-01	**RIS Internship – sustainable and structured internship programme for RawMaterials master students and organization from RIS regions** Sibila Borojević Šoštarić, Kristina Koret, Vječislav Bohanek, Ferenc Madai
P3-02	**Thermal treatment of serpentinized olivine wastes, obtained from chromite mineral enrichment operations, as an example of circular economy in the mining sector** Evgenios Kokkinos, Peleka Efrosyni, Zouboulis Anastasios
P3-03	**Recovery of Critical Raw Materials from abandoned mine waste, some potential case studies in North-Western Italy** Gabriele Baldassarre, Adriano Fiorucci Paola Marini
P3-04	**Electric Arc Furnace Dust vitrification via soda-lime recycled glass** Andronikos Maris, Dimitra Ioannidou, Ilias Sammas, Stavros Deligiannis, Petros Tsakiridis
P3-05	**Using natural and synthetic zeolites for polluted soils clean-up** Charalampos Vasilatos, Maria Roulia
P3-06	**Optimization of the demolition waste incorporation to cement mortar by response surface methodology** Ikbel Bejaoui, Halim Hammi, Khaoula Mkadmini, Rym Abidi
P3-07	**Recovery of stainless steel from end-of-use dishwashers** Eirini Evangelou, Georgios Anastassakis, Spyridon Karamoutsos, Athanasios Stergiou
P3-08	**ARTeMIS – A European training-through-research program for exploration geologists** Alexandre Tarantola, Jean Cauzid, Marie-Camille Caumon, Cécile Fabre, Rasool Mehdizadeh,

Panagiotis Voudouris, Christina Stouraiti, Konstantinos Soukis, Constantinos Mavrogonatos, Karsten Haase, Manuel Keith, Vasilios Melfos, Alexandros Chatzipetros, Grigorios-Aaarne Sakellaris, Janja Mihajlovic, Tim Baker, Olivier Dossmann, Cedric Gavier

P3-09	**Utilization of an industrial waste for the development of fire resistant geopolymers** Konstantinos Sakkas, Christos Georgopoulos, Yiannis Makrigiannis, Efthymios Balomenos, Panagiotis Davris
P3-10	**Empowering Students for the Future: Enhancing Soft Skills through non-formal educational paths** Vasileios Loukadakis, Doris Skenderas, Nicolas Antoniadis, Eva Stachouli, Magdalini Mylona
P3-11	**Preliminary study of low cost raw materials for new syntheses of geopolymers targeting environmental applications.** Marina Christopoulou, Paraskevi Lampropoulou, Petros Petrounias, Aikaterini Rogkala, Panagiota Giannakopoulou, Petros Koutsovitis, Dionisios Panagiotaras, Nikolaos Koukouzas
P3-12	**Sustainable Valorisation of Quarry Waste from Granite Ornamental Rocks for Extracting Critical Raw Materials** Antonello Aquilano, Valeria Indelicato, Elena Marrocchino, Rosalda Punturo, Carmela Vaccaro
P3-13	**Techno-environmental assessment of novel pathways of red mud waste use to improve extraction efficiency of valuable metals** Monika Vitvarova, David Novacek, Shareq Nazir, Frederico Marques Penha, Onuralp Yucel, Pedro Cabral De Souza, Efthymios Kantarelis, Filiz Sahin, Kağan Benzeşik, Adela Svobodova, Rafael Rodriguez Trias, Arif Karaca, Ilayda Ozbag, Ahmet Turan, Sergei Preis, Selçuk Kan, Camila Barreneche Guerisoli, Umay Çınarlı
P3-14	**Environmental Footprints of Bauxite alternatives for Alumina production - regional characteristics in Central Europe and Turkey,** Monika Vitvarova, Kamila Milnerova, David Novacek, Ahmet Turan, Selcuk Kan, Frantisek Pticen, Stanislav Kapr, Dita Cerna, Umay Çınarlı, Camila Barreneche Guerisoli, İlayda Özbağ, Onuralp Yucel, Kagan Benzesik, Hasan Guney, Filiz Sahin, Arif Karaca, Adela Svobodova
P3-15	**Re-use of historical thermal plant ash deposits as supplementary cementing materials** Bogdan Vasile, Adrian Nicoara, Arian Surdu, Ovidiu Oprea, Roxana Trusca, Mehmet Gulgun, Zeynep Başaran Bundur, Saso Sturm, Sorour Parapari, Otilia Vasile, Mirijam Vrabec
P3-16	**BR valorisation with enhanced Al extraction by hydrothermal conversion of hematite to magnetite** Paschalis Oustadakis, Panagiotis Angelopoulos, Maria Georgiou, Georgios Anastasakis, Ioannis Paspaliaris, Michael Pissas
P3-17	**Limonitic laterite reduction with hydrogen** Evangelos Palavos, Michail Samouhos, Dimitrios Kotsanis, Eamonn Devlin, Georgios Pillatos, Antonis Peppas, Anthimos Xenidis
P3-18	**Use of aluminium scrap for the production of high-quality recycled aluminum products. Design and production control criteria -The project DeReAL** Vasileios Akrivos, Ilias Georgiopoulos, Anastasios Triantafyllou, Grigorios Paschalis, Constantina-Dia Andreouli
P3-19	**Assessment of hand-held XRF analyser performance for the characterization of aluminium scrap** Michail Galetakis, Angeliki Ntourntoureka, Basileios Deligiorgis

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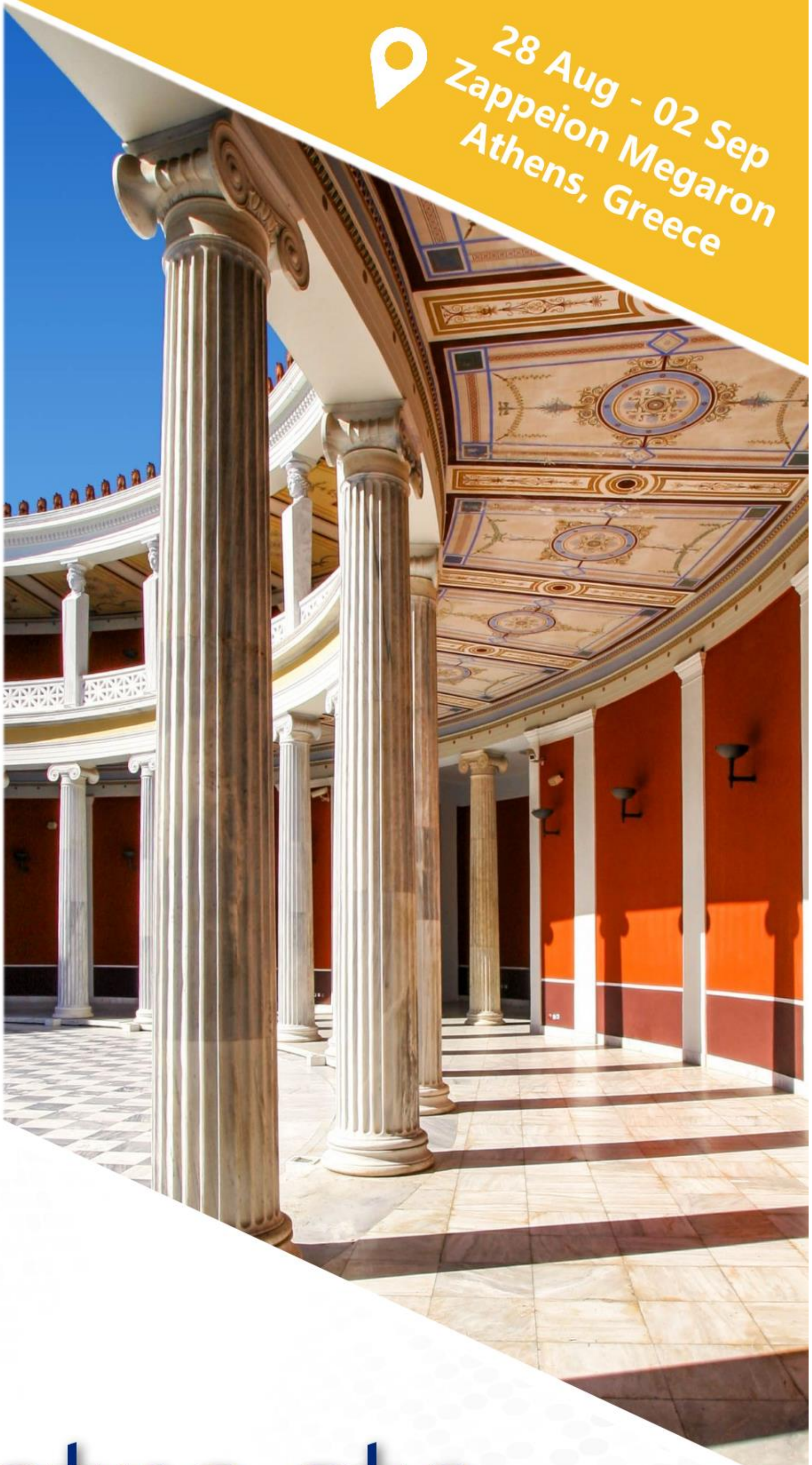
2nd International Conference on Raw Materials and Circular Economy

Raw Materials: Setting the foundations for the Green Transition



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σύνδεσμος επιχειρήσεων μαρμάρου μακεδονίας-θράκης

RawMat2023

2nd International Conf. on Raw Materials and Circular Economy

"*Raw Materials: setting the foundation for the Green Transition*"

Raw materials are strongly connected to human development and the prosperity of Earth's population and therefore, they are crucial to every country's economy. Raw materials form a strong industrial base, producing a broad range of goods and applications used not only in everyday life but also in new strategic and green technologies. The global population growth, the rise in the standard of living and the drive for clean energy technologies are increasing the demand of mineral resources. According to the International Energy Agency (IEA), there could be a 20-fold increase in demand for nickel and cobalt by 2040 to meet the needs of an increasingly electrified world, and the total copper demand will nearly double by 2035. Other raw materials, such as lithium, rare earth elements, vanadium, etc. are critically important for the transition to green energy, higher mobility and the digital world. At the same time, raw materials must be sourced in a sustainable and responsible way, achieving high-level environmental standards and social acceptance. All the above present both an opportunity and a challenge for the raw materials industry.

Reliable and unhindered access to certain raw materials is a growing concern across the globe. To ensure the sustainable supply of raw materials, it is crucial that the minerals sector, apart from exploring new regions and opening new projects, can also embrace the concept of a circular economy and identify opportunities for the rational use of raw materials, such as reducing and optimizing the use of materials, industrial symbiosis, recycling, reuse, remanufacturing, etc. By conserving materials embodied in high-value products, or returning waste to the economy as high-quality secondary raw materials, a circular economy could increase the efficiency of primary resource consumption. The transition from linear to circular economy is essential in achieving a resource-efficient and sustainable society.

In that respect, the 1st international conference entitled "Raw Materials and Circular Economy - Technological Developments and Future Challenges" (RawMat2021), was organized on September 2021 in Athens, Greece, which was embraced by stakeholders involved in all steps of the materials value chain. The 2nd international conference entitled "**Raw Materials and Circular Economy - *Raw Materials: setting the foundation for the Green Transition*" (RawMat2023)** is **organized** again in Athens, Greece, by the School of Mining and Metallurgical Engineering, **National Technical University of Athens** and the **Technical Chamber of Greece** under the auspices of Hellenic Ministry of Environment and Energy, Association of Mining Enterprises and Association of Marble Enterprises of

Macedonia and Thrace. It is also **co-organized** by the *Hellenic Survey of Geology and Mineral Exploration*, *Geotechnical Chamber of Greece*, *Geological Society of Greece*, School of Mineral Resources Engineering, *Technical University of Crete*, Department of Mineral Resources Engineering, *University of Western Macedonia*, Department of Geology and Department of Chemistry, *Aristotle University of Thessaloniki*, Department of Geology and Geo-environment, *National and Kapodistrian University of Athens*, Department of Geology, *University of Patras*, *Centre for Renewable Energy Sources and Saving* and *EBETAM SA - Company of Industrial Research, Technological Development and Laboratory Testing, Certification and Quality*. In addition, it is **supported** by The Metallurgy and Materials Society of Canadian Institute of Mining and Petroleum (*MetSoc/CIM*), The Minerals, Metals & Materials Society (*TMS USA*) and the Australasian Institute of Mining and Metallurgy (*AusIMM*).

RawMat2023 topics cover a wide range of raw materials related activities, including strategies on raw materials supply, exploration, mining, mineral processing, metallurgy, energy, waste valorisation, recycling, Industry 4.0 transformation with emphasis on Green Transition issues. RawMat2023 brings together industry executives and engineers, junior and senior scientists, stakeholders and policy makers, professionals and academics from the whole raw materials value chain, for a comprehensive, cross-discipline exchange of knowledge. New tools, methods, research findings, methodological frameworks and hypotheses as well as innovative ideas are going to be presented in its scientific and technical sessions.

We are looking forward to your participation and attendance at the RawMat2021 Conference!

Prof. Anthimos Xenidis
Chair RawMat2023

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CONFERENCE DETAILS

RawMat2023 is organized by the **Technical Chamber of Greece**, the **School of Mining and Metallurgical Engineering of the National Technical University of Athens** under the auspices of Hellenic Ministry of Environment and Energy, Association of Mining Enterprises and Association of Marble Enterprises of Macedonia and Thrace.

It is also **co-organized** by the *Hellenic Survey of Geology and Mineral Exploration*, *Geotechnical Chamber of Greece*, *Geological Society of Greece*, School of Mineral Resources Engineering, *Technical University of Crete*, Department of Mineral Resources Engineering, *University of Western Macedonia*, Department of Geology and Department of Chemistry, *Aristotle University of Thessaloniki*, Department of Geology and Geo-environment, *National and Kapodistrian University of Athens*, Department of Geology, *University of Patras*, *Centre for Renewable Energy Sources and Saving* and *EBETAM SA - company of Industrial Research, Technological Development and Laboratory Testing, Certification and Quality*.

In addition, it is **supported** by The Metallurgy and Materials Society of Canadian Institute of Mining and Petroleum (*MetSoc/CIM*), The Minerals, Metals & Materials Society (*TMS USA*) and the Australasian Institute of Mining and Metallurgy (*AusIMM*). Finally, RawMat2023 is co-funded by the Greek Green Fund “Extrovertial Actions, Natural Environment and Innovative Actions”

TOPICS

RawMat2023 covers a broad list of topics as follows

- EU Industrial Strategy / Circular and Resource Efficient Economy
- Minerals Exploration and Resource Characterization: securing critical and strategic raw materials supply
- Mining: Trends and Perspectives
- Advances in Mineral Processing Technologies
- Sustainable Metallurgy
- Industrial Minerals
- Environment, Energy and Sustainability
- Reuse - Recycling and Valorisation
- Education
- Occupational Health and Safety (OHS)
- Greece - Specific Issues

PRESENTATION GUIDELINES

Oral contributions

Regular oral presentations will last 15 minutes which include a 12 min speech by the presenting author and another 3 min for questions by the audience. Plenary and keynote presentations will last 30 min(25 min speech and 5 min for discussion) unless otherwise indicated in the final program. In order to keep the program on time, all authors are requested to be accurate in their timetable

Poster presentations

The presenting authors should hang their printed posters in the morning of their presentation and remove them at the end of the poster session. The preferable dimensions for posters should be 80 cm x 120 cm (width x height). All posters are required to conform to portrait orientation. Type size should be sufficiently large to allow people to read from 2-3 meters. There is no template to hold you back, so feel free to explore your artistic prowess and create a stunning poster that truly stands out.

All presentations should be prepared in English language (official language of the Conference).

AWARDS

The most outstanding presentations during RawMat2021 will receive one of the awards from the following categories:

- **Best Oral Presentation Award.** Most distinguished paper combining high scientific quality and presentation significance. The award is sponsored by the journal Minerals MDPI.
- **Best Poster Award.** Dedicated to the best presentation during the poster sessions of the conference.
- **Young Researcher Award.** For the best presentation by a young scientist.

Selected high-impact presentations will get a waiver for full paper submission in the peer-review journals collaborating with RawMat2023.

Presented papers will be evaluated by the Award Committee according to the following criteria: Significance of the paper, Originality, Presentation impact, Young researcher. The winners of RawMat2023 awards will be announced during the closing ceremony of the conference.

PROCEEDINGS

Conference participants may submit a full paper which is oriented to be published in the RawMat2023 Proceedings Volume hosted in Materials Proceedings journal. Publication in the Proceedings is free of charge for all registered participants and the paper will be available as an open access document.

PUBLICATION IN JOURNALS

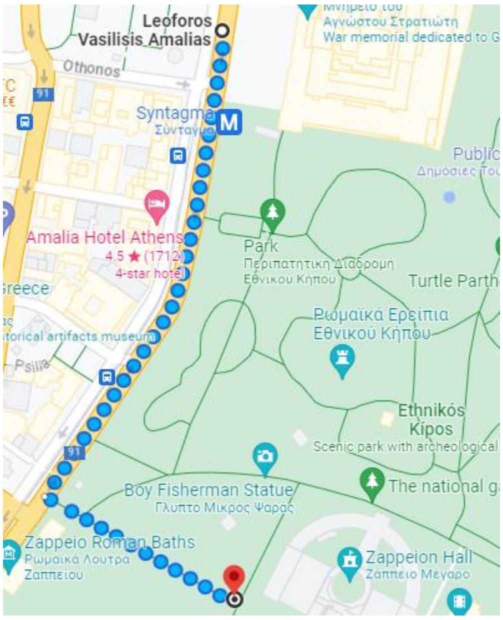
For selected papers presented RawMat2023, the opportunity to publish a full paper in one of the collaborating peer-review journals will be offered after the end of the conference. Some of the mentioned journals are open access requiring an Article processing charge from the side of the authors. RawMat2023 provides a significant discount of this amount for all participant and a number Papers related to metallurgical processes and research aiming at improving the sustainability of metals production, with an emphasis on materials recovery, reuse, and recycling, energy and environmental impacts minimization will be invited to submit in a Special Issue of the **Journal of Sustainable Metallurgy** (Springer, Impact factor 3.068 (2021)).

Papers related to minerals, minerals processing, mining and environment will have an opportunity to be submitted in the Special Issue entitled "***Exploration, Mining, and Processing of Minerals: Enabling the Clean Energy Transition***" of the journal **Minerals** (MDPI, open access, impact factor 2.818 (2021)).

Selected papers in the area of Raw Materials and Circular Economy will be also published in a Special Issue of the Open Access e-**Technical Annals** Journal. It is a relatively new international journal, formerly a national one having published engineering articles for decades, that recently started publishing high-quality original research articles, reviews, and technical notes in various fields of engineering and technology. The journal is edited by the Technical Chamber of Greece through the e-Publishing Platform.

VENUE

RawMat2023 shall take place in Athens, the historical heart of Greece known as the birthplace of democracy and home to some of the most significant philosophers. The **Zappeion Exhibition Hall** or **Zappeion Megaron**, located in the Athens city center, is the conference venue. It has been an active part of Greece's history and that of Hellenism, for the last 130 years, surrounded by some of the most important buildings in Athens, such as the Parliament building, the Tomb of the Unknown Soldier, the Maximou Palace, which is the official residence of the Prime Minister, the Foreign Ministry, and other public buildings. Nearby are the National Gardens and, opposite, on the side of the Ardittos Hill, the Panathinaic Stadium, Hadrian's Arch and the ancient Temple of the ROOM 13n Zeus. Athens International Airport Eleftherios Venizelos is about 35 km away from the venue (about 50 minutes trip by public transportation or 30 minutes' drive) and easily accessible. The Zappeion Megaron is served by a metro station (Syntagma: red and blue lines) located within walking distance (6 minutes-500m). Website: https://www.zappeion.gr/en/



EXHIBITION

In the framework of the RawMat2023, a parallel exhibition will be organized where supporting companies and organizations dealing with the raw materials sector are going to provide detailed information on their activities and future plans to the conference participants. The exhibition area is located in Room 3.

SOCIAL EVENTS / FIELD TRIPS

Opening ceremony	28-8-2023	Zappeion / Room 13		09:00
Welcome reception	28-8-2023	Zappeion / Peristilio		20:00
Gala dinner	29-8-2023	Royal Olympic Hotel-Ioannis Roof Garden		20:00
Field Trip 1 to AoG / Mytilineos and Delphi	31-8-2023	Aluminium of Greece - Delphi archeological site	Departure: Return:	08:00 19:00
Field Trip 2 to Lavrion and Sounion	1-9-2023	Lavrion Historical Mine Sounion archeological site	Departure: Return:	08:00 18:15

PARALLEL EVENTS

- **Greek specific issues** 29-8-2023 09:00-13:00

Presentations by companies and government bodies discussing current situation, problems, challenges and future trends in the field of raw materials in Greece. Event language will be Greek.

- **ERA MIN** 29-8-2023 09:00-16:30

ERA-MIN3 is a global, innovative and flexible pan-European network of 25 European and non-European research funding organisations, aiming to continue strengthening the mineral raw materials community through the coordination of research and innovation programmes on non-fuel and non-food raw materials (metallic, construction, and industrial minerals).

Attracting and promoting innovations for increased raw material efficiency and circular economy is crucial for the transition to a climate-neutral and digital economy. ERA-MIN3 organizes three sessions which address recent research results and future challenges and research needs for raw materials and the circular economy.

The first two ERA-MIN sessions (Session B2 "***Sustainable Mining, Processing and Production Processes***" and Session B5 "***Recycling of EoL products and immovable assets, e.g. batteries, magnets***" will highlight the results of the 22 out of 24 transnational research projects that have ended recently or will end soon. The transnational projects target R&I innovations that cover the entire raw materials value chain (exploration, mining, processing, production and recycling of EoL products, including batteries and magnets). Within a systemic view, research the transnational R&I projects address both technological and non-technological aspects, e.g. circular economy business models. By joining these sessions, you will learn from Europe's leading players in the research sector who will share insights into their recent research results and their plans for future exploitation. To discuss challenges and the future research and innovation needs towards a sustainable raw materials supply which should be addressed by a partnership of funding programmes is the aim of the 3rd session (Session B8 "***ERA-MIN SRIA workshop***").

- **Critical metals sourcing - Experts Panel Discussion** 30-8-2023 17:00-19:00

This session will give delegates the opportunity to learn about and discuss with industrial experts. Five experts from SME, large and small enterprises, and consultancies are invited. They represent important economic sectors, scandium and related alloys, gallium, aluminium (bauxite), titanium dioxide, and magnesium. Each metal has its specific supply and market issues, driven by the choice of technologies, related economic and financial matters.

The important titanium and aluminium industries may unlock by-products from residual waste streams or secondary products. Magnesium, and other critical metals can be recovered with innovative extraction processes reducing energy consumption, and C-footprint. Critical raw materials can and will thus be available in Europe for refiners and end-users.

What are the challenges, strength, opportunities, and threats for a European metal transformation and production? What are European solutions to be competitive with Asian produced critical metals.

PROGRAM STRUCTURE

	Monday 28 Aug. 2023	Tuesday 29 Aug. 2023	Wednesday 30 Aug. 2023
08^{00}-09^{00}	Registration	Registration	Registration
09^{00}-10^{30}	**Opening speeches** **PLENARY LECTURES**	**B1** GREECE-SPECIFIC ISSUES **B2** ERA-MIN3 at RawMat2023 **B3** ENERGY AND CO_2 STORAGE	**PLENARY LECTURES**
10^{30}-11^{00}	Coffee break - Poster session I	Coffee break - Poster session II	Coffee break - Poster session III
11^{00}-13^{00}	**PLENARY LECTURES** **Sponsors presentations**	**B4** GREECE-SPECIFIC ISSUES **B5** ERA-MIN3 at RawMat2023 **B6** ENVIRONMENT AND SUSTAINABILITY I	**C1** CRITICAL METALS RECOVERY FROM WASTE **C2** SUBSTITUTION & RECYCLING IN THE AUTOMOTIVE SECTOR **C3** INDUSTRIAL MINERALS & WASTE REUSE - VALORIZATION I
13^{00}-14^{30}	Lunch break - Poster session I	Lunch break - Poster session II	Lunch break - Poster session III
14^{30}-16^{30}	**A1** EU STRATEGY-CIRCULAR ECONOMY **A2** MINERALS EXPLORATION - RESOURCE CHAR. I **A3** CRITICAL ELEMENTS REC. FROM EoL PRODUCTS	**B7** MINING: TRENDS AND PERSPECTIVES I **B8** ERA-MIN SRIA WORKSHOP **B9** ENVIRONMENT AND SUSTAINABILITY II	**C4** MAGNETS AND REEs **C5** ENERGY TRANSITION METALS - ENICON & EXCEED **C6** REUSE-RECYCLING AND VALORISATION II
16^{30}-17^{00}	Coffee break - Poster session I	Coffee break - Poster session II	Coffee break - Poster session III
17^{00}-18^{30}	**A4** ADVANCES IN MINERAL PROCESSING **A5** MINERALS EXPLORATION - RESOURCE CHAR. II **A6** Li-ion BATTERIES RECYCLING	**B10** MINING: TRENDS AND PERSPECTIVES II **B11** HYDROMETALLURGICAL PROCESSES **B12** OSH and EPD REPORTING	**C7** ADVANCED METALLURGICAL PROCESSES **C8** CRITICAL METALS SOURCING - EXPERTS PANEL DISCUSSION **C9** EDUCATION
18^{30}-19^{00}	**PLENARY LECTURES**		
19^{00}-19^{30}			19^{00} Closing ceremony Awards
20^{00}-22^{30}	20^{00} Welcome reception	20^{00} Gala Dinner	

PROGRAM AT A GLANCE

Monday 28 August 2023

ROOM 13	09:00-09:30	**Welcome** and brief introduction by the **organizers**
	09:30-10:00	**Welcome** speeches
	10:00-10:30	**Plenary** lectures
ROOM 3, 16	**10:30-11:00**	**Coffee break – Poster session I**
ROOM 13	11:00-12:00	**Plenary** lectures
	12:00-12:50	**Sponsors** presentations
	12:50-13:00	**Honorary Award** to Dr. Nikolaos Arvanitidis
ROOM 2, 3 Peristilio	**13:00-14:30**	**Lunch break**
ROOM 3, 16	**Poster Session I – Exhibition**	
	14:30-16:30	**Parallel sessions**
ROOM 13	A1. EU Strategy-Circular economy	
ROOM 5	A2. Minerals Exploration and Resource Characterisation I	
ROOM 6	A3. Critical elements recovery from End-of-Life products	
ROOM 3, 16	**16.30-17.00**	**Coffee break – Poster session I**
	17:00-18:45	**Parallel sessions**
ROOM 13	A4. Advances in mineral processing technologies	
ROOM 5	A5. Minerals Exploration and Resource Characterisation II	
ROOM 6	A6. Li-ion Batteries recycling	
ROOM 3, 16	**18:30-18:45**	**Coffee break – Poster session I**
ROOM 13	18:45-19:45	**Plenary** lectures
PERISTILIO (Zappeio)	20:00	**Welcome reception**

PROGRAM AT A GLANCE

Tuesday 29 August 2023

	09:00-10:30	**Parallel sessions**
ROOM 13	B1. Greek specific issues (in Greek)	
ROOM 5	B2. ERA-MIN3 at RawMat2023 *(starts at 08:30)*	
ROOM 6	B3. Energy and CO_2 storage	
ROOM 3, 16	**10:30-11:00**	**Coffee break – Poster session II**
	11:00-13:00	**Parallel sessions**
ROOM 13	B4. Greek specific issues (in Greek)	
ROOM 5	B5. ERA-MIN3 at RawMat2023	
ROOM 6	B6. Environment and Sustainability I	
ROOM 1, 2, 3	**13:00-14:30**	**Lunch break**
	Poster Session II – Exhibition	
	14:30-16:30	**Parallel sessions**
ROOM 13	B7. Mining: Trends and perspectives I	
ROOM 5	B8. ERA-MIN SRIA workshop	
ROOM 6	B9. Environment and Sustainability II	
ROOM 3, 16	**16:30-17:00**	**Coffee break – Poster session II**
	17.00-19.00	**Parallel sessions**
ROOM 13	B10. Mining: Trends and perspectives II	
ROOM 5	B11. Hydrometallurgical processes for metals recovery from EoL and ores	
ROOM 6	B12. OSH and EPD Reporting	
Royal Olympic Hotel	20:00	**Gala dinner**

PROGRAM AT A GLANCE

Wednesday 30 August 2023

ROOM 13	09:30-10:30	**Plenary** lectures
ROOM 3, 16	**10:30-11:00**	**Coffee break – Poster session III**
	11:00-13:00	**Parallel sessions**
ROOM 13	C1. Critical metals recovery from mining/metallurgical waste	
ROOM 5	C2. Substitution and Recycling of Critical Raw Materials in the Automotive Sector - The Industrial Perspective	
ROOM 6	C3. Industrial minerals & Waste reuse - valorisation I	
ROOM 1, 2, 3	**13:00-14:30**	**Lunch break**
	Poster Session III – Exhibition	
	14:30-16:30	**Parallel sessions**
ROOM 13	C4. Magnets and REEs	
ROOM 5	C5. Energy transition metals - ENICON & EXCEED HE projects	
ROOM 6	C6. Reuse-Recycling and Valorisation II	
ROOM 3, 16	**16:30-17:00**	**Coffee break – Poster session III**
	17:00-19:00	**Parallel sessions**
ROOM 13	C7. Advanced metallurgical processes	
ROOM 5	C8. Critical metals sourcing - Experts Panel Discussion	
ROOM 6	C9. Education	
ROOM 13	19:00	**Closing ceremony - Awards**

Thursday 31 August 2023

	08:00-19:00	**Field trip 1**
Aluminium of Greece / Mytilineos SA and Delphi	Tour of Aluminium of Greece/Mytilineos plant, Visit of Bauxite Residues valorisation pilots, Visit of BR disposal site and the "House of Bauxite" – the enviromental awareness pavilion in Aspra Spitia, Visit of Delphi Archaeological Site and Museum	

Friday 1 September 2023

	08:00-18:15	**Field trip 2**
Lavrion Historical Mine Site and Sounion	Visit to Lavrion Technological and Cultural Park (Mineral processing and Metallurgical plants), Mineralogical Museum, Archaeological Sites of Thorikos, Souriza and Poseidon Temple	

Monday 28 August 2023

08^{00}- 09^{00} ***Registration***

OPENING SESSION

ROOM 13 *Chair: Anthimos Xenidis, Konstantinos Komnitsas, Dimitris Kaliampakos*

09^{00}-09^{30}	**Welcome and brief introduction by the organizers**
	Anthimos Xenidis, Conference Chair
	Georgios Stasinos, President, Technical Chamber of Greece
	Dimitris Kaliampakos, Dean, School of Mining and Metallurgical Eng., NTUA
	Andreas Boudouvis, Rector, National Technical University of Athens
09^{30}-10^{00}	**Welcome speeches**
	Maximos Senetakis, Deputy Minister of Development
10^{00}-10^{15}	**Plenary lecture 1**
PL-01	**Konstantinos Yazitzoglou**, President of Greek Mining Enterprises Association, CEO, GEOHELLAS SA ***NON-critical raw materials. Can we afford to ignore them?***
10^{15}-10^{35}	**Plenary lecture 2**
PL-02	**Maria Nyberg**, European Commission, DG for Internal Market, Industry, Entrepreneurship and SMEs, unit 'Energy Intensive Industries, Raw Materials, Hydrogen' ***European Critical Raw Materials Act Proposal for a Regulation-establishing a framework for ensuring a secure and sustainable supply of critical raw materials***

10^{35}-11^{00} ***Coffee Break – Poster session 1***

ROOM 13 *Chair: Anthimos Xenidis, Nikolaos Arvanitidis, Mark Rachovides*

11^{00}-11^{15}	**Plenary lecture 3**
PL-03	**Anna-Michelle Asimakopoulou**, Member of European Parliament ***How Europe can win the race to secure its Critical Raw Material Needs***
11^{15}-11^{30}	**Plenary lecture 4**
PL-04	**Mark Rachovides**, President Emeritus Euromines ***Opportunities, challenges and paradoxes in Raw Materials for Europe today***
11^{30}-12^{00}	**Plenary lecture 5**
PL-05	**Antje Wittenberg**, Bundesanstalt für Geowissenschaften und Rohstoffe, **Daniel Oliveira**, LNEG, Chair of EuroGeoSurveys Mineral Resources Expert Group, Critical raw materials in Europe ***Critical Raw Materials resource potential in Europe***
12^{00}-12^{50}	**Sponsors presentations**
12^{00}-12^{15}	**Filio Lanara**, Communication & Marketing Director, Corporate Affairs & Communication General Division MYTILINEOS Energy & Metals Representative of MYTILINEOS Energy & Metals
12^{15}-12^{35}	**Panos Tserolas**, Sustainability Senior Manager of ElvalHalcor's Aluminium Rolling Division **George Georgiadis**, Operational Excellence Manager of ElvalHalcor's Copper and Alloys Extrusion Division ***Aluminium and Copper solutions tailored for sustainable growth***

12^{35}-12^{50}		**Michalis Papasotiriou**, Deputy General Manager of Operations, Hellas Gold
12^{50}-13^{00}		**Honorary Award to Dr. Nikolaos Arvanitidis for his pioneer work in the Development of Mineral Raw Materials in Europe** *Award presented by Mark Rachovides, President Emeritus Euromines, with testaments by friends and colleagues of Dr. Arvanitidis*

13^{00}-14^{30} *Lunch – Poster Session 1*

PARALLEL SESSIONS

SESSION A1
EU Strategy-Circular economy

ROOM 13 *Chair: Antje Wittenberg, Ioannis Paspaliaris*

14^{30}-15^{00}		**Keynote presentation** **Mining wastes as potential sources for critical raw materials**
	KN-01	**Kaj Lax**, Geological Survey of Sweden
15^{00}-15^{15}		**The Jevons Paradox and Vernon's Theory of Product Life Cycle: A Study of Copper and Aluminum Markets**
	O-01	<u>Antonio Alonso-Jimenez</u>, Manuel Regueiro y González-Barros, Enrique Álvarez Areces
15^{15}-15^{30}		**Characterization of waste from the dicalcium phosphate industry as a potential secondary source of YREEs**
	O-02	<u>Marcin Plachciak</u>, Fidel Grandia, Vladimir Roddatis, Marcin Syczewski
15^{30}-15^{45}		**CO_2 utilization in Added-Value Construction Products from Magnesia Production**
	O-03	<u>Guilherme Rubio</u>, David Konlechner
15^{45}-16^{00}		**A Proposal for the use of recycled aggregates in concrete in Greece**
	O-04	<u>Maria Nomikou</u>, Charalampos Kouris, Thalassis Karkaletsis, Vasileios Kaloidas, Efstratios Badogiannis
16^{00}-16^{15}		**Mining Wastes - An integrated thermochemical process for the conversion of multi-layer packaging waste into coal, hydrogen, and chemical flocculating agent**
	O-05	<u>Andrea Salimbeni</u>, Marta Di Bianca, Andrea Maria Rizzo, David Chiaramonti
16^{15}-16^{30}		**Benefits from the incorporation of ICME in the metallurgical industry**
	O-06	<u>Vasileios Loukadakis</u>, Spyros Papaefthymiou

SESSION A2
Minerals Exploration and Resource Characterisation I

ROOM 5 *Chair: Stefanos Kilias, Konstantinos Laskaridis*

14^{30}-15^{00}		**Keynote presentation** **Seabed mining and blue growth: Exploring the potential of marine mineral deposits as a sustainable source of strategic and critical raw materials**
	KN-02	**Francisco Javier Gonzalez**, Geological Survey of Spain

15^{00}-15^{15} Magnetite-hematite characterization at micron scale with implications for metallurgical processing and decarbonisation

O-07 Beate Orberger, Christiane Wagner Raffin, Omar Boudouma, Nicolas Rividi, Christine Bauer, Rebecca Wagner, Ghassem Nabatian, Maryam Honarmand, Iman Monsef

15^{15}-15^{30} Battery Mineral commodities characterisation – A case study for Nickel reference material

O-08 Lorenza Sardisco, Nikolaos Apeiranthitis, Sari Lukkari, Ester Jolis, Pasi Heikkila, Jesal Hirani, Johanna Tepsell, Tim Pearce, Alan Butcher

15^{30}-15^{45} Application of portable spectroscopic tools in the exploration of manganese oxide minerals: the case study of Drama Mn-oxide deposits, Northern Greece

O-09 George Soulamidis, Marjolene Jatteau, Christina Stouraiti, Panagiotis Voudouris, Constantinos Mavrogonatos, Konstantinos Soukis, Cécile Fabre, Marie-Camille Caumon, Jean Cauzid, Alexandre Tarantola

15^{45}-16^{00} Fast and cost-effective quantitative assessment of the chemical and mineral composition of heavy mineral sands ores: an application to the Grande Cote Operation Ti-Zr mine of the new SOLSA combined XRF-XRD analytical solution.

O-10 Maud Herbelin, Sylvain Delchini, Henry Pilliere, Luca Lutterotti, Marion Nicco, Moctar Dia, Monique Le Guen, Thomas Riegler

16^{00}-16^{15} Exploration potential of Cu isotope fractionation in magmatic-hydrothermal Au-rich deposits in the Cyclades continental back-arc: insights from the Aegean Kolumbo submarine arc-volcano

O-11 Nikolaos Zegkinoglou, Stephanos Kilias, Ryan Mathur, Linda Godfrey, Vasilios Pletsas, Paraskevi Nomikou, Nina Zaronikola

16^{15}-16^{30} Assessing CRM's content of abandoned mine sites of Greece.

O-12 Vassiliki Angelatou, Athanasios Exikis, Adamantia Hatziapostolou

SESSION A3
Critical elements recovery from End-of-Life products

ROOM 6 *Chair: Helena Soares, Paschalis Oustadakis*

14^{30}-14^{45} End-of-life mobile phones: re-thinking its recycling based on pillars of circularity and economic and environmental sustainability

O-13 Liliana Martelo, Márcia Silva, Cátia Graça, Marta Azevedo, Adrian Silva, Margarida Bastos, Helena Soares

14^{45}-15^{00} Advances in the bioleaching of copper from end-of-life printed circuit boards

O-14 Alessandro Becci, Alessia Amato, Giulia Merli, José Miguel Rodrìguez Maroto, Francesca Beolchini

15^{00}-15^{15} Integrated production and recycling of silicon for pv application

O-15 Gabriella Tranell, Maria Wallin, Nishan Simkhada, Mathilde Meling, Elif Emil Kaya

15^{15}-15^{30} Indium recovery from solar cell waste by means of layer-by-layer membrane filtration

O-16 Meret Amrein, Michael Thomann, Frank Nüesch, Markus Lenz

15^{30}-15^{45} LCDs screens from smartphones wastes: towards a nearly circular and zero-waste process for recycling Indium plus other raw materials

O-17 Liliana Martelo, Márcia Silva, Hugo Bacelo, Margarida Bastos, Helena Soares

15^{45}-16^{00} **Beneficiation of Critical Metals from fine fraction of End-of-Life printed circuit boards, with the use of Column Flotation Process**
O-18 Kyriakos Syrmakezis, Kostas Tsakalakis

16^{00}-16^{15} **Impact of Extractant Type and pH on Yttrium Recycling from End of Life Fluorescent Lamp**
O-19 Tülay Koç Delice, Gülşah Türker, Hüseyin Eren Obuz; Belma Soydas

16^{15}-16^{30} **Hydrometallurgical recovery of tin from waste Printed Circuit Boards**
O-20 Dimitrios Vlasopoulos, Paschalis Oustadakis, Emmanouella Remountaki, Styliani Agatzini -Leonardou

16^{30}-17^{00} ***Coffee Break - Poster session 1***

SESSION A4
Advances in mineral processing technologies

ROOM 13 *Chair: Kostas Tsakalakis, Georgios Anastasakis*

17^{00}-17^{30} **Keynote presentation**
Evaluation of the processing routes for the "hard lithium" European deposits
KN-03 Lev Filippov, Inna Filippova

17^{30}-17^{45} **Investigation of industrial residues and waste materials to expand the raw material base for the production of lightweight aggregates**
O-21 Jacob Fenner, Andrej Zeller, Steffen Liebezeit, Manuela Knorr, Alexander Schnell, Luka Mettke, Daniel Goldmann

17^{45}-18^{00} **METALLICO EU PROJECT**
O-22 María González-Moya, Ana Lara

18^{00}-18^{15} **The applicability of screening and ore sorting to the beneficiation of low-grade gold ore from Western Australia**
O-23 Bogale Tadesse, Laurence Dyer

18^{15}-18^{30} **On the flotation of sulphide minerals using organosolv lignin as collector**
O-24 Panagiotis Angelopoulos, Nikolaos Kountouris, Georgios Anastasakis, Maria Taxiarchou

SESSION A5
Minerals Exploration and Resource Characterisation II

ROOM 5 *Chair: Kaj Lax, Francisco Javier Gonzalez*

17^{00}-17^{30} **Keynote presentation**
The environmental, social and governance challenges in the Lithium Triangle supply chain
KN-04 Evi Petavratzi, Andrew Hughes, Jonathan Ford

17^{30}-17^{45} **Bauxite Residue deposition in Corinth Gulf, Greece: a potential REE resource**
O-25 Efthymios Douros, Margarita Iatrou, Nikolaos Sofis, Maria Elli Damoulianou, Georgios Papatheodorou, Stavros Kalaitzidis

17^{45}-18^{00} **Rare earth and trace element behaviour in different size fraction in an old uranium mine (centre-north of Portugal)**
O-26 Andres Cardenas Nino, Maria Dias, Rosa Marques, Dulce Russo, Catarina Diamantino, Edgar Carvalho, Fernando Rocha, Maria Cristina Sequeira

18^{00}-18^{15} Mineral exploration at the Kimmeria Fe-skarn deposit, N. Greece: Reassessment and new perspectives focusing on the CRMs
O-27 Konstantinos Laskaridis, Michalis Fitros

18^{15}-18^{30} Mine and mineral exploration projects within the Natura 2000 areas: Case studies from northern Finland
O-28 Toni Eerola, Nike Luodes, Hannu Panttila

SESSION A6
Li-ion Batteries recycling

ROOM 6 — *Chair: Panagiotis Xanthopoulos*

17^{00}-17^{30} Keynote presentation
The COOL-Process – a holistic recycling approach for lithium recovery
KN-05 Sandra Pavon Regana, Alexander Nickol, Sebastian Hippmann, Mareike Partsch, Alexander Michaelis

17^{30}-17^{45} Development of a process for low-cost LFP batteries treatment
O-29 Rafaella - Aikaterini Megaloudi, Alexandros Galanes, Paschalis Oustadakis, Anthimos Xenidis

17^{45}-18^{00} Closed-loop Recycling of Li, Ni, Co, and Mn From Spent NMC Batteries
O-30 Fırat Tekmanlı, Hüseyin Eren Obuz, Bengi Yağmurlu

18^{00}-18^{15} Removal of metal contaminants from LFP black mass leachates
O-31 Ilias Lampropoulos, Daniel Reyes Martinez, Alexandra Thiere, Panagiotis Xanthopoulos, Anthimos Xenidis, Alexandros Charitos

18^{15}-18^{30} Investigation of recycling behaviour of lithium iron phosphate battery batteries with different thermal pre-treatments
O-32 Hüseyin Eren Obuz, Fırat Tekmanlı, Luka Nils Mettke, Marius Müller, Bengi Yagmurlu

18^{30}-18^{45} ***Coffee Break - Poster session 1***

PLENARY LECTURES – Funding Opportunities for Research and Innovation Projects

ROOM 13 — *Chair: Maria Taxiarchou, Vitor Correia*

18^{45}-19^{05} Plenary lecture 6
PL-06 **Dimitrios Biliouris**, Project Adviser for the Health and Digital Executive Agency (HaDEA), European Commission
Horizon Europe raw materials funding opportunities

19^{05}-19^{20} Plenary lecture 7
PL-07 **Antonis Politis,** EIT Raw Materials
EIT RawMaterials. World largest innovation community in the Raw Materials sector

19^{25}-19^{45} Plenary lecture 8
PL-08 **Dina Carrilho**, Senior Science Officer, ERA-MIN3 Project Coordinator
Advances and contributions to the EU Raw Materials policies via Pan-European coordinated funding

20^{00} ***Welcome reception – Zappeion (Peristilio)***

Tuesday 29 August 2023

PARALLEL EVENT - Greece specific issues *(in Greek)*

Greece-specific issues (*in Greek*)

SESSION B1
New raw materials/energy projects in Greece I

ROOM 13 *Chair: Anthimos Xenidis, Peter Tzeferis*

09^{00}-09^{15}	**Αλεξάνδρα Σδούκου,** Υφυπουργός Περιβάλλοντος και Ενέργειας ***Κρίσιμες πρώτες ύλες: Η στρατηγική αυτονομία της χώρας***
09^{15}-09^{30}	**Λάμπρος Μπίσαλας,** Διευθύνων Σύμβουλος της Sunlight Group Energy Storage Systems ***Παραγωγή και ανακύκλωση μπαταριών LFP***
09^{30}-09^{50}	**Μιχάλης Παπασωτηρίου,** Αναπληρωτής Γενικός Διευθυντής Λειτουργιών, Ελληνικός Χρυσός ***Υπό εξέλιξη μεταλλευτικά έργα της Ελληνικός Χρυσός***
09^{50}-10^{10}	**Δημήτριος Κούτρας, Βασίλειος Λάμπος,** ΕΛΛΗΜΕΤ ΑΕ ***Μονάδα παραγωγής μεταλλουργικού πυριτίου*** ***Μονάδα παραγωγής σιδηροχρωμίου υψηλής περιεκτικότητας άνθρακα***
10^{10}-10^{30}	**Κώστας Γάτος**, Διευθυντής QHSE και R&D, ΤΕΡΝΑ ΛΕΥΚΟΛΙΘΟΙ Α.Ε. ***Εξόρυξη και βιομηχανική επεξεργασία μαγνησίτη στη Βόρεια Εύβοια)***

10^{30}-11^{00} ***Coffee Break – Poster session 2***

SESSION B4
New raw materials/energy projects in Greece II

ROOM 13 *Chair: Anthimos Xenidis, Peter Tzeferis*

11^{00}-11^{15}	**Παναγιώτης Δάβρης**, MYTILHNAIOS SA **/**Αλουμίνιο της Ελλάδος ***Δυνατότητες για παραγωγή γαλλίου στην Ελλάδα***
11^{15}-11^{30}	**Χρήστος Σκεύας,** Διευθυντής Ελλάδος, ΕΛΛΗΝΙΚΑ ΟΡΥΚΤΑ ΑΕ ***Το Νέο Έργο μεταλλευτικής έρευνας και εκμετάλλευσης βασικών και κρίσιμων μετάλλων Μολάων Λακωνίας***
11^{30}-11^{45}	**Κωνσταντίνο Λασκαρίδη,** Διευθ. Ορυκτών Πόρων και Μεταλλευτικής-Εθνικό Εκπρόσωπο της Ε.Α.Γ.Μ.Ε. στα EuroGeoSurveys ***Η συμβολή της Ε.Α.Γ.Μ.Ε. στην έρευνα των στρατηγικών και κρίσιμων Ορυκτών Πρώτων Υλών και την εφαρμογή της κυκλικής οικονομίας***
11^{45}-12^{00}	**Ηλιόπουλος Παναγιώτης,** Αντιπρόεδρος ΣΕΜΜΘ, Γεν. Διευθυντής ΜΑΡΜΥΚ ΗΛΙΟΠΟΥΛΟΣ ΑΕ ***Το ελληνικό μάρμαρο στο μέλλον***
12^{00}-12^{15}	**Πελοπίδας Καλλίρης**, Διοικητής της Ειδικής Υπηρεσίας Δίκαιης Αναπτυξιακής Μετάβασης ***Πορεία σχεδίου δίκαιης αναπτυξιακής μετάβασης για τη Δ. Μακεδονία και Μεγαλόπολη***
12^{15}-12^{30}	**Γεώργιος Τσιφουτίδης**, Διεύθ. Ορυκτών Πρώτων Υλών, Υπουργείο Περιβάλλοντος και Ενέργειας, ***Νέος διεθνής διαγωνισμός εκμίσθωσης δικαιωμάτων έρευνας γεωθερμικού δυναμικού***
12^{30}-13^{00}	**Ερωτήσεις -- Συζήτηση**

13^{00}-14^{30} ***Lunch – Poster Session 2***

PARALLEL SESSIONS

SESSION B2
ERA-MIN3 at RawMat2023

ROOM 5 *Chair: Francesca Beolchini*

08:30-10:30 Sustainable Mining, Processing & Production Processes

Exploration

	Critical metals and environmental risks: better understanding to better predict
O-33	Eric Gloaguen, Giada Iacono-Marziano, Pablo Higueras, Alexandre Lima, Fabienne Battaglia, Charles Gumiaux, Axel Aurouet, Daniel Pierre, Romain Augier, Laurent Guillou-Frottier, Johann Tuduri, Anthony Pochon
	Multi-scale and interdisciplinary approaches to the granite-related ore-forming systems in the Segura-Argemela-Panasqueira-Góis belt (Portugal); insights for innovative exploration surveys
O-34	Antonio Mateus, Michel Cathelineau, Colombo Tassinari, Marie-Christine Boiron, Maria Helena Hollanda, Rute Salgueiro, Alexandra Guedes, Patrícia Moita, Alcides Pereira *(online)*
	Regional to Deposit scale exploration (D-Rex) project
O-35	Maxim Smirnov, Jochen Kamm, Graham Hill, Jan Vozar

Sustainable Mining Operations

	The cuttability of carbonate rocks using a new microwave-assisted laboratory cutting machine
O-36	Sair Kahraman, Ramazan Çomakli, Masoud Rostami
	Use of nanobubble technology in the development of next-gen sustainable liquid mining and phytoextraction processes for the recovery critical and strategic metals
O-37	Georgios Kolliopoulos, Nicolas Kalogerakis, Kostas Komnitsas, Quartus Paulus Botha
	Project REVIVING – Bio- Remining mine tailings to the production of critical metals
O-38	Paula Morais, Rita Branco *(online)*

Ore Processing

	The MiCCuR project for improved copper recovery from chalcopyrite
O-39	Mark Dopson
	RETECH - Recovery of rare earth elements from complex ores in Turkey and their potential use in high tech industrial applications
O-40	Belma Soydaş Sözer, Gülşah Türker, Tülay Koç Delic, Arda Temizkalb, Fazlı Cabbar Metin, Halil Yalcın Elerman, Radu-Robert Piticescu, Marius Zlagnean
	Electro-electrodialysis technology on the copper electrorefining operation for the recovery of antimony and recycling of the solution media
O-41	Manuel César Martí-Calatayud, Lorena Hernández-Pérez, Andréa Bernardes, Marco Antonio Rodrigues, Gerardo Cifuentes, Gabriel Riveros, Valentín Pérez-Herranz

Closing cycles in mining and production

	MINECO – New eco-innovative materials for mining infrastructures
O-42	Tiago Miranda, Nuno Cristelo

Tuesday 29 August 2023

REEScue-An Integrated process for the recovery of Rare Earth Elements and Scandium from Bauxite Residues

O-43 Paschalis Oustadakis, Panagiotis Angelopoulos, Maria Georgiou, Ioannis Paspaliaris, Murat Kabataş, Tuğba Selcen Atalay Kalsen, Hakan Burak Karadağ, Yasin Ramazan Eke, Bayram Ünal, Meral Baygül, Gökhan Demir, Sedat Arslan, Panagiotis Davris, Efthymios Balomenos, Gheorghe Dobra, Alina Boiangiu

SMART Geopolymers

O-44 Dinos Sakkas, Silviana Onisei, Hubert Rahier

SESSION B3
Energy and CO_2 storage

ROOM 6 — *Chair: Vassilis Gaganis, Charis Vasilatos*

09^{00}-09^{15} **Carbon dioxide storage in depleted oil fields**
O-45 Georgios Avraam, Konstantinos Vatalis

09^{15}-09^{30} **A unified approach to describe flow dynamics in geothermal energy production systems**
O-46 Stefanos Lempesis, Sofianos Panagiotis Fotias, Vassilis Gaganis

09^{30}-09^{45} **Energy Transition and Evaporitic formations utilization as potential subsurface storage for H_2 and CO_2**
O-47 Spyridon Bellas, Emmanuel Stamatakis, Ioannis Vakalas

09^{45}-10^{00} **Sensitivity of CO_2 flow in production/injection wells in CPG (CO_2 Plume Geothermal) systems**
O-48 Sofianos Panagiotis Fotias, Sofia Stamataki, Vassilis Gaganis

10^{00}-10^{15} **Optimizing Geothermal Energy Extraction in CPG (CO_2 Plume Geothermal) systems**
O-49 Sofianos Panagiotis Fotias, Spyridon Bellas, Vassilis Gaganis

10^{15}-10^{30} **Well Control Strategies for Effective CO_2 Subsurface Storage: Optimization & Policies**
O-50 Ismail Ismail, Vassilis Gaganis

10^{30}-11^{00} ***Coffee Break – Poster session 2***

PARALLEL SESSIONS

SESSION B5
ERA-MIN3 at RawMat2023

ROOM 5 — *Chair: Francesca Beolchini*

11^{00}-13^{00} **Recycling of EoL products and immovable assets e.g. batteries, magnets**

Battery recycling

Challenges and opportunities for recycling of spent lithium ion batteries – a summary of results of the NEXT-LIB project
O-51 Guozhu Ye

Biotechnological recycling and recovery of metals from waste printed circuit boards & spent Li ion batteries- ERAMIN EU BaCLEM Project
O-53 Sandeep Panda, Ata Akcil, Stoyan Gaydardzhiev, Eric van Hullebusch (*online*)

Tuesday 29 August 2023

Magnets and E-Waste

	Recovery of valuable metals from Nd-Fe-B magnet leach liquor using antisolvent crystallization and non-aqueous ion exchange
O-54	Brecht Dewulf, Dženita Avdibegović, Kerstin Forsberg, Srečo Škapin, Koen Binnemans
	Siderophores assisted recovery of Ga, In from the end-of-the life product
O-56	Rohan Jain, Christian Hintersatz, Kun Zheng, Katrin Pollmann, Eric van Hullebusch, Luis Rojas

Minerals Material Cycles

	Evaluation of EOL Materials as SCMs for OPC
O-57	Mehmet Ali GULGUN, Mirijam Vrabec, Saso Sturm, Bogdan Stefan VASILE, Cleva Ow-Yang , Zeynep Başaran Bundur, Adrian Ionut NICOARA, Sorour Samsari Parapari, Yasemin Akyol, Kosar Hassan Nezhad, Otilia Ruxandra VASILE
	ReFina - Novel methods for enhanced recovery of metals and minerals from fine incineration ash
O-58	Héctor Muñiz Sierra, Michal Šyc
	PROPER: New sustainability metrics to improve refractories recycling performances regarding resource use, environmental impacts and economic benefits
O-59	Stephanie Muller, Frédéric Lai, Antoine Beylot, Ambroise Lachat, Tom Huppertz, Elisabeth van Overbeke, Quentin Ricoux

Enabling circular economy

	RedOx Recycling - A new approach for the recovery of gold from E-waste
O-60	Claudio Baldizzone
	LiCoBAT - LIthium and Cobalt recovery from batteries coming from the reverse logistics chain of WEEE
O-61	José Rocha Andrade da Silva
	End-of-life Li-ion Battery Management Integration and Technology Evaluation
O-62	Rudolph van Schalkwyk, Ersin Yazici, Jan Ots, Erik Emilsson, Martina Petranikova, Esra Eken Torunoglu, Alexandra Wu, Hacı Deveci, Guven Akdogan, Louis Louw, Nilay Elginöz Kanat, Roelof Maritz, Dominic Vooght, Theuns Kuhn, Ayse Nur Ozturk, Henric Lassesson, Christie Dorfling

SESSION B6
Environment and Sustainability I

ROOM 6 — *Chair: Nikos Kalogerakis, Ariadne Argyraki*

11^{00}-11^{15}	**Immobilization of Rare Earth Elements and Yttrium (REY) by iron (bio)precipitation in sulphated acid waters from El Bierzo (Spain)**
O-63	Blanca Rincón-Tomás, Francisco Javier Gonzalez, Enrique López-Pamo, Esther Santofimia
11^{15}-11^{30}	**First study of microbial diversity living at Nisyros volcano extreme environment - Future applications**
O-64	Vassiliki Angelatou, Stefano Fazi, Franco Tassi, Orlando Vaselli, Georges Vougioukalakis
11^{30}-11^{45}	**Grain size distribution of rare earth elements in a passive treatment system installed in a legacy polymetallic sulfide mine in Portugal**
O-65	Cynthia Obregón Castro, Isabel Prudêncio, João Carlos Waerenborgh, Bruno Vieira, Dulce Russo, Catarina Diamantino, Edgar Carvalho, Rosa Marques

11^{45}-12^{00} **Long-term assessment of surface cover geochemical characteristics of a treated sulfidic mining waste pile in Lavrion, Greece**

O-66 Ariadne Argyraki, Zacharenia Kypritidou, Khaled Imbrahim

12^{00}-12^{15} **Risk assessment of Metal transportation mechanism from mining source by rainfall runoff as a contribution to the bioaccumulation in seafood**

O-67 Rafi Ullah, Shaikh Mohiuddin

12^{15}-12^{30} **Environmental assessment of replacing fossil fuels with hydrogen for motorized equipment in the mining sector**

O-68 Antonis Peppas, Sotiris Kottaridis, Chrysa Politi, Paschalis Oustadakis

12^{30}-12^{45} **A scenario-based analysis for the selection of post-mining land uses applying a cellular automata model**

O-69 Konstantinos Karalidis, Christos Roumpos, Aikaterini Servou, Nikolaos Paraskevis, Francis Pavloudakis

12^{45}-13^{00} **Towards the exploitation of unconventional heavy oils: Electrostatic technologies for the minimization of dehydration cost**

O-70 Christina Argyropoulou, Vassilis Gaganis, Dimitris Marinakis

13^{00}-14^{30} ***Lunch – Poster Session 2***

PARALLEL SESSIONS

SESSION B7
Mining: Trends and perspectives I

ROOM 13 *Chair: Ioannis Kapageridis, Christos Roumpos*

14^{30}-15^{00} **Keynote presentation**
Mining and Challenges for the Transformation in Energy Sector

KN-06 Carsten Drebenstedt

15^{00}-15^{15} **Evaluation methodology of open pit mine overall slope failure risks**

O-71 Natalija Pavlovic, Branko Petrovic, Tomislav Subaranovic

15^{15}-15^{30} **A Glimpse to a Holistic Approach to Environmental Monitoring of the Kolumbo Submarine Volcano with Implications for Deep Seafloor Mining, Ocean Governance and Policy**

O-72 Stephanos Kilias, Vasilios Pletsas, Nikolaos Zegkinoglou, Paraskevi Nomikou, Theodoros Mertzimekis, Paraskevi Polymenakou, Andreas Gondikas

15^{30}-15^{45} **Narrow Reef Mining (NRE) – innovative mining technology for narrow, sub-horizontal PGE ore bodies**

O-73 Vječislav Bohanek, Luka Petro, Sibila Borojević Šoštarić

15^{45}-16^{00} **Using force field analysis for examining and managing the stakeholders' perceptions in mining projects**

O-74 Francis Pavloudakis, Philip-Mark Spanidis, Christos Roumpos

16^{00}-16^{15} **Application of International Standards to Evaluate the Potential of Sustainable Secondary Production of Tin and Tungsten in Portugal**

O-75 Md Ariful Islam, José Brito Iria, Georg Meißner, George Barakos, Helmut Mischo

16^{15}-16^{30} **Machine Learning Techniques to model and predict airflow requirements in underground mining**

O-76 Maria Karagianni, Andreas Benardos

SESSION B8
ERA-MIN3 at RawMat2023

ROOM 5 *Chair: Pontus Westrin*

14^{30}-16^{30} ERA-MIN SRIA workshop

This workshop aims to collect feedback and expert opinions on the new Strategic Research and Innovation Agenda (SRIA) on raw materials supply for the green and digital transition. The SRIA will serve as a basis for a future international research and innovation partnership within the field of non-energy, non-food raw materials. The workshop discussion will be based on the current draft agenda structure, and focus on identifying technological and structural challenges, as well as research and innovation needs, in six thematic areas:

- *Resilient primary and secondary raw materials supply*
- *Efficient use of raw materials in design and production*
- *Sustainable use and reuse of products*
- *Effective policy development and governance*
- *Maximizing societal benefits*
- *World-class innovation capacity*

See the ERA-MIN website (https://www.era-min.eu/sria) for more information.

SESSION B9
Environment and Sustainability II

ROOM 6 *Chair: Toni Eerola, Antonis Peppas*

14^{30}-14^{45} **Reconciliation conflicting societal objectives: Nature protection vs. raw materials supply resilience**

O-77 Vitor Correia, Eberhard Falck

14^{45}-15^{00} **Assessment of the environmental behavior of phosphogypsum with the application of lab-scale experimentation**

O-78 Georgios Gaidajis, Maria Pliaka

15^{00}-15^{15} **Can We Alleviate the NIMBY Effect?**

O-79 Demetrios Constantinides

15^{15}-15^{30} **Remote Sensing Analysis for Flood Detection in Complex Surface Mining Areas Using Satellite Data**

O-80 Konstantinos Karalidis, Georgios Louloudis, Christos Roumpos, Eleni Mertiri, Francis Pavloudakis

15^{30}-15^{45} **Durability of red-mud concrete pavement slabs**

O-81 Aggeliki Skaropoulou, Konstantinos Tsivolas, Ioanna Angelou, Konstantinos Sakkas, Christos Georgopoulos, Maria Taxiarchou, Efstratios Badogiannis

15^{45}-16^{00}	**Investigation of thermal behavior of cementitious pastes, mortars and concrete- Effect of Closed Structured Expanded Perlite addition**
O-82	Chrysanthi Panagiotopoulou, Maria Taxiarchou, Iliana Douni, Katerina Maliachova, Aggeliki Skaropoulou, Ioanna Angelou, Stratis Badogiannis
16^{00}-16^{15}	**Integrated mine water management system in mixed sulphide mines – case study: Kassandra mines**
O-83	Vithleem Gazea

16^{30}-17^{00} *Coffee Break – Poster session 2*

SESSION B10
Mining: Trends and perspectives II

ROOM 13 — *Chair: Michail Galetakis, Ioannis Kapageridis*

17^{00}-17^{15}	**Artificial Intelligence Engineering System for a Tailings Storage Facility**
O-84	Bartłomiej Bursa, Paweł Stefanek, Paweł Stefaniak, Bartosz Świderski
17^{15}-17^{30}	**Onsite characterisation of magnesite and laterite mining blocks by using novel sensing technologies – An experimental approach**
O-85	Basileios Deligiorgis, Declan Vogt, Ferenc Mádai, Michail Galetakis
17^{30}-17^{45}	**Risk analysis in underground marble quarries using geotechnical data from monitoring equipment**
O-86	Christos Gravalos, Lampros Lamprinidis, Ioannis Kapageridis
17^{45}-18^{00}	**Applying Model-Based Systems Engineering to Tailings Storage Facility Structures**
O-87	Bartłomiej Bursa, Paweł Stefaniak, Ioannis Kakogiannos
18^{00}-18^{15}	**Industry 4.0 roadmap for the mining industry**
O-88	Doris Skenderas, Chrysa Politi
18^{15}-18^{30}	**Machine Learning Based Domaining of a Porphyry Copper-Gold Deposit**
O-89	Ioannis Kapageridis, Agni Patra, Argyro Asvesta, Ioannis Sinatkas
18^{30}-18^{45}	**Transforming decommissioned mines to gravity energy storage system**
O-90	Michail Galetakis, Georgios Biotakis, Basileios Deligiorgis, Emmanouil Varouchakis
18^{45}-19^{00}	**Multi-risk assessment in post-mining lignite areas**
O-91	Dafni Nalmpant-Sarikaki, Alexandros Theocharis, Nikolaos Koukouzas, Andreas Benardos, Ioannis Zevgolis

SESSION B11
Hydrometallurgical processes for metals recovery from EoL and ores

ROOM 5 — *Chair: Sofía Riaño, Efthymios Balomenos*

17^{00}-17^{15}	**Recycling platinum and palladium from autocatalysts: searching for alternative processes combining efficiency with environmental sustainability**
O-92	Hugo Bacelo, Michiel de Brauwer, Liliana Martelo, Helena Soares
17^{15}-17^{30}	**Gold recovery from integrated circuits: proposal of an innovative and greener hybrid process**
O-93	Márcia Silva, Liliana Martelo, Margarida Bastos, Helena Soares

17^{30}-17^{45} **Leaching and recovery of gold from ores using alternative lixiviants to cyanide**
O-94 Maria Taxiarchou, Ioannis Paspaliaris, Nymphodora Papassiopi, Katerina Adam

17^{45}-18^{00} **Solvent extraction for iron removal and HCl recovery from Ni/Co pregnant leach solutions: flowsheet optimization and thermodynamic modelling**
O-95 Brecht Dewulf, Rayco Lommelen, Koen Binnemans, Sofía Riaño

18^{00}-18^{15} **Gold recovery from refractory auriferous sulphides applying the Platsol Process**
O-96 Nymphodora Papassiopi, Paschalis Oustadakis, Panagiota Georgopoulou, Evangelia Mylona, Maria Taxiarchou, Ioannis Paspaliaris, Katerina Adam

18^{15}-18^{30} **An innovative approach for the crystallization of battery grade cobalt sulfate**
O-97 Luka Nils Mettke, Marius Müller, Bengi Yağmurlu

18^{30}-18^{45} **Recovery of antimony from alkaline sulphide leaching solutions**
O-98 Marianna Stathogianni, Rafaella - Aikaterini Megaloudi, Paschalis Oustadakis, Anthimos Xenidis

SESSION B12
OSH and EPD Reporting

ROOM 6 *Chair: George Barakos, Katerina Adam*

17^{00}-17^{30} **Keynote presentation**
Occupational Health and Safety in industry-improvements and perspectives
KN-07 Rena Bardani

17^{30}-17^{45} **The experience on the implementation of Risk Management in OSH and environmental issues in the extractive companies**
O-99 Petros Maraboutis, Niki Iliana Poulimenou, Elena Nikolaou

17^{45}-18^{00} **Piloting the establishment of soil geochemical baselines for Potentially Toxic Elements (PTEs) in Greece- Preliminary results from Attica and Boeotia**
O-100 Artemis Kontomichalou, Alexandros Liakopoulos, Ariadne Argyraki, Zacharenia Kypritidou, Fotini Botsou, Antonis Vlastos

18^{00}-18^{15} **Evaluation of occupational health and safety issues in coal mining Industry**
O-101 Petkani Zoi, Vatalis Konstantinos

18^{15}-18^{30} **Understanding the Social License to Operate from a Cultural Perspective: The case studies of Australia, Greece, and India**
O-102 Chrysanthi Rodolaki, George Barakos

18^{30}-18^{45} **EPD reporting in the metal and mineral sector**
O-103 Maria Vastardi, Eugenia Filtikaki, George Mavraganis, Katerina Adam

18^{45}-19^{00} **Sustainability Reporting in the Raw Materials Industry**
O-104 Eugenia Filtikaki, Maria Vastardi, Katerina Adam

20^{00} *Gala dinner*

Wednesday 30 August 2023

PLENARY LECTURES

ROOM 13 — *Chair: Anthimos Xenidis, Petros Koutsovitis, Stavros Kalaitzidis*

09^{30}-10^{00}	**Plenary lecture 9**
	Gian Andrea Blengini, Politecnico di Torino
PL-09	***From List of Critical Raw Materials to List of critical projects***
10^{00}-10^{30}	**Plenary lecture 10**
	Slavko Solar, United Nations Economic Commission for Europe (UNECE) Sustainable Energy Division
PL-10	***The Application of United Nations Framework Classification for Resources (UNFC) to European Mineral Deposits***

10^{30}-11^{00} ***Coffee Break – Poster session 3***

PARALLEL SESSIONS

SESSION C1
Critical metals recovery from mining/metallurgical waste

ROOM 13 — *Chair: Angel Lopez-Buendia, Dimitris Panias*

11^{00}-11^{05}	**PROMETIA: innovation and sustainability in mineral processing, extractive metallurgy & recycling**
	Patrick d'Hugues, PROMETIA chairman & Director of the Mineral Resources and Circular Economy Programme at BRGM
11^{05}-11^{30}	**Keynote presentation**
	Holistic valorisation of bauxite residue: Results from pilots demonstrations
KN-08	**Efthymios Balomenos**, Mytilineos SA
11^{30}-11^{45}	**Efficient Use of Sulfuric Acid in Bauxite Residue Leaching**
O-105	Aikaterini Toli, Danai Marinos, Maria Psoma, Dimitrios Kotsanis, Panagiotis Davris, Efthymios Balomenos, Dimitrios Panias
11^{45}-12^{00}	**HCl- based leaching method for extracting Ni/Co from ore deposits and tailings**
O-106	Seyedehmaryam Sadeghi, Sofía Riaño, Koen Binnemans, Stylianos Tampouris, Vitalis Chipakwe
12^{00}-12^{15}	**Microwave roasting of bauxite residues**
O-107	Angel Lopez-Buendia, Eduardo Brau, Efthymios Balomenos
12^{15}-12^{30}	**Alumina and iron recovery from the BR-Ca reduced pellets by simultaneous magnetic separation and alkali leaching**
O-108	Manish Kumar Kar, Jafar Safarian, Casper van der Eijk
12^{30}-12^{45}	**Recovery of copper and zinc from ash from incinerated municipal waste**
O-109	Ragnhild Dirdal, Aslak Skåra, Erik Nedkvitne, Jon Omtvedt, Dag Ø Eriksen
12^{45}-13^{00}	**Unlocking the Potential of Bauxite Residue: A Comparative Exergy Analysis of Emerging Valorisation Techniques**
O-110	Eleni Mikeli, Efthymios Balomenos, Dimitrios Panias

SESSION C2
Substitution and Recycling of Critical Raw Materials in the Automotive Sector - The Industrial Perspective

ROOM 5 — *Chair: Iakovos Yakoumis*

11^{00}-11^{15} **Raw Materials Act - opportunities in recycling and substitution for Industry, from Innosup Mine The Gap, to I3 and Regional Innovation Valleys**
O-111 Santiago Cuesta Lopez, Icamcyl, Spain

11^{15}-11^{30} **Promoting Sustainable Value Chains: Ford Otosan's Approach to Critical Raw Materials Recovery**
O-112 Mehmet Celik, Ford Otosan, Turkey

11^{30}-11^{45} **Recycling of lithium ferrophosphate (LFP) batteries in Greece**
O-113 Panagiotis Xanthopoulos, Sunlight Energy Group, Greece

11^{45}-12^{00} **Recovering and Substituting of Noble Metals from Fuel Cells and Electrolyzers**
O-114 Christos Chochos, Advent Technologies, Greece

12^{00}-12^{15} **Recovering and Substituting of Rare Earth Elements from Permanent Magnets**
O-115 Milana Karajic, Magneti, Slovenia

12^{15}-12^{30} **Recovering of Critical Raw Materials from Electric and Electronic Devices**
O-116 Teresa Sessa, TREEE, Italy

12^{30}-12^{45} **Universal Hydrometallurgical Up-Scaled Process for Recovering Critical and Strategic Materials from Automotive EoL Streams**
O-117 Anastasia-Maria Moschovi, Monolithos Catalysts & Recycling Ltd., Greece

12^{45}-13^{00} **Roundtable discussion**

SESSION C3
Industrial minerals and Waste reuse - valorisation I

ROOM 6 — *Chair: Charis Vasilatos, Kostas Komnitsas*

11^{00}-11^{30} **Keynote presentation**
Pathways towards Sustainability and Decarbonisation in the Construction Industry: The Role of Industrial Minerals and Geopolymers
KN-09 Maria Taxiarchou, National Technical University of Athens

11^{30}-11^{45} **Factors affecting the properties of slag-based alkali activated materials**
O-118 Kostas Komnitsas, Vasiliki Karmali, Dimitra Vathi, Lefteris Kaklamanos

11^{45}-12^{00} **Composite lightweight materials with upgraded physicochemical functionality and improved economic feasibility**
O-119 Antonia Ekonomakou, Xenofon Simos, Ioanna Kitsou, Michaela Papageorgiou, Maria Eleni Mamassi, Theodoros Gikarakis, Achilleas Amanatidis, Georgios Anastasakis, Athena Tsetsekou

12^{00}-12^{15} **Creating public acceptance in building products made from metallurgical wastes**
O-120 Efthymios Balomenos, Nikolaos Patsavos, Alexandros Peteinarelis, Panagiotis Davris, Grigorios Paschalis

12^{15}-12^{30} **Li extraction from a-spodumene concentrate by carbonizing calcination**
O-121 Katerina Maliachova, Nikos Doukas, Danai Tsakiri, Michail Samouhos, Lefkothea Sakellariou, Iliana Douni, Maria Taxiarchou, Ioannis Paspaliaris

12^{30}-12^{45} **Crystalline and Amorphous Phases in Fe-Rich Slags: Implications for As and Sb leaching Behaviour**
O-122 Konstantina Koukouza, Glenn Beersaerts, Valérie Cappuyns, Yiannis Pontikes

12^{45}-13^{00} **Eco-friendly composites – environmental assessment of mine tailings based geopolymers**
O-123 Kinga Korniejenko, Beata Figiela, Michał Łach, Barbara Kozub

13^{00}-14^{30} *Lunch – Poster Session 3*

PARALLEL SESSIONS

SESSION C4
Magnets and REEs

ROOM 13 *Chair: Kerstin Forsberg, Stavros Kalaitzidis*

14^{30}-14^{45} **High-performance solid phase extraction chromatography for recycling of NdFeB magnet waste.**
O-124 Tiaan Punt, Kerstin Forsberg, Michael Svärd

14^{45}-15^{00} **Advancing sustainable magnets for electric mobility and renewable energy: Innovating processing and recycling routes for Nd-Fe-B permanent magnets**
O-125 Kristina Žužek, Tomaž Tomše, Mihaela Rebernik, Sina Khoshsima, Amit Mishra, Sorour Semsari Parapari, Spomenka Kobe, Laurence Schieren, Carlo Burkhardt, Sašo Šturm

15^{00}-15^{15} **Process mineralogy applied to mineral processing for the development of REE deposits**
O-126 Tassos Grammatikopoulos, Stavros Kalaitzidis

15^{15}-15^{30} **Investigation and Optimization of the Chemical and Operational Parameters of the Stripping Process Using Oxalic Acid to Recycle REEs from Permanent Magnets**
O-127 Soroush Rahmati, Ionela Birloaga, Francesco Vegliò

15^{30}-15^{45} **Potential application of modified diglycolamide resin For Rare Earth Element extraction**
O-128 Junnile Romero, Carlito Tabelin, Ilhwan Park, Richard Alorro, Leaniel Silva, Joshua Zoleta, Takunda Mandu, Kosei Aikawa, Mayumi Ito, Steffen Happel, Naoki Hiroyoshi, Vannie Joy Resabal

15^{45}-16^{00} **Recovery of Scandium from industrial acidic solutions through ion-exchange**
O-129 Eleni Mikeli, Aikaterini Toli, Danai Marinos, Efthymios Balomenos, Dimitrios Panias

16^{00}-16^{15} **Utilization of graphite industrial wastes for the sustainable production of silicon carbide**
O-130 Charikleia Vourgidi, Ioanna Giannopoulou, Apostolos Kourtis, Maria Magganiari, Anthimos Xenidis

16^{15}-16^{30} **Securing the supply chain for rare earth polymer-bonded magnets by recycling**
O-131 Iliya Radulov, Eva Brouwer, Jan Leitloff, Jürgen Gassmann, Cyril Aymonier, Guido Sonnemann, Benjamin Balke, Anke Weidenkaf

SESSION C5
Energy transition metals - ENICON & EXCEED HE projects

ROOM 5 *Chair: Kostas Komnitsas*

14^{30}-14^{40} **Energy transition metals: Future demand and low carbon processing technologies**
O-132 Kostas A Komnitsas, Ilias Lazos, Toni Eerola

14^{40}-14^{55} **Challenges in Li minerals recovery from different deposits**
O-133 Lev Filippov

14^{55}-15^{10} **Exploring barriers to the implementation of circular economy processes for batteries**
O-134 Vasileios Rizos, Patricia Urban

15^{10}-15^{25} **Preliminary assessment of the social license to operate in four European lithium projects**
O-135 Toni Eerola, Kostas Komnitsas

15^{25}-15^{40} **Strategic and critical raw materials in the battery supply chain - skills, education and training**
O-136 Kulczycka Joanna

15^{40}-15^{50} **Round table discussion including representatives from Larco, Euronickel and Sunlight**

15^{50}-16^{00} **Q and A**

SESSION C6
Reuse-Recycling and Valorisation II

ROOM 6 *Chair: Clive Mitchell, Vasilis Melfos*

14^{30}-14^{45} **Fuelling the Foundation Industries: discovering the hidden value of mineral waste in the UK**
O-137 Clive Mitchell

14^{45}-15^{00} **EcoGlassFab: Eco-Glass-Fabrication from the assembly of secondary precursors**
O-138 Sophie Schuller, Kahina Hamadache, Frédéric Angeli, Frederic Goettmann, Benoit Darbouret, Frédéric Boisumeau

15^{00}-15^{15} **Valorizing mineral wool ash as a supplementary cementitious materials**
O-139 Tolga Aydin, Zeynep Başaran Bundur, Kaan Aksoy, Turker Ince, Ezgi Perin, Baris Karabiyik, Mihriban Sari

15^{15}-15^{30} **Microwave chemistry for enhanced carbon capture by serpentine quarry waste**
O-140 Marcello Campione

15^{30}-15^{45} **Effect of by-pass filter dust on durability of self-compacting concrete**
O-141 Andreas Kounadis, Konstantinos Tsivolas, Efstratios Badogiannis

15^{45}-16^{00} **How to convert your waste into a resource?**
O-142 Duane Runciman, Matt Dey

16^{00}-16^{15} **Valorisation of aplite in alkali-activated materials**
O-143 Georgia Maria Tsaousi, Georgia Flessoura, Dimitrios Panias

16^{15}-16^{30} **Optimization of the demolition waste incorporation to cement mortar by response surface methodology**
O-144 Ikbel Bejaoui, Halim Hammi, Khaoula Mkadmini, Rym Abidi

16^{30}-17^{00} ***Coffee Break – Poster session 3***

PARALLEL SESSIONS

SESSION C7
Advanced metallurgical processes

ROOM 13 *Chair: Casper van der Eijk, Dimitris Panias*

17^{00}-17^{30} **Keynote presentation**
The possibilities and limitations of the use of hydrogen in different metallurgical sectors
KN-10 Casper van der Eijk, Jafar Safarian, Halvor Dalaker

17^{30}-17^{45} **Isothermal Pre-reduction behaviour of Nchwaning Manganese Ore in H_2 atmosphere**
O-145 Alok Sarkar, Trygve Lindahl Schanche, Jafar Safarian

17^{45}-18^{00} **Optimization of Fe, Al, and Na recovery from H_2 Reduced Bauxite Residue (Red mud) using Response surface methodology (RSM)**
O-146 Ganesh Pilla, Tobias Hertel, Bart Blanpain, Yiannis Pontikes

18^{00}-18^{15} **Contribution to the optimization of the smelting reduction of nickeliferous laterites, based on the recent industrial experience.**
O-147 Charalabos Zografidis, Konstantinos Betsis

18^{15}-18^{30} **Exploring the leaching potential of lemonitic laterites with nitrate solutions**
O-148 Iraklis Varsamos, Paschalis Oustadakis, Konstantinos Betsis, Anthimos Xenidis

18^{30}-18^{45} **Aluminothermic reduction of iron and titanium from metallurgical wastes**
O-149 Dimitris Sparis, Efthymios Balomenos, Dimitrios Panias

18^{45}-19^{00} **Wastes from olive oil production as a perspective component for biocoke production**
O-150 Małgorzata Wojtaszek-Kalaitzidi, Michał Rejdak, Michał Książek, Sten Yngve Larsen, Stavros Kalaitzidis

SESSION C8
Critical metals sourcing - Experts Panel Discussion

ROOM 5 *Moderators: Thymis Balomenos, Beate Orberger*

17^{00}-19^{00} **How can EU Critical Raw Materials extraction from waste or low-grade ore compete with Asian production?**

Industrial Minerals: The sleeping giant of European CRM resources?
O-152 Anastasios Kladis, AdMiRIS

Waste to resource - secondary resourcing from waste
O-153 Duane Runciman, Mures Magnesium Srl.

Gallium Supply Chain - EU Resilience
O-154 Stefan Eichler, Freiberger Compound Materials

A European Stockpile Organization is a must have for Europe to reduce its supply disruptions for Critical Materials
O-155 Henk Van der Laan, VIC

SESSION C9

Education

ROOM 6 — *Chair: George Barakos, Maria Menegaki*

17^{00}-17^{30}	**Keynote presentation**
	European Universities and New Tools in the Raw Materials Education
KN-11	**Katerina Adam,** National Technical University of Athens
17^{30}-17^{45}	**TIMREX – an EIT labelled master programme in innovative mineral exploration**
O-156	Sibila Borojević Šoštarić, Ferenc Madai, Gabriela Paszkowska, Nils Jansson
17^{45}-18^{00}	**Integrated Mine Planning Education for the Modern Engineer**
O-157	Ioannis Kapageridis, Kyros Koios
18^{00}-18^{15}	**The interactive advancement of the Australian Mining Industry and Academia toward the sustainable supply of critical raw materials**
O-158	George Barakos, Danielle Thompson, Michael Hitch
18^{15}-18^{30}	**Program for achieving progress in transfer the science to business developed within teaching project for staff at Eastern and Southeastern European universities**
O-159	Malwina Kobylańska, Agnieszka Urbańska-Ciszek
18^{30}-18^{45}	**Discussion on Knowledge Gaps in Mining Operations: Empirical Evidence from the Greek Mining Industry**
O-160	Philip-Mark Spanidis, Francis Pavloudakis, Christos Roumpos
18^{45}-19^{00}	**EIT Deep Tech Talent Initiative**
O-161	Francesca Barisani, Cross-KIC Outreach and Stakeholder Manager, EIT RawMaterials

19^{00} Closing ceremony-Awards

Wednesday 30 August 2023

POSTER SESSION 1

EU Strategy on Circular economy / Mineral exploration and characterization / Mineral Processing / EoL products / LiBs

Monday 28 August 2023 *ROOM 16*

P1-01 **Effect of thermal treatment on flotation and leaching in EV lithium-ion battery recycling**
Marius Müller, Luka Nils Mettke, Bengi Yagmurlu

P1-02 **Effect of freeze-thaw cycles on the flexural strength of Greek natural stones**
Konstantinos N Laskaridis, Angeliki Arapakou

P1-03 **Structural and electrochemical characterization of Natural Manganese Oxides from Drama Mn-oxide Deposits of Greece**
George Soulamidis, Christina Stouraiti, Harilaos Tsikos, Maria Kourmousi, Eleni Charalampous, Christiana Mitsopoulou

P1-04 **Mineralogical and geochemical constrains of the critical and rare metals in the vein-type mineralization at the Vertiskos unit, northern Greece**
Christos Stergiou, Grigorios Aarne Sakellaris, Vasilios Melfos, Panagiotis Voudouris

P1-05 **Sustainable blue economy as a supplier of Strategic and Critical Raw Materials**
Fani Sakellariadou, Francisco Javier Gonzalez, James Hein, Blanca Rincón-Tomás, Nikolaos Arvanitidis, Thomas Kuhn

P1-06 **The suitability of mafic volcanics from the island of Patmos for acidic water purification applications: Report on initial experimental results**
Efi Kosti, Natalia Aggelopoulou, Petros Koutsovitis, Christina Lazaratou, Alkiviadis Sideridis, Petros Petrounias, Dimitrios Papoulis

P1-07 **The Hydrogeological Conditions as a Crucial Factor for Creating Pit Lakes. The Case of Kyparissia Mine in Megalopolis, Greece.**
Georgios Louloudis, Christos Roumpos, Eleni Mertiri, Georgios Kasfikis, Eleni Vasileiou

P1-09 **Magmatic controls on Zr-Ti-U-Th-REE enrichment in potassic mafic-intermediate rocks and evaluation of their economic significance**
Charalampos Vasilatos, Angeliki Papoutsa

P1-10 **Application of magnetic geophysical survey for the identification of buried bauxite deposits in Fokis, Central Greece.**
Panagiotis Zachariadis, Armand Dubus, Emmanuel Pizzo

P1-11 **Application of MCDM methods in mineral processing – a review**
Zoran Štirbanović, Dragiša Stanujkić, Jovica Sokolovic, Ivana Ilić

P1-12 **Mineral characterization of Ni-Co sulphide ores and tailings from Kevitsa Mine, Finland**
Nivea Magalhaes, Hannah Hughes, Jens Andersen, Richard Crane, Fernando Prado Araújo, Philippe Muchez

P1-13 **Mapping the soil chemical properties of the Sarigkiol Basin, Western Macedonia, Greece, in the view of the transition to the post-lignite era**
Despoina Psarraki, Panagiotis Papazotos, Eleni Vasileiou, Maria Perraki

P1-14	**The Controlled-source Audio-frequency Magnetotellurics (CSAMT/AMT) method tested in the search for deep Fe-Skarn mineralization at Kimmeria, Xanthi, N. Greece** Petros Karmis, Magdalini Angeli, Dimitrios Tsouvalas, Constantinos Mavrogonatos, Michalis Fitros, Marianthi Anastasatou, Adamantia Chatziapostolou, Konstantinos Laskaridis
P1-15	**Recycling concrete to aggregates. Implications on CO_2 footprint** Ioannis Bampanis, Charalampos Vasilatos
P1-16	**Circular Economy for Critical Raw Materials in India** Anjali Singh
P1-17	**Investigating the recovery of noble metals from single-use medical technology specific waste streams** Kokkinos Evgenios, Merachtsaki Domna, Lampou Angeliki, Prochaska Charikleia, Peleka Efrosyni, Konstantinos Simeonidis, George Vourlias, Zouboulis Anastasios
P1-18	**Granulometric, chemical, and mineralogical evaluation of Greek lignite bottom ash for potential utilization in the concrete manufacturing** Argyro Asvesta, Ioannis Kapageridis, Agapi Vasileiadou, Kyros Koios, Nikolaos Kantiranis
P1-19	**A comparative study on the properties of volcanic rocks from Aegean islands, Greece, for utilization as pozzolanic additives in cement** Theodoros Sainis, Glikeria Kakali, Panagiotis Pomonis, Charalampos Vasilatos
P1-20	**Hydrometallurgical pilot plant reconfiguration for the recycling of automotive waste for the recovery of precious and critical metals: H2020 Treasure project** Pietro Romano, Nicolò Maria Ippolito, Marco Passadoro, Valentina Innocenzi, Hossein Shalchian , Giorgio Pellei, Ionela Poenita Birloaga, Francesco Ferella, Francesco Vegliò
P1-21	**SEMACRET-Geophysical exploration of magmatic ore deposits** Isla Fernández, Andrea Viezzoli, Elena Kozlovskaya, Shenghong Yang, Vojtěch Wertich, Ana Patricia Jesus, Olga Rosowiecka

POSTER SESSION 2

Mining, Energy Environment and Sustainability, Hydrometallurgical Processes

Tuesday 29 August 2023 *ROOM 16*

P2-01	**Geochemical and limnological characterization of the Corta Atalaya pit lake (Riotinto mines, Spain)** Esther Santofimia, Blanca Rincón-Tomás, Enrique López-Pamo, Francisco Javier Gonzalez, Ricardo Amils
P2-02	**Preliminary Environmental Assessment of Carbonated Slags as a CCUS in Agricultural Applications** Ponnapat Watjanatepin, Laura Steinwidder, Anthony de Schutter, Giuseppe Granata, Sara Vicca, Tom Van Gerven, Karel Van Acker
P2-03	**Evolution of alluvial gold mining technologies** Spyridon Mathioudakis, George Xiroudakis, Evangelos Petrakis, Emmanouil Manoutsoglou

P2-04	**Capacity of Nerium oleander to phytoremediate mining spoils assisted by air nanobubbles and biochar** Petroula Seridou, Vasiliki Karmali, Evdokia Syranidou, Anna Kritikaki, Kostas Komnitsas, Georgios Kolliopoulos, Nicolas Kalogerakis
P2-05	**Extractive waste management in coal surface mining projects - A circular economy approach** Ariadni Sokratidou, Christos Roumpos, Nikolaos Paraskevis, Aikaterini Servou, Francis Pavloudakis
P2-06	**Dynamic adsorption of Pb by Fe-Mg clay–quartz beds using micro-columns** Zacharenia Kypritidou, Maria-Anna Gatou, Ariadne Argyraki, Vasileios Zotiadis
P2-07	**Potential use of leaching gravel as a raw material to the preparation of geopolymeric material as an alternative to conventional cement materials** Arturo Reyes Roman, Francisca Balarezo Olivares, Daniza Castillo, Francisco Arriagada, Miguel Maulen Tapia
P2-08	**Alluvial gold mining from Argonauts to Agricola** Spyridon Mathioudakis, George Xiroudakis, Evangelos Petrakis, Emmanouil Manoutsoglou
P2-09	**A Review about the methods and techniques for evaluating the waters and soils in mining regions.** Ioanna Petropoulou, Maria-Sotiria Frousiou, Eleni Vasileiou
P2-10	**Groundwater monitoring system based on Arduino platform and IIoT platform** Marcin Paterek
P2-11	**Face Mapping in Open Pit Mines-A new approach** Agni Patra, Konstantinos Pilalidis, Francis Pavloudakis, Ioannis Kapageridis
P2-12	**Potential benefits from Carbon Capture Utilisation and methanol production in magnesite processing line** Antonis Peppas, Doris Skenderas, Chrysa Politi, Dimitris Sparis
P2-13	**Potential application of RES and underground $_{H2}$ storage in abandoned mines** Antonis Peppas, Sotiris Kottaridis, Chrysa Politi
P2-14	**Prediction of hydrate dissociation conditions in natural/acid/flue gas streams in the presence and absence of inhibitors** Ismail Ismail, Vassilis Gaganis
P2-15	**Evaluation of an iron nanocomposite material for heavy metals removal under flow conditions** Christiana Mystrioti, Nymphodora Papassiopi, Anthimos Xenidis
P2-16	**Manganese Recovery from Nickel and Cobalt Production Facility MHP Leach Waste** Fırat Tekmanlı, Bengi Yağmurlu, Hüseyin Eren Obuz
P2-17	**An innovative approach for the recovery of cobalt sulfate from battery leach solutions by anti solvent crystallization** Luka Nils Mettke, Marius Müller, Bengi Yagmurlu
P2-18	**Raw materials and circular economy: bioelectrochemical copper removal and recovery from wastewater** Hyusein Yemendzhiev, Valentin Nenov
P2-19	**Evaluation of thiosulphate for gold recovery from pressure oxidation residues** Christiana Mystrioti, Konstantina Kousta, Nymphodora Papassiopi, Katerina Adam, Maria

	Taxiarchou, Ioannis Paspaliaris
P2-20	**Hydrometallurgical recovery of EoL LFP batteries using oxalic acid as lixivient** Rafaella - Aikaterini Megaloudi, Nikos Konsolas, Paschalis Oustadakis, Anthimos Xenidis
P2-21	**Leaching of Bauxite Residues from Turkish, Greek and Romanian Plants Using Concentrated Sulphuric and Hydrochloric Acids for Potential Application in an Industrial Recovery Plant** Murat Kabataş, Tuğba Selcen Atalay Kalsen, Hakan Burak Karadağ, Yasin Ramazan Eker, Bayram Ünal, Panagiotis Angelopoulos, Paschalis Oustadakis, Ioannis Paspaliaris, Meral Baygül, Gökhan Demir, Sedat Arslan, Panagiotis Davris, Efthymios Balomenos, Gheorghe Dobra, Alina Boiangiu
P2-22	**Unlocking the potential of intermediate type C2 laterites through nitrate leaching: Investigating leaching behavior for efficient metal recovery** Ioannis Varsamos, Paschalis Oustadakis, Rafaella - Aikaterini Megaloudi, Anthimos Xenidis
P2-23	**Acid Leaching of Cu/Fe polymetallic alloy: Process alternatives & Challenges** Michail Vafeias, Amalia Bempelou, Dimitrios Panias

POSTER SESSION 3

Industrial Minerals, Reuse and Valorisation, Advances in Metallurgy, Education

Wednesday 30 August 2023 ***ROOM 16***

P3-01	**RIS Internship – sustainable and structured internship programme for RawMaterials master students and organization from RIS regions** Sibila Borojević Šoštarić, Kristina Koret, Vječislav Bohanek, Ferenc Madai
P3-02	**Thermal treatment of serpentinized olivine wastes, obtained from chromite mineral enrichment operations, as an example of circular economy in the mining sector** Evgenios Kokkinos, Peleka Efrosyni, Zouboulis Anastasios
P3-03	**Recovery of Critical Raw Materials from abandoned mine waste, some potential case studies in North-Western Italy** Gabriele Baldassarre, Adriano Fiorucci Paola Marini
P3-04	**Electric Arc Furnace Dust vitrification via soda-lime recycled glass** Andronikos Maris, Dimitra Ioannidou, Ilias Sammas, Stavros Deligiannis, Petros Tsakiridis
P3-05	**Using natural and synthetic zeolites for polluted soils clean-up** Charalampos Vasilatos, Maria Roulia
P3-06	**Optimization of the demolition waste incorporation to cement mortar by response surface methodology** Ikbel Bejaoui, Halim Hammi, Khaoula Mkadmini, Rym Abidi
P3-07	**Recovery of stainless steel from end-of-use dishwashers** Eirini Evangelou, Georgios Anastassakis, Spyridon Karamoutsos, Athanasios Stergiou
P3-08	**ARTeMIS – A European training-through-research program for exploration geologists** Alexandre Tarantola, Jean Cauzid, Marie-Camille Caumon, Cécile Fabre, Rasool Mehdizadeh, Panagiotis Voudouris, Christina Stouraiti, Konstantinos Soukis, Constantinos Mavrogonatos, Karsten Haase, Manuel Keith, Vasilios Melfos, Alexandros Chatzipetros, Grigorios-Aaarne Sakellaris, Janja Mihajlovic, Tim Baker, Olivier Dossmann, Cedric Gavier

P3-09 **Utilization of an industrial waste for the development of fire resistant geopolymers**
Konstantinos Sakkas, Christos Georgopoulos, Yiannis Makrigiannis, Efthymios Balomenos, Panagiotis Davris

P3-10 **Empowering Students for the Future: Enhancing Soft Skills through non-formal educational paths**
Vasileios Loukadakis, Doris Skenderas, Nicolas Antoniadis, Eva Stachouli, Magdalini Mylona

P3-11 **Preliminary study of low cost raw materials for new syntheses of geopolymers targeting environmental applications.**
Marina Christopoulou, Paraskevi Lampropoulou, Petros Petrounias, Aikaterini Rogkala, Panagiota Giannakopoulou, Petros Koutsovitis, Dionisios Panagiotaras, Nikolaos Koukouzas

P3-12 **Sustainable Valorisation of Quarry Waste from Granite Ornamental Rocks for Extracting Critical Raw Materials**
Antonello Aquilano, Valeria Indelicato, Elena Marrocchino, Rosalda Punturo, Carmela Vaccaro

P3-13 **Techno-environmental assessment of novel pathways of red mud waste use to improve extraction efficiency of valuable metals**
Monika Vitvarova, David Novacek, Shareq Nazir, Frederico Marques Penha, Onuralp Yucel, Pedro Cabral De Souza, Efthymios Kantarelis, Filiz Sahin, Kağan Benzeşik, Adela Svobodova, Rafael Rodriguez Trias, Arif Karaca, Ilayda Ozbag, Ahmet Turan, Sergei Preis, Selçuk Kan, Camila Barreneche Guerisoli, Umay Çınarlı

P3-14 **Environmental Footprints of Bauxite alternatives for Alumina production - regional characteristics in Central Europe and Turkey,**
Monika Vitvarova, Kamila Milnerova, David Novacek, Ahmet Turan, Selcuk Kan, Frantisek Pticen, Stanislav Kapr, Dita Cerna, Umay Çınarlı, Camila Barreneche Guerisoli, İlayda Özbağ, Onuralp Yucel, Kagan Benzesik, Hasan Guney, Filiz Sahin, Arif Karaca, Adela Svobodova

P3-15 **Re-use of historical thermal plant ash deposits as supplementary cementing materials**
Bogdan Vasile, Adrian Nicoara, Arian Surdu, Ovidiu Oprea, Roxana Trusca, Mehmet Gulgun, Zeynep Başaran Bundur, Saso Sturm, Sorour Parapari, Otilia Vasile, Mirijam Vrabec

P3-16 **BR valorisation with enhanced Al extraction by hydrothermal conversion of hematite to magnetite**
Paschalis Oustadakis, Panagiotis Angelopoulos, Maria Georgiou, Georgios Anastasakis, Ioannis Paspaliaris, Michael Pissas

P3-17 **Limonitic laterite reduction with hydrogen**
Evangelos Palavos, Michail Samouhos, Dimitrios Kotsanis, Eamonn Devlin, Georgios Pillatos, Antonis Peppas, Anthimos Xenidis

P3-18 **Use of aluminium scrap for the production of high-quality recycled aluminum products. Design and production control criteria -The project DeReAL**
Vasileios Akrivos, Ilias Georgiopoulos, Anastasios Triantafyllou, Grigorios Paschalis, Constantina-Dia Andreouli

P3-19 **Assessment of hand-held XRF analyser performance for the characterization of aluminium scrap**
Michail Galetakis, Angeliki Ntourntoureka, Basileios Deligiorgis

Monday 28 August 2023

ROOM 13

SESSION A1

EU Strategy – Circular economy

Chair: A. Wittenberg, I. Paspaliaris

Mining wastes as potential sources for critical raw materials
KN-01

Kaj Lax

Geological Survey of Sweden

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Mining waste is sometimes described as a potential resource that can be used as a complimentary source of raw materials, or even replace primary resources, especially for the long list of raw materials needed for the transition to a low carbon dioxide society. Many of these commodities are listed as critical and/or strategic in the critical raw materials act currently processed by the European Union. The Geological Survey of Sweden has carried out a series of projects during the last decade to better understand the potential of mining waste as a resource, with a special focus on such raw materials. The results show that while there is some potential for some of the metals and minerals, there are several problems connected to usage of mining waste as a resource, ranging from technical to legal. Given that the assumption that the situation in Sweden is valid also elsewhere and that the projected demand for raw materials is correct, it is obvious that while mining waste has the potential to contribute, it cannot replace the need for mining.

The Jevons Paradox and Vernon's Theory of Product Life Cycle: A Study of Copper and Aluminum Markets

O-01

Antonio Alonso-Jimenez[1], Manuel Regueiro y González-Barros, Enrique Álvarez Areces[1]

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The Jevons and Product Life Cycle Theories were economic theories developed by Raymond Vernon in response to the failure of the Heckscher-Ohlin model in 1966.
Due to a number of economic, political, and environmental factors, the market for recycling aluminum and copper has seen a significant growth over the past two decades. According to a report from the International Copper Study Group (ICSG), the demand for recycled copper has increased by 33% over the past 20 years, while the demand for recycled aluminum has increased by 30% over the same time period.
The need to lessen reliance on these metals' primary sources and, consequently, lessen the environmental effect of their extraction, accounts for the rising demand for recycled metals. Additionally, manufacturing metals from recycled scrap is more profitable than manufacturing them from raw materials and can save production costs by 20–40% (European Aluminium, 2020).
Companies like Sims Metal Management, Aurubis AG, European Metal Recycling, and Novelis, among others, are the main players in the global market for metal recycling (Grand View Research, 2021). Due to the rise in demand for recycled metals, there is intense competition between these businesses and it is expected that it will continue in the future.

Characterization of waste from the dicalcium phosphate industry as a potential secondary source of YREEs
O-02

Marcin Plachciak[1], Fidel Grandia[1], Vladimir Roddatis[2], Marcin Syczewski[2]

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[2] Helmholtz Zentrum Potsdam Deutsches GeoForschungsZentrum

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Fluorite-rich sludge is the main waste from dicalcium phosphate (DCP) production. This sludge consists of 40-60% of CaF2, which precipitates during the reaction between fluorapatite (the main com-ponent of phosphorite raw material) and HCl. In addition, the sludge contains elevated amounts of critical elements such as REEs. In this study, two industrial sites producing DCP in Spain have been studied to assess the potential valorization of these sludges. Currently, almost 2 Mt of waste re-mains landfilled in these sites. The concentrations of Y, La, Nd, Dy and Gd found within the res-idues are about 1100 ppm, 450 ppm, 300 ppm, 80 ppm and 75 ppm respectively. Fluorite, being the host mineral of the REEs occurs as a very fine-grained spherules (<5 µm), smaller than other minerals in the waste (quartz, gypsum), favoring the options of hydrometallurgical separation. REEs extraction from the fluorite could be an advantageous option, if separated from uranium, which is the main environmental concern of a future valorization of this kind of waste.

CO_2 utilization in Added-Value Construction Products from Magnesia Production

O-03

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The Paris Agreement on climate change aims to limit global warming to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C. To achieve this goal, countries have pledged to reduce their greenhouse gas emissions, including CO2. The European Union has set a target to reduce greenhouse gas emissions by at least 55% below 1990 levels by 2030. However, achieving these goals is difficult, as many industries still rely on carbon-intensive processes. For example, in the magnesia industry, the direct CO_2 emissions from the thermal decomposition of magnesium carbonate contribute to greenhouse gas emissions. Similarly, the steel industry emits CO2, often combined with waste slags with very little market value, further exacerbating the problem. The co-funded Horizon Europe project Carbon4Minerals (No.101091870) aims to reduce the process industry's greenhouse emissions and focus on hard-to-abate CO_2 emissions from steel and cement production by capturing and recycling these emissions. The project seeks to unlock a vast stock of resources for low-carbon binders and construction materials, thereby reducing greenhouse gas emissions from the process industry. Interestingly, these technologies could also be applied to the magnesium oxide industry, another major precursor to the steel industry. By using them, the magnesia industry could reduce its direct CO2 emissions and contribute to the overall reduction of greenhouse gas emissions. This demonstrates the potential for cross-industry collaboration and the importance of developing sustainable solutions that can be applied across different sectors. In this paper, we propose a solution for the enrichment of CO_2-containing streams from the production of magnesium oxide based on an oxyfuel process for further utilization as raw material in the carbonation of building materials. A simulation of a specific case in the magnesia industry was investigated, and the results were analysed.

A Proposal for the use of recycled aggregates in concrete in Greece
O-04

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Regulations for building materials in Greece do not allow the use of recycled aggregates in concrete. HERACLES Group aiming to motivate for a national regulation launched a project to evaluate the safe use of recycled aggregates in ready-mix concrete units. In this report updated results are presented comparing the technical properties of concrete mixes containing only crushed limestone aggregates (reference mixes) and mixes containing partially replaced crushed limestone aggregates with recycled aggregates (control mixes). The current results indicate equivalence between the reference and control compositions in terms of both physicomechanical and durability properties.
These experimental results and the practices of other European countries indicate that in Greece, based on EN 12620 and EN 206 standards, it is at least safe to use recycled coarse aggregates (≥ 4 mm) of classes Rc90 and Rcu95 with production and quality certification and a substitution rate up to 20% of crushed limestone aggregates. In addition the application concerns non prestressed concrete with strength class up to C30/37 and exposure class up to XS1.

Mining Wastes - An integrated thermochemical process for the conversion of multi-layer packaging waste into coal, hydrogen, and chemical flocculating agent
O-05

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Around 12.5 Mt of multi-layer packaging waste are produced in Europe annually. This waste consists of a mix of plastics (olefins), metallic films, and bio-based polymers. The concentration of chlorine, organic matter and low-T metals, such as aluminium, is a barrier against the valorisation of this waste by combustion or high temperature thermochemical processes. In this study, a sample of packaging waste was processed in a slow pyrolysis 2 kg/h pilot plant at 400 °C and 500 °C. At the process conditions, a char mass yield of 31 % and 33 % was obtained. Due to the high concentration of ashes (36 % dry basis), the chars resulted to contain only 25 % of the feedstock chemical energy, while the 75 % was recovered in the form of pyrogas, usable for local energy generation. The characterization of the char showed a high concentration of Cl, Ca and Al. Thus, chemical leaching tests were performed on both chars using a HCl 1.4 M solution so that to remove more than 90 % of Al, Ca and Cl and to upgrade the char to a coal-like material with low ash content (< 15%). Moreover, H2 was produced by reacting with Al during the chemical leaching process, obtaining around 8 g of H2 per kg of char processed. Chemical precipitation was performed to recover Cl and Al as Aluminium Polychloride, which was successfully tested as flocculating agent. The recycled, coal-like solid, was characterized and tested to be validated as alternative to coal in the steel sector. Finally, a techno-economic assessment of the process was performed on an industrial case study, showing attractive economic perspectives.

Benefits from the incorporation of ICME in the metallurgical industry
O-06

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The incorporation of Integrated Computational Materials Engineering (ICME) in metallurgical industry has the potential to provide significant economic and societal benefits. We discuss how ICME approach can be used to design and optimize materials and processes that are energy efficient, reduce industrial energy demand and contributes to an increased competitiveness. On the basis of an industrial material development case study, it is discussed how ICME can be used to accelerate the development, to reduce costs and emissions, and enhance the alignment with the various SDGs while, in parallel offers job openings. This paper provides insights into the potential benefits of incorporating ICME in metallurgical industrial applications and encourages further re-search in this area.

Monday 28 August 2023

ROOM 5

SESSION A2
Minerals exploration and Resource Characterisation I

Chair: S. Kilias, K. Laskaridis

Seabed mining and blue growth: Exploring the potential of marine mineral deposits as a sustainable source of strategic and critical raw materials
KN-02

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Minerals are major geopolitical actors in the present world. Supply chains of strategic and critical raw materials like cobalt, copper, lithium, nickel and rare earth elements are highly concentrated, generating risks. Clean energies, high- and new-technologies depend on the sourcing of several elements to Industry, and the mining activity is the core of the solution. Scarcity of critical minerals and the exhausting situation of many of the onshore mineral deposits is conducting to new developments to explore deeper, not only the Continental Crust but also on the seafloor, from coastal areas to deep sea abyssal plains.

A number of mineral deposit types, including high and low temperature hydrothermal, phosphorites, cobalt-rich ferromanganese crusts, and manganese nodules in deep-sea; and marine placers in shallow waters are covering, in a pristine conditions, the seafloor. All these deposits are particularly attractive for their polymetallic nature with high contents of strategic and critical metals.

The International Seabed Authority, the intergovernmental regulator for the exploration and future exploitation of seabed minerals beyond the national jurisdictions, is in the loop of a complex and challenging equation. Co, Ni, Mn, Te or REEs from seabed minerals, can contribute to replace oil and gas with solar panels or wind turbines looking to minimize carbon emissions. But there is a price, the pristine and not yet well understood marine environment. During the last years the technological developments on nascent deep-sea mining have been continuous but concerns over the potential environmental impacts are increasing at the same time. A precautionary principle is proposed by EU in order to protect life and health of the oceans. The international community needs to increase its knowledge on the seas before any commercial mining contract. New investments in exploration and research are mandatory, including regulations, geosphere, biosphere and hydrosphere studies.

Magnetite-hematite characterization at micron scale with implications for metallurgical processing and decarbonisation
O-07

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Magnetite deposits represent important iron ore resources. Selective sorting of valuables from gangue and targeting of potential critical metals which can be recovered from waste streams must be implemented from the exploration and excavation state on. Optical and scanning electron microscopy, electron microprobe analysis, electron backscatter diffraction, dual energy X-ray transmission and computed tomography were applied to determine the mineralogy and classify the iron oxides of different iron-ore types. These characteristics can be used for sorting at exploration and extraction steps to reduce unvaluable materials at the loading and hauling steps, which contribute with about 50 % to the greenhouse gas emission of the iron ore mining and mineral processing sector. These data also contribute to fine-tune mineral processing parameters.

Battery Mineral commodities characterisation – A case study for Nickel reference material
O-08

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Battery metals are often used in the manufacture of batteries, and typically include one or more of the following: Li, C, Ni, Co, Mn, Cu, Zn, V, and P. All are ultimately sourced from naturally-occurring mineral phases. More specifically, nickel (and cobalt) miner-als have historically been overlooked at many mine sites, as they were considered sec-ondary to the main minerals of commercial interest (typically gold, silver, PGM, chrome). However, these have seen a renewed interest as a saleable product from pri-mary ores, and even harvesting of historic tailings and waste dumps, where they were unceremoniously discarded, is underway.
As part of the BATCircle 2.0, funded by Business Finland, and led by Aalto University (Finland), GTK has been researching the characterisation of key battery minerals, and in the process, we are creating a set of Reference Materials (RM). In this paper, the results of the analytical work performed for nickel (Ni)-bearing ores are presented using a multidisciplinary geomaterial workflow, known as META or Mineral, Elemental, Textural Analysis (M.E.T.A.).
Samples of drill core, Run-of-Mine ore, and nickel concentrate (Figure. 1) , from Bo-liden's Kevitsa Mine, Finland, were analysed with multiple techniques, comprising: X-ray Diffraction (XRD), Automated Mineralogy by Scanning Electron Microscopy us-ing Energy Dispersive Spectrometry (AMICS by SEM-EDS), LECO, Inductively Cou-pled Plasma Mass Spectrometry/Optical Emission spectroscopy (ICP-MS/OES), Energy Dispersive X-ray Fluorescence (ED-XRF), scanning micro-XRF, Electron Probe Microa-nalysis (EPMA), Raman microscopy, Laser-Induced Breakdown Spectroscopy (LIBS) and Fourier Transform Infra-Red spectroscopy (FTIR). These techniques reveal the dis-tribution and enrichment of key Ni-hosting minerals, as well as the relative enrich-ment of metals (Ni, Fe, Cu, Co and trace elements of interest), across three stages of the mining cycle (ore to final concentrate).

Application of portable spectroscopic tools in the exploration of manganese oxide minerals: the case study of Drama Mn-oxide deposits, Northern Greece
O-09

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The use and development of portable spectroscopic tools pXRF, pLIBS, pRAMAN, pVNIR-SWIR aid in the mineral exploration sector by obtaining fast and flexible geochemical data. This is the aim of the educational research program ERASMUS+ ARTeMIS (Action for Research and Teaching). As a side project of this higher-education collaborative programme, our study applies to the specific detection of Manganese oxides. A combination of pXRF and pLIBS, both oriented for elemental analysis, is applied in the exploration of manganese mineralization in Kato Nevrokopi mining center, Drama district, N. Greece. The mineralization is hosted in marbles and displays zonation with the deeper mineralized hydrothermal veins comprising mixed sulphides (sphalerite-rich and minor pyrite-pyrrhotine-chalcopyrite-marcasite), rhodochrosite, ankerite, and quartz. The upper mineralized zones occur at high altitude plateaus of Mt. Falakron; they are of supergene origin and constitute the economically most important ore. The main orebodies of Mn-oxide ore are those found in the weathered upper levels of the veins and in karstic cavities and consist of todorokite, nsutite-chalcophanite or nsutite-birnessite-cryptomelane-pyrolusite and nanocrystalline Mn-oxides, depending on the degree of alteration/oxidation of the primary ore.
Conventional XRF analysis of bulk ore indicated a significant difference in the metal endowment of Mn-oxide minerals between the orebodies of the 25th km and Mavro Xylo mines. The nsutite-rich samples show enrichment in most metals, e.g., Pb (0.3%), Zn (1.3%), Cu (138 ppm), Sr (0.11%), Sb (81 ppm), Ag (67 ppm), As and Au. Todorokite shows accumulation of Mo and W, as opposed to nsutite. Bulk ore analysis by pXRF, elemental mapping through pLIBS, and mineralogical analysis by conventional techniques are applied to complex manganese oxide ore for the identification of systematic relationships of Mn-oxide minerals – host rock alteration –characteristic trace metal accumulation.

Fast and cost-effective quantitative assessment of the chemical and mineral composition of heavy mineral sands ores: an application to the Grande Cote Operation Ti-Zr mine of the new SOLSA combined XRF-XRD analytical solution.
O-10

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Mine optimisation and anticipation of ore behaviour in the mineral processing and separation circuits are major economic drivers for all mining operation. Recent methodological developments with the inception of geometallurgy across multiple commodities has highlighted the importance of mineralogy in addition to grades. Since several decades many quantitative tools have been developed, mostly SEM-based such as QEMSCAN®, and used to provide quantitative mineralogical compositions of samples. Their main drawback is the time and cost associated with the sample preparation, acquisition time and data QA/QC. The combined XRF-XRD of the SOLSA analytical solution brings a new methodology able to produce quantitative mineralogical and geochemical data at a speed compatible with a production environment, from exploration to control on the different streams of minerals in a processing plant. The first results have demonstrated the ability of the SOLSA combined analysis to quantify ore-forming minerals, and bulk chemical composition on complex mechanical mixes of Ti-bearing minerals, zircon and silicate gangue minerals with the analysis of run-of-mine ores, concentrates as well as matrix match standards for heavy minerals. The strength of the combined analysis being the internal QA/QC where both chemical and mineralogical datasets are acquired and used jointly to provide the quantitative mineral composition. This innovant instrument is perfectly suited to optimize exploration data, anticipate yields, quality of the different mineral concentrates and provide a more accurate and efficient way to pilot and operate heavy mineral sand industrial operations.

Exploration potential of Cu isotope fractionation in magmatic-hydrothermal Au-rich deposits in the Cyclades continental back-arc: insights from the Aegean Kolumbo submarine arc-volcano
O-11

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We examined Cu isotope ratios of primary auriferous pyrite, chalcopyrite, sphalerite, and orpiment, in actively boiling, seafloor massive sulfide diffusers, in the Aegean Kolumbo submarine arc-volcano. The unprecedented total range of δ65Cu values is –0.94 — +25.70‰. Chalcopyrite has δ65Cu values between −0.45 to –0.09‰, whereas pyrite and sphalerite are relatively heavy with δ65Cu varying from −0.94‰ to +6.38‰, and –0.58 to +2.87‰, respectively. Orpiment has an extreme range of δ65Cu between +4.49 and +25.70‰. The overlapping δ65Cuchalcopyrite and δ65Cupyrite values around −0.5 to 0.5‰, are like porphyry copper deposits and signify a mantle source for the Cu; the latter is positively correlated with Au, suggesting a common mantle source for Cu and Au. The highest δ65Cu values and maximum Au content correlate strongly (R2=0.98) in all analyzed minerals: the greatest δ65Cu variations in diffuser outer surface orpiment (Δδ65Cuorpiment=21.21‰) correlate with extreme enrichment in Au (≤ 861 ppm Au), and the narrowest variation in internal channel-lining chalcopyrite (Δδ65Cuchalcopyrite=0.36‰) with the lowest Au content (≤ 3 ppm Au). Similarly, relatively heavy pyrite (δ65CuMAX-pyrite=+6.38‰), and sphalerite (δ65CuMAX-sphalerite=+2.87‰), inside the diffusers, correlated to high Au enrichment, up to 131 ppm Au, and 40 ppm Au, respectively. Extreme enrichment in the heavy Cu isotope is explained by extreme boiling, induced by episodic influx of magmatic vapors, and vapor Cu and Au transport. Copper stable isotopes can clarify Au metallogenic processes, like sourcing (i.e., metasomatized mantle) and enrichment (boiling), and could assist Au exploration in arc-related magmatic-hydrothermal systems, in the eastern Mediterranean Tethyan orogenic belt.

Assessing CRM's content of abandoned mine sites of Greece
O-12

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The Green Economy is one of the main action pillars of the United Nations World Conference on Sustainable Development Rio+20, aiming at the promotion of economic development while ensuring the protection of the environment and society. To address the growing concern of securing valuable raw materials for the EU economy such as CRM's that are particularly important for high tech applications and products whilst at the same time minimizing environmental footprint, every possibility of exploitation and utilization of the Secondary Raw Materials has to be considered.

In this spirit, a project has been designed by HSGME, funded by national structural funds, to revisit and assess the CRM content of mining wastes at abandoned mines (available to the public/ on state-owned territory/ public spaces) on Greek territory, while at the same time checking their environmental behavior on a systematic basis. Bearing in mind that the data on the content of CRM's in the already exploited mines is very limited or even null even on European basis, the information collected will be useful for estimating even the content of the primary sources CRM's .

Several mines have been visited and samples have been collected, the areas of interest have been mapped (digitized), followed by laboratory work on sample characterization (chemical and mineralogical analyses). Environmental characterization was carried out as well .

More than 300 samples have been collected and characterized chemically and mineralogically. More than 60 environmental characterization tests have been run.

The database constructed is continuously fed with data providing useful information on a systematic basis and maps are been produced.

Monday 28 August 2023

ROOM 6

SESSION A3
Critical elements recovery from End-of-Life products

Chair: H. Soares, P. Oustadakis

End-of-life mobile phones: re-thinking its recycling based on pillars of circularity and economic and environmental sustainability
O-13

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Waste Mobile Phones (WMPs) is a secondary mining source of Precious Metals (PMs) and critical materials (CMs) that could provide a larger supply for the booming industry and reduce primary mining.

In order to achieve environmental and metal sustainability in circular economy, green processes for recycling WMPs should be designed envisaging to: (i) recover valuable raw materials (metals and nonmetals) as effective as possible; (ii) take care of hazardous substances contained in e-waste in an environmentally sound manner while preventing emissions; (iii) create economically and environmentally sustainable businesses.

To answer positively to these challenges, efficient and selective processes for recycling the main (Al, Cu and Fe), valuable (Au, Ag, Pd, Pt) and critical (In) metals, which are the driving metals present in WMPs, should be implemented after a proper disassembly and pre-sorting of the Electronic Components (ECs) attached to the Printed Circuit Boards (PCBs) and the Liquid Crystal Displays (LCDs) of the WMPs. For prosecuting these goals, in this communication, we will present the main results achieved from a nationally funded project based on the following activities: (i) development of an hybrid (based on physical and chemical) process for liberating the metal from the non-metal parts of the PCBs followed by the subsequent separation and purification of Au and Cu from the PCBs; (ii) testing the direct application of the Cu-containing non-metal parts of the PCBs for catalytic advanced oxidation treatment of persistent pollutants; (iii) development of a hybrid method that combines mechanical and chemical steps for removing the polymeric film attached to the ITO substrate and allows recovering the utmost amount of In, the plastic fraction and the glass substrate of the LCD screens.

Advances in the bioleaching of copper from end-of-life printed circuit boards
O-14

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The increase of waste from electric and electronic equipment, rich in valuable elements, combined with the current raw material scarcity, has pushed the research towards the development of high-sustainability treatments for its exploitation. The end-of-life printed circuit boards (PCBs) represent one of the most significant wastes in this category. In addition to their availability, the interest for these scraps is justified by the high Cu concentration (around 30% w/w), which makes them a promising secondary resource of the strategic element. This work presents an innovative biotechnology able to solve the main limit of this kind of techniques due to the capacity to treat low PCB concentration, making unsustainable the further scale-up. The present bioleaching process was carried out by At. Ferrooxidans, followed by metal recovery. The technology allows to reach high PCB concentration thanks to the high-efficiency two-step design, able to reduce the metal toxicity on the bacteria metabolism. The kinetic of the chemical reaction between Cu and Fe^{3+} (added as oxidant agent) has been studied by mathematical models and an activation energy of 18-25 kJ/mol has been estimated. The Cu recovery includes the preliminary Fe precipitation with NaOH (ready for reuse), followed by the Cu cementation with Zn and a final Zn recovery with oxalic acid. The metals show recovery efficiencies and purities higher than 95%. The sustainability of the experimental results is confirmed by the carbon footprint assessment which quantified the environmental gains resulting from the innovative solution of PCB recycling, able to implement the circular economy principles.

Integrated production and recycling of silicon for pv application
O-15

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The objective of the Horizon Europe "Resilex" project is to assure resilience in the silicon value chain from raw material to use in solar cells or batteries. The industrial production of silicon from silica is a carbothermal, SAF-based process, directly emitting on average approximately 5 tonnes of CO2/tonne Si produced. As a low-carbon direct emission technology, the SisAl process, based on aluminothermic production of silicon has been demonstrated in 100´s of kg scale in a on-going Horison 2020 project. The low degree of recycling of waste in the silicon-based solar cell production chain and that of EoL solar cells is a problem for the sustainability of this industry. The current paper describes an approach and results from the Resilex project where SisAl production and recycling of silicon of solar grade has been integrated.

Indium recovery from solar cell waste by means of layer-by-layer membrane filtration
O-16

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New generation thin film photovoltaics are a promising alternative to conventional silicon solar cells, since they exhibit high efficiencies and require less material and energy in production. These technologies use a thin semiconductor layer (few nm) instead of a thick crystalline silicon layer (several µm) giving them the opportunity to be solution processed and cost effective. However, they rely on valuable and / or critical raw materials (e.g. Ga, In), whose recovery in the context of a recycling process is essential for the large-scale implementation of the technology.
The current study discusses the challenge of recovering Indium (In) from thin film photovoltaic solar cells using a new processing option that offers to be environmentally friendly and economically feasible. Currently available methods (such as acidic leaching followed by liquid-liquid extraction) involve high costs and chemical impacts. It has been demonstrated that an intermediate nanofiltration (NF) step can reduce the use of chemicals due to a concentration of the waste stream. Still, with currently available membranes an economically feasible process can hardly be accomplished due to high energy demand resulting from the high operating pressure required for conventional NF.
This study demonstrates the applicability of layer-by-layer (LbL) modified membranes for In recovery from an acidic solar cell leachate. The modified membranes showed high In retention (70%), and at low applied pressure (5 bars), a high transmembrane flux exceeding previous benchmark data by over 10 times. This provides the basis for developing an economically attractive In-recovery process from end-of-life thin film solar cells.

LCDs screens from smartphones wastes: towards a nearly circular and zero-waste process for recycling Indium plus other raw materials
O-17

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Indium tin oxide (ITO) films used in liquid crystal displays (LCDs) screens of smartphones account for nearly 80% of the total consumption of indium (In) worldwide. According to Eurostat, only 0.1% of recycled (In) contribute to new raw material products. Due to these reasons, In is considered a critical raw material.
The current implemented recycling process usually adopts mechanical crushing or pyrolysis as the primary step for the treatment of LCDs screens. However, toxic liquid crystals (LCs) and valuable recyclable (In) materials are treated together and the recovery rate of In is considerably low. Furthermore, in a circular economy perspective, the recovery of glass and plastics from the LCDs screens should be targeted too to close the loop of the recycling chain. Unfortunately, those fractions are often overlooked.
To address this problem, here we propose a hybrid method that combines mechanical and chemical steps that removes the polymeric film (PF) attached to the ITO substrate and allows recovering the utmost amount of In, the plastic fraction and the glass substrate. The screens were cut in pieces and put in a mixture of water and ethyl acetate (5:1) in a low-pressure reactor (1 hour at 180 ºC) for detaching the PF and separate it and dissolve the LCs in the solvent. Then, In was extracted from the ITO substrate under microwave-assisted acid leaching conditions (0.50 M of HCl, solid/liquid ratio: 1/5, 3 cycles of 30 s. at 840 W), with a high recovery yield (99.0%) followed by continuous column ion-exchange technology (IET) to purify In from other impurities (mainly, Al, Cu and Fe). Subsequently, the remaining plastic fraction and the glass substrate were separated gravimetrically.
At the end of this hybrid method, it was possible to recover In with a high rate (99 %) and purity (92 %) plus all the other fractions that constitute the screen of a smartphone, such as glass and plastic, being a step forward to the circularity of the supply chain.

Beneficiation of Critical Metals from fine fraction of End-of-Life printed circuit boards, with the use of Column Flotation Process
O-18

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The continuously changing and growing demands of modern societies for raw materials posed their reliable and unobstructed supply at risk. European Commission and United States Geology Survey regularly conduct a criticality assessment on various raw materials and announce a regularly reviewed list of critical metal commodities, applying reliable and widely acceptable scientific methods.
Meanwhile, End-of-Life Printed Circuit Boards constitute a rich source of unexploitable metallic values, and exploitation remains a significant environmental, social, and economic challenge for research and industrial communities.
Based on the systematic research work, conducted in the Laboratory of Mineral Processing of the National Technical University of Athens, concerning the application of column flotation in the treatment of EoL PCBs fine particles, the experimental results, their following analysis and assessment revealed the promising potential of column flotation adoption in the pretreatment of EoL PCBs' fine particles.
In this context, the proposed paper presents some findings of the research work conducted in the recovery of Critical Metals identified in End-of-Life Printed Circuit Boards through column flotation as a pretreatment process.
Focusing on critical metals (antimony, titanium, aluminium, and magnesium) included in the most recent respective lists of the European Commission and United States Geology Survey, in the present research paper suitable mathematical models, demonstrating their response in the above-mentioned treatment procedure, were developed and proposed.

Impact of Extractant Type and pH on Yttrium Recycling from End of Life Fluorescent Lamp
O-19

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Rare earth elements (REEs), which are indispensable for high technology and renewable energy, are becoming more significant due to their unique properties (such as catalytic, metallurgical, magnetic etc.) and their diverse applications in a wide range of contemporary technologies, environmental and economic fields. For an environmentally friendly, sustainable, circular economy, recycling and utilizing secondary rare earth resources may be an alternative to mining in order to meet future raw material demands. Fluorescent lamps, LEDs, magnets, wind turbines, electric motors and batteries are examples of secondary REE sources. Powders used in fluorescent lamps contain approximately 3% phosphorus, and these powders comprise a high ratio of precious REEs such as Y,Eu,La,Ce, and Tb. Therefore, fluorescent lamps can be considered as a rich potential secondary source. This study involves the recovery of Yttrium from end-of-life fluorescent lamps. The contents of end-of-life fluorescent lamp were analyzed after they were ground into powder. The leaching process has been conducted to determine the effects of S/L ratio, acid type, temperature, and reaction time on the efficiency of the reaction. In the subsequent phase of the study, Y purification from the solution obtained with the optimum leaching efficiency was carried out using the Solvent Extraction (SX) method. Different extractants and pH values were used during the SX process, and the impact of each on yttrium recovery was examined. XRF and ICP(OES) techniques were used to characterize the obtained yttrium oxide powders.When the results were examined, it was seen that high yield and purity Y2O3 powders were obtained.

Hydrometallurgical recovery of tin from waste Printed Circuit Boards O-20

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This study presents a hydrometallurgical process for the leaching and recovery of tin from waste printed circuit boards (wPCBs). The process aims to separate and recover tin from filter dust produced during the crushing of wPCBs in a recycling facility. In order to separate the plastic from the metallic fraction, the dust was submitted to gravimetric separation, and the originated material consisted mainly of Cu (23.8%), Fe (17.8%), Sn (12.7%), Pb (6.3%) and Zn (3.4%). During the leaching tests, the effects of (a) HCl concentration (2M, 4M, 6M), (b) pulp density (0.1 g/ml, 0.2 g.ml, 0.3 g/ml) and (c) the addition of NaCl (no addition, 1M, 3M) were investigated. All tests were conducted at ambient temperature without agitation. Leaching efficiency of 78.2% was obtained during leaching with 6M HCl and 0.3g/ml pulp density, while 94.8% of tin was leached, at the same conditions with the addition of 3M NaCl. The recovery of tin, as a precipitate, from the pregnant solution, by the addition of 2M NaOH, was studied. The tin recovery efficiency, for a pH value of 3.0 was 97.4%. Tin was recovered as an amorphous precipitate. The precipitate was easily filtered and consisted of 64.7% Sn, while the content of other impurities was less than 2%. The integrated proposed process consists of a leaching stage in 6M HCl, 3M NaCl, 0.3g/ml pulp density and contact time of 24h, and a recovery stage by chemical precipitation for a pH value of 3.0. The total tin recovery of the suggested process was 92.3%.

Monday 28 August 2023

ROOM 13

SESSION A4

Advances in mineral processing technologies

Chair: K. Tsakalakis, G. Anastasakis

Evaluation of the processing routes for the "hard lithium" European deposits
KN-03

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Top ten deposits account for more than 83% of world lithium resources with a domination of the brines. Estimated "hard Li" resources were significantly increased recently due to the advanced exploration and discovery of new deposits and the number of advanced mining projects has increased in several European countries.

Granitic pegmatites and rare metals granites (RMG) have been exploited in Europe mainly for the industrial minerals (quartz, feldspar, kaolinite). Granitic pegmatite is an important lithium source and also the source of many other critical metals, such as Ta, Nb, Sn, Be, Cs, Ru, Sc, U, Th and REE. The supply of some of these elements i.e. Li and Ta is of concern, therefore, it is very important to investigate recovery of such metals from granitic pegmatite. Thus, it is crucial to evaluate the potential and contribution of "hard Li" sources to decrease the supply risks of critical materials for the European economy.

European Commission supported several research and innovation large scale projects involving the partners from industry, academia and engineering companies. The work performed in the framework of several European projects (Stoicism, FAME, EXCEED) targeted to unlock the "hard Li" European deposits. The main Li-bearing mineral was lepidolite for the feldspar/aplite pegmatite (Gonçalo, Portugal) and RMG (Beauvoir, France) ores, while the spodumene recovery was evaluated from the LCT pegmatite from Länttä and Syväjärvi deposit (Finland).

The flotation route is used for the recovery of the Li-bearing minerals (lepidolite, spodumene) from all types of ores to produce battery quality Li hydroxide. The processing circuits target also the by-product recovery such as Ta, Nb, Sn, W, quartz and feldspar product for ceramic industry. The processing flow-sheets for the metallic by-product recovery includes sorting, gravity and magnetic separation methods and the flotation for the quartz/feldspar separation allowing to reach near-zero waste operation.

Investigation of industrial residues and waste materials to expand the raw material base for the production of lightweight aggregates O-21

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More than 218 million tonnes of mineral construction waste are produced in Germany every year. In view of the shortage of domestic raw materials and an increasing demand for light-weight aggregates and gypsum, it is important to find alternative sources of raw materials for the production of light aggregates. The main focus of our investigations is on construction and demolition waste and industrial by-products, which have so far only been used at a low level.

Chemical analyses can be used to classify potential substances in the ternary diagram according to RILEY and to examine their basic suitability. However, the results show that the suitability of a raw material for the production of lightweight aggregates cannot be determined solely on the basis of the classification in the ternary diagram. Experimental investigations are necessary in any case.

From the range of residual and waste materials investigated, the rhyolite fractions showed the best swelling properties. Without the addition of bloating agents, bloating values of 1.4 can be achieved. The addition of iron slurry to a reduction of the bloating temperature by about 100°C, however, is associated with a slight reduction of the bloating value. With our investigations, we were able to show that an expansion of the raw material base for the production of lightweight aggregates is also possible beyond the use of classic, heterogeneous building rubble containing bricks

METALLICO EU PROJECT
O-22

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To boost the green transition, the availability of critical raw materials needs to be ensured. The battery sector has been experiencing increasing demand for raw materials for years and is vulnerable for supply risks. Various strategies are being pursued to meet the growing demand for critical raw materials and to build up viable, sustainable and innovative value chains. Waste valorization by recovery and recycling plays a central role. In this background, METALLICO EU funded project started in January 2023 and will:

1) Recover valuable materials from primary and secondary resources: METALLICO will develop and optimize five innovative processes to recover Lithium, cobalt, copper, manganese and nickel. For this, primary and secondary resources will be processed and valorised.

2) Produce and recover (critical) battery metals sustainably: METALLICO is committed to a sustainable and zero-waste approach. This includes the five innovative processes, a better recovery of resources from generated waste and the reduction of waste during the production of (critical) battery metals.

3) Assess end-use of the recovered (critical) battery metals: The final products, obtained and recovered in the case studies, will be assessed and validated in the battery, cement, painting and ceramic industry. In doing so, we demonstrate that the final products will suit the needs of the markets and can be fed back into the value chain. Thus, METALLICO contributes to a circular economy.

4) Identify and characterize (critical) battery metals with innovative technologies: In METALLICO, a digital (open source) platform will be developed in which, on the one hand, primary and secondary battery metal sources will be identified and characterized. On the other hand, digital twins of innovative plants for the recovery and production of metal will make it possible to simulate the efficiency as well as the economic, environmental and social impacts of the respective metal.

The applicability of screening and ore sorting to the beneficiation of low-grade gold ore from Western Australia
O-23

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Lower grade deposits are increasingly being considered as option for value extraction due to the continuing depletion of high-grade ores. Sustainable mining and processing practices that better account for socio-economic and environmental concerns are receiving tremendous attention in recent years. Integrated mining approaches that include exploration, grade control drilling, mine planning and processing are vital to optimize resource extraction. Particle sorting is a coarse particle separation technique used in the minerals industry to upgrade low grade ore prior to the energy intensive milling and downstream processing stages. Screening as a preparation stage for particle sorting can provide insights to metal deportment and optimum particle size for sorting amenability.

This paper aims to present results on the amenability of a low-grade gold ore from Western Australia to grade deportment by particle size and sensor-based sorting technology. The integrated screening and particle sorting results indicated that significant upgrade in low grade ores was achieved with >80% metal recoveries in about <30% of the mass for the ore type investigated. Induction and XRT sensor sorting technologies have been found to be suitable because they showed better sorting outcomes and upgrade potential for the ore type investigated.

On the flotation of sulphide minerals using organosolv lignin as collector
O-24

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Xanthate are widely used collectors on the flotation of sphalerite, pyrite and arsenopyrite minerals . Despite their efficiency, as toxic substabce it possess negative environemntal impact, its production is centralized in China, while the frequent quality deviations affect the separation efficiency. Lignin is a low-cost material obtained from abundant forest residues and side streams of the pulp industry, and it has been shown that, lignin can be used as collectors in copper recovery by froth flotation process. In this paper, we present flotation results obtained by partial replacement of Sodium Isopropyl Xanthate (SIPX) by lignin nano and microparticles. Results were evaluated in terms of the grade and recovery achieved at the concentrate for the valuable minerals, but also in terms of the collector selectivity by calculating relevant indexes (Selectivity Index, SI and Sepatation Efficiency, SE).

Monday 28 August 2023

ROOM 5

SESSION A5
Minerals exploritation and resource characterization II

Chair: K. Lax, F. J. Gonzalez

The environmental, social and governance challenges in the Lithium Triangle supply chain
KN-04

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The electrification transition has intensified the demand for lithium. The Lithium Triangle has significant lithium resources, but physical availability is not the only condition required to bring new supply to stream. Although market momentum provides a strong driver for the expansion of the lithium sector, its success is likely to also depend on our ability to provide lithium under the principles of sustainable and responsible supply. The decarbonisation agenda, together with the sustainable development goals (SDGs) set high aspirations for the sustainable and responsible supply of raw materials However, the time window for bringing lithium supply to market is noticeably short.
During the past 5 years we have worked through a variety of projects related to lithium sustainability, exploring different perspectives (e.g. geoscience, ecology, markets, supply chains etc). In this work, we discuss the environmental, social and governance (ESG) challenges that are likely to influence the future of sustainable lithium extraction from the Lithium Triangle. We present the findings of a qualitative analysis undertaken to prioritise the risks associated with these challenges and discuss their interlinkages. We provide urgent mitigation actions that can be used to address challenges associated with the brine and water extraction, the loss of biodiversity, societal and governance issues. We argue that the consideration and resolution of ESG issues becomes a priority for all critical or otherwise raw materials and that the management of such complex challenges relies on holistic approaches that incorporate a range of methods and tools.

Bauxite Residue deposition in Corinth Gulf, Greece: a potential REE resource
O-25

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The Parnassus-Ghiona area is one of the most active mining districts in Europe, regarding bauxite extraction, as well as metallurgical Alumina production. The "B3 bauxite horizon" is the richest in Al-minerals and is currently exploited, while "B2 horizon" has been the subject of mining in the past.

Although bauxites are included in European Union's list of critical raw materials (CRM), market's growing demand for rare earth elements (REE) has shifted the exploitation focus towards the latter. Bauxites might contain considerable amounts of REE, and particularly in the waste from their metallurgical treatment (Bauxite Residue-BR).

During the previous decades, BR has been deposited in the Corinth Gulf through a pipeline from the metallurgical factory of the area. Up until 2010, when offshore deposition was permanently ceased, 25 Mt had been deposited in the Corinth Gulf, while nowadays annually around 700-800 t of BR is produced and stored as dry residue on land. A seabed mapping of the area in front and south of Antikyra Bay revealed that the BR deposition is comprised by two layers, one almost on the seafloor with a thickness of up to 2cm and one as a sub-seafloor layer with thickness up to 4cm. The total volume of the bauxite residues deposited in the area has been valued to be approximately 1.96 x 106 m3. The main mineralogical assemblage of BR is calcite, hematite, quartz, Fe-chlorite, clays, and traces of REE minerals. Geochemical analyses performed on BR samples within the scope of this research indicates REE contents ranging between 297 and 771 ppm with Ce, Sc and Nd being the predominant ones.

Rare earth and trace element behaviour in different size fraction in an old uranium mine (centre-north of Portugal)
O-26

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The trace and rare earth elements (REE) contents in the environment can be increased by anthropogenic sources such as mining, agriculture, and industrial activities. Uranium mining has presented vast amounts of these elements in this activity's residues. Also, mining activity can influence the behaviour and concentration of these elements in the soil system, water, and plants, inside, outside and surrounding the mine area. However, limited research on the behaviour of REE and trace elements in different size fractions of soil and sediments from old uranium mines exists. For the present work, soil and sediment samples were collected inside and outside the Quinta do Bispo old uranium mine, aiming to study the behaviour and distribution of REE and trace elements in different-size fractions (<2mm, <63 µm, <2 µm) and their correlation with the mineralogy. Samples were analyzed by ICP-MS, INNA, XRD and SEM. The preliminary results showed an REE and trace elements enrichment in the finer fraction (< 63 µm) relative to < 2 mm fraction, which could be related to the secondary/unstable mineral phases. In addition, a higher REE fractionation, high positive europium anomaly and an LREE enrichment relative to HREE were found in the clay fraction. This behaviour might be explained by the preferential incorporation of these elements in kaolinite, the dominant clay mineral in these samples. In conclusion, trace elements and REE distribution may vary significantly with the grain size, depending on the mineralogy and weathering process that occurs in the soil and sediment samples.

Mineral exploration at the Kimmeria Fe-skarn deposit, N. Greece: Reassessment and new perspectives focusing on the CRMs
O-27

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Following the worldwide increasing demand for Critical Raw Materials (CRMs), the Hellenic Geological Survey (HSGME) implements a national project focused on the re-evaluation of certain Public Mining Areas in Greece. In this framework, exploration activities including geological mapping, and mineralogical, geochemical, and geophysical studies, revealed elevated contents of certain CRMs in the Kimmeria Fe-skarn deposit.

The mineralization is related to the contact metamorphic aureole of the Oligocene Xanthi pluton and develops in various forms i.e., massive replacement bodies, disseminated, and veins. Various skarn-minerals form the following paragenetic zones in order of decreasing temperature: i) garnet-wollastonite, ii) garnet-clinopyroxene, iii) garnet-epidote, and iv) vesuvianite-scapolite. The skarn zones are associated with magnetite-rich mineralization occurring along with sulfides (chalcopyrite, pyrite, bismuthinite, molybdenite), scheelite, and minor sulfosalts (aikinite, wittichenite, cubanite) and native elements (Au, Bi). Bulk-rock geochemical analyses yielded significant values as follows: Fe_2O_3 < 58 wt%, Cu < 6.6 wt%, Bi <1100 ppm, W <670 ppm, V <200 ppm, Nb < 28 ppm, and Au < 2.1 g/t.

Soil and stream-sediments geochemistry reveals spatial and linear trends for certain groups of associated elements (i.e., Fe_2O_3-Cu-Bi-W, Mo-W-Zn). These trends reflect the surficial distribution of mineralized zones and imply the existence of partially unexposed mineralization in the western part of the study area, a fact also supported by geophysical evidence.

A preliminary drilling project has been proposed to evaluate the qualitative characteristics of the deeper parts of the mineralization, investigate buried ore zones in the western part, and overall, reassess the economic potential of the deposit.

Mine and mineral exploration projects within the Natura 2000 areas: Case studies from northern Finland
O-28

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During the last decades, only three significant mineral deposits have been found in Finland: Rompas-Rajapalot (Au-Co) in Ylitornio-Rovaniemi and Sakatti (Ni-Cu-PGE-Co), and Ikkari (Au) in Sodankylä, Lapland. Here we focus on the Sakatti and Rompas-Rajapalot projects, which are partially located within Natura 2000 areas (Natura). Those are among sensitive contexts in which mining and mineral disputes emerge in Finland.

The Rompas uranium deposit was discovered by the French Areva nuclear company in 2008. The property was sold to Canadian company Mawson Oy in 2010, which also found gold and cobalt. Mawson found another deposit in Rajapalot which is not associated with uranium. The company is preparing an environmental impact assessment (EIA). However, the Ministry of the Environment plans to expand the Natura in the area.

The world-class Sakatti deposit was discovered in 2011 by the AA Sakatti Mining Oy, a subsidiary of the British company Anglo American plc. The company is preparing an EIA and plans an underground mine to avoid impact on Natura. Even then, the company will do ecological compensation.

Because of Natura, both companies apply low impact mineral exploration technologies. They also practice effective stakeholder engagement and communication, and projects seem to be mostly favored by local populations. However, because of their association with Natura (and uranium in the case of Rompas), projects are opposed by the Finnish Nature Conservation Association as well as by reindeer herders in the case of Sakatti.

The projects are case studies of the Horizon Europe project CIRAN (Grant Agreement no. 101091483).

Monday 28 August 2023

ROOM 6

SESSION A6

Li-ion Batteries recycling

Chair: P. Xanthopoulos

The COOL-Process – a holistic recycling approach for lithium recovery KN-05

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Lithium has gained importance especially in recent years due to its unique properties use in batteries. Since Europe lacks most the world's lithium reserves and production, efforts are currently concentrated on extracting such critical raw material from both primary and secondary sources to reduce reliance on exports and support and improve domestic sources. The most employed approaches for recovering lithium from lithium silicate ores are pyrometallurgical methods, which are characterized by high energy consumption and low lithium mobilization.
An example of how future-directed processes could operate is the COOL-Process, which makes use of water and supercritical (sc)-CO_2 to leach lithium from any silicate mineral. Alkali ions are selectively mobilized because of the lower acid strength compared to classical mineral acids. Furthermore, no precipitation reagents are required since lithium hydrogen carbonate forms readily upon leaching and further reacts to lithium carbonate, which then can be separated via hot filtration due to reduced solubility. The process simplifies the Li_2CO_3 production since it is recovered in battery grade just after H_2O/sc-CO_2 digestion followed by an electrodialysis step. The process validation in pilot scale is currently being assessed. To demonstrate its feasibility and its industry implementation, sustainability assessments are performed. Because it is a holistic and hybrid technique, it operates independently of the raw material used and as such upholds the cyclic resource chemistry idea. It is suitable for input material from both primary and secondary sources since the substrate has a wide range of variability and does not distinguish between various ore minerals.

Development of a process for low-cost LFP batteries treatment
O-29

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In the present study, the recycling of lithium-ion batteries from electric and hybrid vehicles was investigated, specifically lithium-iron-phosphate ($LiFePO_4$) batteries, using mechanical pretreatment and hydrometallurgical methods. The aim was to extract Lithium (Li) into the aqueous phase and precipitate iron (Fe) as iron phosphate ($FePO_4$) in solid residue. Samples of lithium-iron-phosphate ($LiFePO_4$) batteries from the company BEEV were used in the study. Initially, pre-processing was performed using mechanical methods and water leaching of the batteries altogether, without manual separation, simulating an economical and integrated industrial approach, with the goal of isolating valuable cathode materials (black mass).
The cathodic material was then leached with sulfuric acid (H_2SO_4) in combination with the use of hydrogen peroxide (H_2O_2) as an oxidizing agent, aimed at oxidizing ferrous to ferric iron and precipitating it as iron phosphate in the solid residue of the leaching. Leaching tests were conducted by varying the concentrations of sulfuric acid and hydrogen peroxide, as well as leaching time, aiming to find the optimal leaching conditions. As a result of the tests, Lithium extraction greater than 95% was achieved (from the first few minutes of leaching), and iron extraction was less than 0.001%, using a sulfuric acid concentration equal to the stoichiometric requirement and hydrogen peroxide 3 to 4 times greater than stoichiometric.

Closed-loop Recycling of Li, Ni, Co, and Mn From Spent NMC Batteries
O-30

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It is crucial to recycle the end-of-life lithium-ion batteries (LiB), due to the future demand as a result of widespread use in electrical vehicles and devices. Waste lithium-ion batteries cannot be freely disposed as they are harmful to the environment and human health while containing many critical metals.
In this work, two different approaches for the recycling of NMC-type LiBs is presented. The first approach concerns using cathode active materials to make new electrodes by stripping them from the current collector foil and converting them into sludge. Pyrolysis, dissolution of PVDF, and dissolution of aluminum foil was investigated as the methods for this approach. The other approach is based on leaching waste lithium-ion cathodes with various acids and reducing agents, and synthesizing new cathode active material by direct co-precipitation from the leachate. As a result of this route, up to 99% Li, 97% Ni, 96% Co and 98% Mn by weight are recovered from the cathode mass, and new cathode active materials were synthesized via the co-precipitation method.
In both processes, it is aimed to design closed-loop recycling processes and to simplify the route compared to the conventional methods. In both of the cases, the closed-loop recycling and resynthesis processes, targeted cathode performance was successfully demonstrated.

Removal of metal contaminants from LFP black mass leachates
O-31

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The lithium iron phosphate battery (LFP) is a type of battery using lithium iron phosphate as cathode material, and a graphitic carbon electrode with a metallic backing as anode. LFP's are expected to play an increasingly important role within the global market, with a demand exceeding 3,000GWh by 2030 because of the importance of clean energy technologies. However, the growth of LFP applications along with their moderate life span, will generate vast amount of waste in the upcoming years. Without proper management, this waste can pose a serious environmental threat and a loss of critical raw materials (i.e., lithium, phosphorus, and graphite). The recycling of the LFP batteries usually starts with pyrolysis, crushing, and sieving. After that the so-called "black mass" containing the LFP material and graphite is obtained. During acidic leaching process, metal impurities (i.e., Cu, Al from the current collectors and Fe from LFP) will inevitably dissolve in the leachate along with Li and will hinder the production of a battery grade lithium carbonate product during metal recovery step. Thus, a leachate purification process is considered essential. In this work, the precipitation of Cu, Al and Fe from simulated Li-bearing sulphate leachates is investigated by using NaOH as precipitating agent. After optimizing the final pH and temperature it is possible to quantitatively precipitate out the metal impurities with rejection of Li.

Investigation of recycling behaviour of lithium iron phosphate battery batteries with different thermal pre-treatments
O-32

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The use of lithium iron phosphate (LFP) batteries are surging in various modern applications such as electric vehicles and large-scale energy storage devices, especially after the restrictions by the EU. Since LFP batteries have lower cost, safer operation, high energy density and long-life cycle compared to NMC alternatives, it is expected to have increased demand similar to China. Globally, the use of LFP-batteries grew from 12,500 tons in 2014, to 32,000 tons in 2015, and with an expectancy of 64,000 tons in 2025.

This demand and use of LFP cells naturally will create a huge waste from end-of-life products in near future. Due to the components of the batteries, the waste could not be disposed to nature. Moreover, the planned battery directive by the EU requires the recycling of batteries with a special focus on lithium. Therefore, the correct recycling of LFP batteries will both reduce the damage to the environment and contribute to the circular economy. According to the European Commission's list of critical raw materials (CRM) in 2023, lithium and graphite are listed as CRM for the future due to both their economic importance and supply risk.

LFP battery recycling can be done by both pyrometallurgical and hydrometallurgical methods. In this study, different thermal pre-treatments were applied and the effect of these thermal treatments on the following recycling operations were investigated with a focus on flotation and leaching. The results from various treatments are compared and an optimized process route for a robust and highly efficient process was designed.

Monday 28 August 2023

ROOM13

PLENARY LECTURES

Funding Opportunities for Research and Innovation Projects

Chair: M. Taxiarchou, V. Correia

Horizon Europe raw materials funding opportunities

Dimitrios Biliouris, Project Adviser for the Health and Digital Executive Agency (HaDEA), European Commission

Antonis Politis, EIT Raw Materials EIT RawMaterials' Eastern Co-Location Centre

Advances and contributions to the EU Raw Materials policies via Pan-European coordinated funding

Dina Carrilho, PhD, ERA-MIN Joint Call Secretariat

Monday 28 August 2023

ROOM 16

POSTER SESSION 1

Mineral exploration and characterization
EU Strategy on Circular economy
Mining trends and perspectives
Waste Valorisation

P1-01
Effect of thermal treatment on flotation and leaching in EV lithium-ion battery recycling

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The recycling of spent EV lithium-ion batteries is becoming increasingly important in order to reduce dependence on primary raw materials and the risk of supply shortages of critical raw materials, as well as to promote a circular economy. To achieve this, a combined process approach of thermal pre-treatment, flotation and leaching was investigated in this study to enable efficient recycling of graphite and cathode active material.

In the hydrometallurgical treatment of black mass, it has been observed that, the remaining high-boiling organic components after inadequate thermal treatment have a significant influence on the efficiency of the separation process as well as on process control (e.g. in the area of operating media control in leaching) both in direct leaching and flotation. It is crucial to remove the high boiling point fraction and the binder in a way that does not damage some critical components such as graphite.

The aim is therefore to determine the effect of volatile substances (organic solvents / thermally unstable substances) on the process control and the product quality of the hydrometallurgical processes for the production of battery-grade metal salt and graphite. It is also essential to determine the positive outcomes of an optimally adjusted thermal treatment. As a result, it is possible to define the obstacles in hydrometallurgical battery recycling processes owing to the circulation of the volatile substances in the operating media.

P1-02
Effect of freeze-thaw cycles on the flexural strength of Greek natural stones

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Hellenic Survey of Geology and Mineral Exploration

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The main objective of this paper is to investigate the potential impact of cyclic freezing-thawing on the flexural strength of Greek natural stones which are widely used as building materials for construction or decoration purposes. These test methods usually prove to be a critical part of the stone selection process because they can evaluate the stone's durability, which is very important especially in locations where freeze/thaw exposure is common. For this purpose, specimens from different types of stones (limestones, calcitic and dolomitic marbles, cipollino marbles, schists, mylonites) were selected and studied to determine their flexural strength under concentrated load, as well as the corresponding values after freeze/thaw cycles according to EN standards. The results show that stones of the same type present almost similar flexural strength behavior except for extreme cases of strength gain or loss. However, specific stones indicated significant decrease in their flexural strength when subjected to freeze-thaw cycles, despite their initially calculated high values, without performing the frost durability test. To determine whether an observed strength loss (or gain) is genuine, the data per stone-type were critically assessed by mathematical-statistical t distribution analysis, a method specifically suited for small sample sizes with fewer than thirty data points (as is the case here), and the corresponding results are presented. The strength deterioration rate due to freeze-thaw cycling, even among samples of the same stone type, might be attributed to intrinsic parameters, such as microstructure, mineral composition etc., which are out of the main scope of this study.

P1-03

Structural and electrochemical characterization of Natural Manganese Oxides from Drama Mn-oxide Deposits of Greece

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Ramsdellite and pyrolusite are the two naturally occurring crystalline polymorphs of MnO2. Nsutite, also known as γ-MnO2, is a disordered intergrowth of ramsdellite and pyrolusite, which, along with its synthetic analogue, the Electrochemical Manganese Dioxide - EMD, are among the most suitable materials for battery applications. The western Rhodope massif contains battery-grade Mn oxide deposits, with typical examples of the Kato Nevrokopi deposit in the Drama district, Northern Greece. The nano-structure of Mn-oxide samples from Kato Nevrokopi is characterized by X-ray diffraction (XRD). X-ray powder diffraction patterns were analyzed in pursuance of the calculation of the cell parameters and the percentage of structural defects. Electrochemically active γ-MnO2 demonstrates two structural defects:

- De Wolff disorder, which involves the random intergrowth of ramsdellite and pyrolusite structure with values 0 (ramsdellite structure) to 1 (pyrolusite structure)
- Micro-twinning (%)

Both of these defects are responsible for the poor quality of X-ray powder diffraction patterns of most γ-MnO2, and their electrochemical behaviour. The results indicate the following structural parameters: Tw (micro-twinning) = 51.36 % and Pr (de Wolff disorder) = 0.42 %, cell parameters: a = 4.461, b = 9.462, c = 2.825. Additionally, its electrochemical properties are measured by conducting cyclic voltammetric tests and comparing the results with those from synthetic analogues. An electrode made by FTO (Fluorine-doped Tin Oxide) glass was prepared using natural γ-MnO2 as a paste. The results from the cyclic voltammetry tests indicate good electroactivity of the natural Mn-oxides comparable to synthetic EMDs indicating its potential use as a cathode material in dry-cell batteries.

P1-04 Mineralogical and geochemical constrains of the critical and rare metals in the vein-type mineralization at the Vertiskos unit, northern Greece

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Critical metals are substantial to the high-tech industry and the development of the low-carbon society. They are characterized by restricted natural availability and supply risk, and thus their exploration and exploitation is of a high priority. The Vertiskos unit of the Serbo-Macedonian massif in Greece includes several Cenozoic polymetallic mineralizations hosted in quartz veins, which are enriched in Cu-As-Pb-Bi-Au-Te or in Sb-W. The most significant polymetallic mineralizations are located at Laodikino, Koronouda, Stefania-Paliomylos, Kolchiko, Drakontio, and Stanos, while the Sb-W mineralization is found at Rizana and Philadelphio. The polymetallic mineralization is characterized by base metal sulfides, mainly chalcopyrite, arsenopyrite, pyrite, Bi-sulfosalts, Bi-sulfotellurides (e.g. joseite-B), and tellurides (e.g. altaite, hessite) associated with Au and Ag. In contrary, Bi-sulfosalts, Bi-sulfotellurides and tellurides are lacking in the Sb-W mineralization. The highest concentration in Au (28.3 ppm) is reported in Koronouda, while at Laodikino Ag reaches up to 2,433 ppm. Significant bulk ore geochemical enrichments in critical metals include Bi (995 ppm), Co (320 ppm) and W (844 ppm) at Kolchiko. The mineralizations were formed from magmatic-hydrothermal fluids at mesothermal to low- to intermediate-sulfidation epithermal conditions. Sometimes they are restricted in extended shear zones, at the transition between ductile and brittle deformation, demonstrating retrograde greenschist facies metamorphism. In this contribution, we present a review of the critical metal concentrations and the associated mineralogy of vein-type mineralization of the Vertiskos unit, with an emphasis at Laodikino, Kolchiko, and Rizana.

P1-05 Sustainable blue economy as a supplier of Strategic and Critical Raw Materials

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Raw materials are essential to advance clean-energy technologies, digital equipment, and sustainable mobility. Critical Raw Materials (CRMs) have a high supply risk and are of significant economic value. The EU has identified 34 raw materials as critical for the green transition. One of the most crucial strategic areas to boost the EU's global leadership is the security and diversification of supply of CRMs.

The idea of a circular economy has received a lot of attention over the past two decades and is gaining momentum as a feasible key to the challenge of sustainable growth. The circular economic concept focuses on ensuring that non-renewable raw materials are always available.

The sustainable blue economy is a low polluting economy which adopts clean technologies and circular material flows while it restores, protects, and maintains the marine ecosystems. In terms of improving the supply of critical materials, seabed mining is anticipated to continue playing a significant role in the shift to a sustainable blue economy. Promising marine sources for strategic and critical minerals and metals are polymetallic sulfides, polymetallic nodules, cobalt-rich crusts, phosphorites, REE-rich muds, and placer deposits.

Bearing in mind the huge increase in metal demand to meet the Paris Agreement to limit global warming to 2°C, the large amount of valuable metals which is being wasted (global recycling rate of e-waste is 20%), the rapidly diminishing quality and quantity of land-based mined deposits, and the uncertainty about the environmental impacts of deep-sea mining, we understand that the throwaway economy is on a collision course with Earth's geological limits.

P1-06 The suitability of mafic volcanics from the island of Patmos for acidic water purification applications: Report on initial experimental results

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Our research efforts focused on compositionally mafic volcanics from the island of Patmos for our experimental research purposes. These consist of plagioclase, clinopyroxene, olivine, whereas glass, Fe-Ti oxides and spinel occur as accessory phases. Olivine is present mostly as subordinate idiomorphic grains, whereas plagioclase as a predominant phase. Clinopyroxene phenocrysts are often coarse-grained, interlocking smaller sized microphenocryst plagioclase. The matrix is poikilitic to variolitic, depending on the participation of glass. Volcanics have been used for the development of filters (Petrounias et al. 2019, Primasari et al. 2020; Liesh 2010; Jiang et al. 2014), although reports on alkali basalts for water purification application purposes are limited. We conducted experiments with a basaltic pyroclastic tuff that resulted in the beneficiation of an acidic water sample, from a pH 2.7 to that of pH 4.8 within only 15 minutes time. However, this is likely associated due to the participation of clay minerals and did not provide a long-lasting effect. On the other hand, the alkali basalt managed to achieve better results, with pH values reaching up to 6.6, although a longer time was required to achieve this result (~100 minutes). The pH values were then stabilized at ~6.3 even after a prolonged time. The high Ca contents present within the plagioclase, the clinopyroxene and even the glass seem, as well as the specific mineralogical, textural and petrophysical properties of alkali basalts seem to be strongly related with their performance and which may interpret the underperformance of more acidic volcanics.

P1-07 The Hydrogeological Conditions as a Crucial Factor for Creating Pit Lakes. The Case of Kyparissia Mine in Megalopolis, Greece.

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The creation and sustainability of the pit lakes, which are considered a small hydrological catchment scale, is a multi-factor problem concerning hydrology, hydrogeology, climatic conditions and many other parameters. Hydrogeological conditions constitute a crucial factor during mining excavations, but they also could define when and how rapidly the final pit voids will be filled with water after the mine closure and influence the final steady state water volume of the formed lake. Such is the case of the Kyparissia surface mine in Megalopolis lignite field, which has ended lignite exploitation since 2012. This paper investigates the hydrogeological conditions of this mine which were the determinant factors for ceasing the exploitation due to the very rapid filling from the three karstic aquifers (Main, North, and West). Continuous pumping was conducted in 2006 aiming to continue the mine exploitation, however with no significant result and thus, the excavations and the lignite production gradually decreased, and the exploitation stopped six years later. Another effort was made, and continuous pumping was conducted from 2015 till 2016, however with no results again and thus, the pumping stopped in 2017. A pit lake has been formed in the mine void with an average depth of 30 m and a maximum depth of approximately 36 m, which extends to a surface of 0.8 km2. The lake is considered in an equilibrium phase as the water table is almost steady for the last 3-4 years. This work also highlights the significant role of the hydrogeological setting in the creation, maintenance and development of the pit lakes for any future uses.

P1-08 Assessment of hand-held XRF analyser performance for the characterization of aluminium scrap

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In comparison to other widely used metals such as copper, lead, magnesium, and steel, aluminium production has one of the largest energy differentials between primary and secondary production. With the use of modern technology, the process of aluminium recycling requires much less energy consumption than its primary production. This helps conserve energy and raw materials while reducing the demands for landfill space for final waste disposal, making it an exemplar of a circular economy. The characterization of aluminium scrap plays a crucial role in its recycling, and hand-held X-ray fluorescence (XRF) analysers offer a portable and efficient solution for on-site analysis. This study focuses on assessing the performance of a hand-held XRF analyser for the characterization of aluminium scrap using the gage repeatability and reproducibility (Gage R&R) method. More specifically the crossed Gage R&R method was used, while the alloying elements and impurities measured by hand-held XRF analyser were: Si, Fe, Cu, Mn, Mg, Cr, Ni, Zn, Pb and Zr. A set of aluminium samples with known composition was used and multiple measurements were taken on each sample using the hand-held XRF analyser by different operators to evaluate the repeatability and reproducibility of the instrument. Furthermore, the accuracy of the hand-held XRF analyser was evaluated by comparing the measured elemental composition with reference values. The results indicated that the hand-held XRF analyser exhibited good repeatability and reproducibility, as well as, a strong correlation between the measurements and the reference values, for the majority of alloying elements and impurities. These findings support the adoption of hand-held XRF analysers as efficient tools for on-site analysis of aluminium scrap, facilitating rapid decision-making and quality control in the recycling industry.

P1-09 Magmatic controls on Zr-Ti-U-Th-REE enrichment in potassic mafic-intermediate rocks and evaluation of their economic significance

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Maronia Pluton is an Oligocene shoshonitic intrusion within the Rhodope Core Complex, emplaced during subduction, following the closure of Pindos Ocean. Three distinct lithologies are recognized within the pluton, namely a basic, an intermediate and an acid group. Mineralogical investigations of selected monzodiorite/monzogabbro samples revealed the presence of magmatic to post-magmatic Zr-Ti-REE minerals. These minerals include allanite-(Ce), solid solutions of huttonite - monazite-(Ce), perrierite-(Ce)-like phases, uraninite-thorianite, thorite-coffinite solid solutions, baddeleyite and zirconolite. Thorite-coffinite, perrierite-like phases, baddeleyite and zirconolite exhibit mineral textures indicative of a late magmatic origin. Allanite-(Ce), monazite-huttonite and uraninite-thorianite are considered of post-magmatic origin, based on their mode of occurrence.

Such a Zr-Ti-REE assemblage are rarely reported in potassic, intermediate-mafic compositions. Magmatic stability and crystallization of such phases in potassic rocks has been interpreted as indicative of late-stage oxidation and magma mixing. Melt derivation from a suitable source, such as metasomatized mantle is fundamental for the occurrence of these metals. Magmatic precipitation, however, of Zr-rich minerals is a major proxy for U, Th, and REE fractionation, resulting in significant enrichments. Deciphering, thus, the magmatic processes in Maronia Pluton, is crucial to understand the factors that control U-Th-REE mineralization in such rocks. This work will contribute towards the exploration of critical metals in potassic mafic-intermediate rocks, and thus evaluate their economic potential in the carbon net-zero era.

P1-10 Application of magnetic geophysical survey for the identification of buried bauxite deposits in Fokis, Central Greece.

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The objective of the project was the optimization of the exploration drilling by applying magnetic geophysical survey for the identification of buried Bauxite lenses of the B3 horizon of the Parnassos-Ghiona zone in Central Greece.
The area selected for the first phase contained Bauxite deposits in variable depths that have been identified from past drilling, to verify the applicability and resolution of the method.
The magnetic susceptibility of the different lithological types was measured to quantify the contrast between the Bauxite and the host rocks and evaluate the limit of resolution of the geophysical method. These were co-evaluated with longitudinal and transverse transect measurements of the magnetic field in the area where bauxite lenses are well known, to identify deep magnetic anomalies in the test area.
The location of the known deposits, as well as structural elements like faults, has been verified during the application of the method and further simulations of the response of the Bauxite lenses for different lithotype contrasts and sizes have been made to evaluate if the method could be used for the purposed of the exploration campaign.
The assessment of the results showed that identification of Bauxite lense at 200m depth was possible for geometries of 700-500m diameter and 10-20m thickness related on susceptibility, at 400m very high susceptibility lenses could be detectable with minimum diameter of 700m and thickness of 15m and at 600m would require very high susceptibility with minimum 800m diameter and thickness of 30m or diameter of 1000m and thickness of 25m.

P1-11 Application of MCDM methods in mineral processing – a review

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Multi criteria decision making (MCDM) methods represent an efficient mathematical tool for making selections between several alternatives which are seemingly similar, and also when a large number of influential criteria need to be taken into consideration. In other words, MCDM methods make difficult choices easier, so that was the reason why they found applications in various areas of life, industry, science, etc.

In mineral processing, when conducting scientific research or also in industrial practice, it is often necessary to make different kinds of decisions based on several not rarely conflicted parameters such as technological, economic and environmental. Making wrong choices can affect the industrial process, make additional expenses and endanger the health of workers and the environment, thus the application of MCDM methods can be the solution and additional help in decision making process.

In past few decades, a large number of MCDM methods were developed and some of them have found application in mineral processing for different purposes such as: selection of various equipment (flotation machines, loaders, etc.), selection of flotation collectors and other reagents used in mineral processing, selection of technologies for processing different raw materials, grinding circuits, and so on. In this paper will be given a comprehensive overview of the used MCDM methods and their applications regarding mineral preparation and processing.

P1-12 Mineral characterization of Ni-Co sulphide ores and tailings from Kevitsa Mine, Finland

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Nickel (Ni) and cobalt (Co) are critical metals for the development of technologies associated with reducing greenhouse gas emission, such as electric-powered vehicles (EV). The demand for these metals is expected to increase in the following years following the increase in demand for EVs in developed and emerging economies. Currently, most of the global production of Ni and Co comes from Indonesia and the DRC, respectively, while Europe only has a minor role in the supply chain. The ENICON project aims to explore the potential of Europe's low-grade Ni-Co geomaterials and create new pathways for the enrichment and refining Ni and Co within Europe.

The Kevitsa mine is a Ni-Cu-(PGE) magmatic-type deposit situated in Northern Finland. This ultramafic-mafic body intruded into the Central Lapland Greenstone Belt at ~2.06 Ga (U-Pb), and its economic potential was identified in 1987 by GTK, with mining starting in 2012. The disseminated ore is comprised of sulphides including pentlandite, pyrrhotite, chalcopyrite, and minor pyrite. Cobalt is an element of interest in this intrusion and is often associated with pentlandite and pyrite with varying concentrations of Co, likely reflecting different generations of sulphide mineralisation. We use a "forensic geometallurgy" approach to characterize materials from different parts of the ore processing flowsheet, from the unprocessed ore to concentrates, in order to identify the mineralogical and textural controls on Co mineralisation at Kevitsa, and how this is linked to other critical metals in the intrusion and throughout mineral processing.

The ENICON project is funded by Horizon Europe (project 101058124) and co-funded by the UK Research and Innovation through Innovate UK. Kevitsa mine is owned and operated by Boliden Group.

P1-13 Mapping the soil chemical properties of the Sarigkiol Basin, Western Macedonia, Greece, in the view of the transition to the post-lignite era

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In this work, the chemical properties of the soils in the Sarigkiol Basin, Western Macedonia, Greece, are studied. The Sarigkiol Basin is of great importance for energy production in Greece. The main activities are lignite mining, power plant operation, agriculture, and livestock farming. Emphasis was placed on the presence of Potentially Toxic Elements (PTEs) in the soils.
An extensive dataset of chemical parameters was analyzed in a total of 34 representative soil samples and selected fertilisers from the Sarigkiol Basin. The data were processed, using statistical methods (Pearson/Spearman correlation coefficients, Factor Analysis-FA, Hierarchical Cluster Analysis-HCA) and spatial distribution maps to reveal the origin of PTEs in the environment. In addition, the enrichment level of PTEs was evaluated using different geoenvironmental indices for soils (i.e., Pollution Load Index-PLI, Enrichment Factor-EF, Geo-Accumulation Index-Igeo).
The results indicate strong associations between Cr, Ni, Co, and As highlighting the influence of ultramafic rocks in the study area. Strong correlations were found between Si, Al, and K suggesting that weathering of silicate minerals associated with pedogenetic processes and the relation of some PTEs (Cu, Zn, Pb, Cd) with P may be attributed to anthropogenic activities such as agriculture, through intensive application of P-bearing fertilisers, used in the study area. The analyses of the applied fertilisers in the Sarigkiol basin revealed new considerations regarding the role of fertilisation in the soil composition. The geoenvironmental indices are most strongly influenced by Cr, Ni, and As, suggesting that these substances are primarily derived from the geological environment and only secondarily from intensive agricultural activities. Mapping soil properties in such a mining area, is of great interest for the next step of the transition to the post-lignite era and the new land uses for sustainable rehabilitation.

P1-14 The Controlled-source Audio-frequency Magnetotellurics (CSAMT/AMT) method tested in the search for deep Fe-Skarn mineralization at Kimmeria, Xanthi, N. Greece

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The CSAMT/AMT method was used for the first time in Greece by HSGME and was field-tested on the ongoing exploration carried out at the Kimmeria Public Mining Area. The skarn mineralization (Fe+Cu±W±Bi) is related to the Xanthi pluton and develops along the contact of the granodiorite and the adjacent metamorphic rocks.
In the magnetotelluric methods (MT), electromagnetic fields are utilized to investigate the electrical properties of the earth and to determine resistivity structures. The electromagnetic fields can be of natural origin (AMT) or created by artificial sources (CSAMT). The AMT fields result from lightning discharges (1 Hz-10 kHz) and the CSAMT far field is created by alternating current run through a grounded cable at frequencies between 0.25 Hz-8 kHz at a large distance (6.5 Km) from the investigation area.
The CSAMT survey was conducted in the eastern part, targeting a skarn zone with Fe-Cu mineralization in the vicinity of the old mine. The results show a highly conductive body with resistivity values of 5-20 Ohm*m, dipping under the granodiorite, at a depth of 200 m, which is probably interpreted as a mineralized skarn zone. The investigation depth of the method reached 800 m. The AMT survey conducted over a skarn zone in the western sector of the area showed a good agreement with IP data with a succession of conductive layers from 40-200 m depth with resistivities of 10-25 Ohm.m and probable correlation to the mineralized zones. The methods confirmed their advantages in terms of investigating at depth and resolution.

P1-15 Recycling concrete to aggregates. Implications on CO_2 footprint

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Over the last decades, the needs of the contemporary way of life and the ongoing population growth have affected the construction industry by causing rapid development of the sector. This accretion combined with the challenging management of construction and demolition waste (CDW) resulted in an increasing amount of waste being produced as well as an associated impact on the environment. Those impacts render their management necessary, in order to contribute to the concepts of sustainable development (SD) and Circular economy (CE).

The present paper discusses the usage of recycled aggregates (RA) from CDW, in correlation with natural aggregates (NA) in the manufacture of concrete, both from quality and environmental perspective. Upon analysis of the physical-chemical and mechanical properties, a replacement ratio of RA of 50% was suggested, considering two factors: 1) the highest acceptable decrease in aggregate properties; and 2) the higher contribution to the environment, which is also accepted by the EN-12620 standard. Furthermore, it was calculated that the net carbon balance of aggregate utilization, based on the above scenario, is approximately 20% lower compared to NA. This study addresses the modern challenge of reducing landfill waste, by rendering recycling of CDW in RA feasible, something that will contribute to reducing the demand for the extraction of natural resources but also reduce the carbon footprint. In this way, it is possible to meet today's requirements without endangering the environment and natural resources for future generations.

P1-16 Circular Economy for Critical Raw Materials in India

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Nations across the world are developing strategies to achieve net zero by adopting energy-efficient pathways and reducing fossil-fuel dependency. In today's globalized world, the demand for critical raw materials has surged, fueled by rapid industrialization and technological advancements. Critical raw materials, also known as strategic or vital minerals, are essential for the production of high-tech goods, renewable energy technologies, and various other applications. However, the conventional linear economy model, characterized by the extraction, consumption, and disposal of resources, is proving to be unsustainable and poses significant challenges for resource availability and environmental degradation.

As India strives to enhance its economic growth to 7 % for becoming $7 trillion economy of world and improve the standard of living for its burgeoning population, it faces a pressing need to address the sustainable management of critical raw materials. The circular economy provides a promising framework to address these challenges by promoting the efficient use, recycling, and reuse of resources, thereby reducing dependence on primary raw material extraction and minimizing waste generation.

We perform criticality assessment for the raw materials used in solar, wind, battery storage technology and hydrogen production to identify the critical raw materials, key drivers for net-zero 2070. In this study, we use applied statistical ranking methodology (qualitative approach) for performing criticality assessment of material. We report projected demand of critical raw materials for net-zero for India. We also discuss, how circular economy can play a vital role in maintain the sustainable supply of critical raw materials for decarbonization.

P1-17 Investigating the recovery of noble metals from single-use medical technology specific waste streams

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Noble metals (Pt, Ir, Au, Ta etc.) have found several applications in specific medical technology products since they present inertness and visiblility through fluoroscopy by an external observer/operator. These products are usually applied as single-use materials and as a result, the corresponding waste streams can be quite rich in valuable metals. On the other hand, limited research has been performed so far regarding the recovery of these precious metals from such products.
The aim of this study was the detailed structural/chemical characterization of the respective raw materials used in these products and the development of a hydrometallurgical methodology to dissolve them, so that the contained noble metals could be subsequently recovered (possibly selectively) from the respective solutions. The examined common medical products in this case were an electrophysiology catheter, a diagnostic guide wire and a stent. According to the proposed methodology the first step (after disinfection) requires the cutting off (separating) the specific parts, containing mainly the noble metals in order to increase their content. Afterwards, pyrolysis was applied, so the plastics covering/organic residues removed completely. The selective dissolution of examined noble metals was followed by using different inorganic acids or proper mixtures of them. Through this work, it was proved that separate flows of the metals of interest can be obtained, and sufficient recovery of them can be finally achieved for potential reuse in similar (or other) applications.
Acknowledgment: The project «Collection, processing and metallurgical recovery of critical raw materials (Au, Pt, Ir, Ta) from discarded medical material» (Project code: KMP6-0084436) was implemented under the framework of the Action «Investment Plans of Innovation» of the Operational Program «Central Macedonia 2014 2020», that is co-funded by the European Regional Development Fund and Greece.

P1-18 Granulometric, chemical, and mineralogical evaluation of Greek lignite bottom ash for potential utilization in the concrete manufacturing

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Bottom ash (BA) is a coal combustion by-product used globally in various applications (e.g. lightweight concrete, cement mortars, asphalt mixes, soil amendment). In Greece, a large quantity of BA was produced in the lignite-fired power plants during the previous decades that was entirely deposited in abandoned lignite mines or landfills. In this study, the potential of selected fractions of lignite BA samples from four power stations in Greece for use in concrete manufacturing was evaluated through granulometric, chemical, and mineralogical analyses. The particle size distribution was obtained by dry sieving. Chemical and mineralogical composition were determined using X-Ray Fluorescence (XRF), Energy Dispersive Spectroscopy (EDS), and X-Ray Diffraction (XRD). Coarse fractions (>1.25 mm) were observed under stereo-microscope, revealing char and inorganic particles of various characteristics. Grain size distribution of the BA particles resembles that of fine aggregates with low percentages of silt-clay, making it suitable for replacing fine aggregates in concrete manufacturing. The high amounts of silica and alumina indicate pozzolanic properties, while the high calcium contents suggest hydraulic/self-cementing properties. However, the high sulphur contents in some samples may inhibit their use in concrete applications due to the potential loss in compressive strength and increase in drying shrinkage. Presence of copper in some samples suggests the need for investigating the possibility of leaching into the environment. The mineralogical analyses reveal the prevalence of amorphous matter, either unburned carbon or inorganic fused ash material, calcite, quartz, aluminosilicate minerals and portlandite, which suggest a beneficial pozzolanic activity in concrete manufacturing, although careful grinding/processing may be necessary for specific applications.

P1-19 A comparative study on the properties of volcanic rocks from Aegean islands, Greece, for utilization as pozzolanic additives in cement

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The utilization of natural pozzolans as cement substitutes is considered as an efficient alternative way to significantly reduce CO2 emissions due to the non-calcinating process that is required for the typical raw materials as limestone and clays in cement production. Major cement industries aim to net zero the CO2 footprint of cement production by 2050 according to the CEMBUREAU 2050 roadmap, a goal that is supported by the substitution of cement by natural or synthetic cementitious materials through which CO2 emissions are estimated to be reduced by 1.3 Gt globally per year.

It is well known that many volcanic rocks of the Aegean region have pozzolanic properties and our research for natural cementitious materials has been focused on pumices from Gyali Island, Pleistocene and Pliocene rhyolites of Kefalos, Kos Island, volcanic tuffs of Kefalos and of Kos plateau, zeolitized rhyolite of Samos island and Ivy tuffs of Chios island. Methods applied for the evaluation of the volcanic materials included XRD, XRF, optical and scanning electron microscopy, energy dispersive micro-analysis and Blaine, while the direct method of measuring pozzolanicity, concerning the consumption of portlandite from each material studied, was the Chapelle hydro-chemical method.

The active silica determination showed that all the formations studied, satisfy the EN 197 1-2 specification for active SiO2 content > 25%. The Pliocene and Pleistocene rhyolites (perlites) of Kefalos, Kos Island demonstrated active silica values above 25% and satisfactory LOI. Despite the fact that they exhibited the lowest Chapelle values, they are considered as the most promising among the studied materials for exploitation as natural pozzolanic source for cement industry due to their homogeneity and specifications compliance along with their wide geographical extend.

P1-20 Hydrometallurgical pilot plant reconfiguration for the recycling of automotive waste for the recovery of precious and critical metals: H2020 Treasure project

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The TREASURE project aims to offer an opportunity to make the automotive sector more circular. This objective is pursued with the realization of tools that support the development of a circular supply chain by testing different technologies. TREASURE's ambition is to concretely support companies in the automotive sector by demonstrating the benefits obtainable from the adoption of the circular economy approach, also from a technical and sustainable point of view. The project can count on a line of pilots on disassembly, recycling, and eco-design to adopt the technologies in ELV management processes. The core of the recycled materials has been provided by car and LCDs manufacturers and dismantlers. Hydrometallurgical recycling processes for the recovery of precious, critical, and base metals are developed for the treatment of different types of waste, such as PCBs, in-mold electronics, and ITO glass from LCDs. Process optimization was focused on the reduction of chemical consumption and on the production of wastewater according to an MLD approach. A pre-existing mobile hydrometallurgical pilot plant, built under a previous European project, was reconfigured according to the TREASURE requirements. The main implementations concerned with solving some critical issues resulting from previous experience in the use of the pilot, making the plant suitable for the treatment of TREASURE materials, and automating according to Industry 4.0 in order that it can be completely governed by the PLC software. Pilot plant tests will demonstrate materials recovery performances by comparing them with the current ones in terms of circularity levels.

P1-21 SEMACRET-Geophysical exploration of magmatic ore deposits

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Critical raw materials (CRMs) are essential for EU industry and strategic sectors, especially about the transition to green energy. However, at present, the EU's domestic supply of primary CRMs is less than 3% for many important raw materials. To gain a better understanding of the EU's critical raw material potential, discover new deposits and thus increase the internal supply of CRMs and secure its raw material autonomy, the EU intends to boost exploration and production of CRMs.
Orthomagmatic mineral systems host important (critical) green transition raw materials such as Ni, Cu, Co, V, Ti, Cr and platinum group elements (PGE). There are currently only two operating mines producing these metals in the EU, although there is potential for other mines in several EU countries. This project is designed to develop exploration methodologies, including socially and environmentally sustainable applied geophysics.
We have a wide knowledge of the geology and can establish geological models with different characteristics within the type of mineralisation sought in the 4 test areas located in Portugal, Czech Republic, Poland and Finland. These geological models have been translated into measurable physical parameters. Exploration procedures have been defined, in which geophysical methods have a very important weight, with different techniques that during the project will be analized in detail to improve them in relation to every type of mineralisation.
This work is co-funded by European Union and UKRI (SEMACRET, GA101057741).

Tuesday 29 August 2023

ROOM 13

SESSION B1

Greece-specific issues (in Greek)

New raw materials/energy projects in Greece I

Chair: A. Xenidis, P. Tzeferis

Tuesday 29 August 2023

ROOM 5

SESSION B2

ERA-MIN3 at RawMat2023

Chair: F. Beolchini

Exploration

Critical metals and environmental risks: better understanding to better predict
O-33

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Antimony (Sb) is a critical metal for Europe and is widely used by the industrial sector (eg flame retardants) and its future use for the energy transition is constantly increasing. Despite its strategic importance and recognized mining potential in the EU, global production remains dominated by China and Russia, and knowledge of the EU's Sb mining potential remains quite limited. However, Sb is also associated with mercury (Hg) and arsenic (As), two toxic metalloids representing a high risk to human health. As the highest concentrations of Sb come from natural sources, an identification of these natural anomalous areas (i.e., primary resources) should be a priority. This project is a multidisciplinary and interdisciplinary approach to unlock knowledge about primary resources and environmental risks. It thus aims to improve the efficiency of Sb ± W mining exploration within the EU, and at the same time to assess the potential large-scale environmental risks linked to toxic metalloids associated with Sb.

Multi-scale and interdisciplinary approaches to the granite-related ore-forming systems in the Segura-Argemela-Panasqueira-Góis belt (Portugal); insights for innovative exploration surveys
O-34

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The Segura-Argemela-Panasqueira-Góis belt (Portugal) extends for ca. 150 km, including various granite-related ore-forming systems: Sn(-Nb-Ta) and Li(-Sn-Nb-Ta) aplite/pegmatite-types and Sn-Li, Sn(-W), W-Cu(-Sn) quartz vein-types.
The pre-Ordovician metasediments are affected by many shear zones and intruded by voluminous Cambrian-Ordovician and Carboniferous-Permian (Variscan) plutons and different arrays of dykes. The Average Shale-normalised composition of metapelites denotes variable enrichments in Li, Cs, Sn, Hf, Bi, As and Sc. Variscan granite suites are more fertile than those of Cambrian-Ordovician age; among them, the strongly differentiated and ferroan leucogranites indicate the most promising targets. The latter two granite groups and related magmatic-hydrothermal ore-forming processes can be traced by Nb/Ta, K/Rb, Y/Ho, Sr/Eu, Eu/Eu*, Zr/Hf, and Rb/Sr ratios. Also, the lanthanide "tetrad effect" parameter (TE1,3) co-varies positively with magmatic differentiation and metal-enrichment. The geochronological data obtained confine to ca. 310-290 Ma the mineralising events within the surveyed belt.
Segura aplite-pegmatite dykes are compositionally close to the Argemela granites, depicting the involvement of highly differentiated, Na2O-rich magmas. Compared to Panasqueira granites, Segura aplite-pegmatite dykes are characterised by excess P not linked to apatite but to amblygonite-montebrasite and to Fe-Mn rich phosphates. These dykes also include Nb-Ta- and Sn-oxides, often displaying complex compositional zonings. The composition of several minerals (e.g., muscovite, tourmaline, and zircon) in different settings, including contact metamorphic aureoles encircling "fertile" granites, are being successfully tested as finger- and footprints to different mineralisation types. Similarly, the abundance and composition of alluvial TiO2-polymorphs, cassiterite, wolframite, and scheelite produce anomaly haloes useful to geochemical exploration in the belt.

Regional to Deposit scale exploration (D-Rex) project
O-35

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The D-Rex project addresses the ERA-MIN Joint Call 2019 “Raw materials for sustainable development and the circular economy”, topic 1: “Supply of raw materials from exploration and mining”. Formation and concentration of metals into economic mineral deposits requires a combination of processes operating at different scales. Mineral deposits are themselves a small part of a very large geological context, the so-called mineral system, which further includes an often deeply seated source for fluids, a source region for metals, an energy source for driving hydrothermal circulation, pathways for the migration of enriched fluids, a depositional mechanism responsible for the formation of the deposit and a fluid outflow. The primary objective of the D-Rex project is to improve the identification of previously unrealised endowed regions. Historically, efforts to understand mineralised systems have focussed on the near surface identification and evaluation of individual resource bodies using shallow imaging techniques. The manageable logistical requirements and small environmental footprint of magnetotellurics coupled with its broadband depth sensitivity (from 10s of meters to 100+ kilometers) are making it an increasingly important and powerful tool for geophysical studies with multiple depth scales of interest. For these reasons magnetotellurics is the primary new geophysical data set collected in D-Rex. We have collected regional datasets at three prospective areas in Sweden, Norway and Finland to generate the regional and deposit scale models needed to identify the deeper footprints of metal concentration. Data are analysed and the first results are presented.

Sustainable Mining Operations

The cuttability of carbonate rocks using a new microwave-assisted laboratory cutting machine
O-36

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The excavation of carbonate rocks by mechanical machines is generally difficult due to low production rate and high tool wear. This difficulty can be overcome by exposing carbonate rocks to microwave energy just before cutting. This paper presents a newly developed microwave-assisted laboratory rock cutting machine. A rock sample is first exposed to microwave energy, then immediately cut by a conical cutter using the test system. Preliminary cutting experiments were conducted on a few different types of rocks exposed to microwave energy and specific cutting energy values are calculated. When compared to samples not subjected to microwave energy, it was found that the optimum specific energy values of the exposed samples were significantly lower.

Use of nanobubble technology in the development of next-gen sustainable liquid mining and phytoextraction processes for the recovery critical and strategic metals
O-37

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As the world transitions towards the electric era, green mining and sustainable metal extraction processes emerge as innovative approaches to meet the skyrocketing demand for metals, while mitigating the environmental impacts of their production. This paper discusses the role of liquid mining and phytomining in the recovery of critical and strategic metals. Liquid mining refers to an energy efficient beneficiation step, where dilute metal-containing aqueous solutions are concentrated via dewatering. This novel processing route enables the recovery of critical and strategic metals from the liquid concentrate in subsequent hydrometallurgical steps, while producing clean water as a by-product. On the other hand, phytomining uses metal-hyperaccumating plant species to harvest metals. In this work, the effect of biochar and irrigation with water containing air nanobubbles (NBs) are presented as means to achieve the optimal growth of plants, ameliorate metal extraction, and ultimately enhance the process. The potential of the NB technology in the development of these next-gen sustainable processing routes is significant, as NBs' unique properties allow them to both improve the efficiency and reduce the environmental footprint of current state-of-the-art technologies. Therefore, the use of the highly innovative NB technology is expected to lead to a zero liquid discharge / zero-waste mining, mineral, and metal processing future, thus enabling the sustainable transition towards the electric era.

Project REVIVING – Bio- Remining mine tailings to the production of critical metals
O-38

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The REVIVING project aims to efficiently recycle metals from residues in case-study mines, based, for the first time, on tailings autochthonous microbiome manipulation. The project addresses the problem of returning residues to the productive cycle, supporting the EU's transition to a circular economy. If tailings are recovered and processed, the pertinent parent material may be regarded as a resource rather than "a mobile good to be disposed of".

The REVIVING project focused on understanding how, previously isolated bacterial strains from the mines of Panasqueira, Portugal, and Minvest Deva, Romania, percolate the residues and their limitations. As an alternative to bioleaching using inoculated microorganisms, the stimulation of the natural microbial community of the residues was used and the increase of relative content of critical metals in the Panasqueira residues was observed at the lab scale. Selective bioaccumulators for the critical metals In and W were developed. This project also explored the use of organic acids produced biologically as a two step strategy to remove metals from tailings. A pilot scale will be achieved, and the results are expected to be positive. This project highlights the relevance of creating biotools that can be explored in new bio or combined methodologies to recover critical metals from low-grade materials

Ore Processing

The MiCCuR project for improved copper recovery from chalcopyrite
O-39

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Bioleaching of copper minerals is usually performed in engineered heaps and this technology accounts for approximately 15-20% of the worldwide copper production. Presently there is an increase in the demand for metals while commercial biomining of chalcopyrite (the largest cop-per resource in the world) is not extensively employed due to slow metal release and limited copper recoveries. In this project, two laboratory-scale, proof-of-concept experiments to in-crease the efficiency of industrial bioleaching of chalcopyrite containing ores will be scaled up to ultimately reach demonstration in pilot bioheaps. Both strategies are aimed at excluding Lepto-spirillum ferriphilum that as a 'strong' iron oxidizer, raises the redox potential above the desired range for efficient chalcopyrite dissolution at moderately thermophilic temperatures. The first strategy is to maintain the redox potential of a chalcopyrite bioleaching system in the favorable range by using 'weak' iron oxidizing microbes such as Sulfobacillus thermosulfidooxidans and the second strategy exploits the lower tolerance of L. ferriphilum to chloride ions (i.e. salt toler-ance) as compared to S. thermosulfidooxidans. In addition, it has been demonstrated that sig-nal molecules control biofilm formation on pyrite and it will be tested if they suppress the growth of L. ferriphilum when grown on chalcopyrite. Although proof-of-concept strategies to suppress L. ferriphilum have been described, the project aims to elucidate how the desired mi-crobial consortium can be maintained in the large-scale bioheaps employed by industry.

RETECH - Recovery of rare earth elements from complex ores in Turkey and their potential use in high tech industrial applications
O-40

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Rare earth elements (REEs) are strategic and critical elements, and vital components for dozens of high-tech industrial products due to unique chemical and physical properties. The overall objective of the project is to conduct R&D studies and develop efficient technologies for valorisation of REEs from existing complex ores, which will contribute to establish a sustainable REE supply chain in Turkiye and EU. Obtaining strategically important REE from a deposit located in Turkiye nearby to EU can reduce dependency of our country and EU to overseas markets, especially to China largest supplier by introducing an alternative source and also it can ensure to have a sustainable and competitive supply chain and/or supply security.
The scope of the project is to extract rare earth oxides from the complex ore reserve in the Eskişehir Beylikova field, which is known to be Turkiye's largest resource. Then, the acquired oxides will be used for metal and subsequently magnet production. The main work packages are complex ore enrichment, purification by solvent extraction, use of rare earth oxides (REOs) and rare erth metals as additives and magnet production.
Sampling, mineralogical-chemical characterization and enrichment studies within the scope workpackages have been carried out jointly with our national partner and completed to a large extent. Mineral characterization tests and mineralogical analysis results show that the ore consist of industrial minerals (fluorite, barite, calcite) and rare earth minerals (bastnaesite, monazite, cerianite, etc.) with trace amounts of silicate and metallic minerals. The rare earths include 2-4 % mass of the whole ore sample. The majority of the rare earth elements are Ce, La, Nd, and Pr in the ore sample. Purification and metal production experiments are ongoing studies now with our Romanian partners.

Electro-electrodialysis technology on the copper electrorefining operation for the recovery of antimony and recycling of the solution media
O-41

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The copper production industry generates several waste effluents that contain valuable elements, among them, antimony, bismuth, iron, lead and arsenic. One of the final steps in the copper production is the use of ion exchange resins to separate some of the impurities that were dissolved from the copper anodes during the electrorefining process. When the resins become exhausted, they are regenerated by washing with highly concentrated hydrochloric acid. The result of this regeneration is a hydrochloric acid solution with antimony and bismuth.

In this work, electrodialysis (ED) and electro-electrodialysis (EED) have been investigated as technologies for the recovery of Sb from wastes and effluents generated during the pyrometallurgical processing of copper sulphide minerals.

First, the electrochemical characterization of the solutions has been carried out employing voltammetric techniques, from which the electrode reactions taking place in the system and their related potentials were identified. The transport of ions through ion exchange membranes has also been studied in order to select the ones with the best properties for the working solution. The electrodeposition of Sb(III) is a mass transport-controlled process, therefore, low current densities have to be applied to perform a selective recovery of antimony. During the treatment, HCl free from metallic impurities is recovered for its subsequent recycling in the regeneration process of the ion exchange resins.

Closing cycles in mining and production

MINECO – New eco-innovative materials for mining infrastructures O-42

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This project intends to develop new materials, based on the tailings resulting from the mining operation, for specific application in the mine infrastructures. Three situations were contemplated, namely the backfilling of the galleries that are left behind, the coating of the walls of the mine tunnels, and the application of protective layers over the tailings' deposits.

Aiming the former of these applications, the tailings were mixed with sustainable binders creating technically competent and environmentally optimized materials. The binders were generated by the alkaline activation technique, forming what is currently known as "alkali activated cements", or AAC, that can replace Portland cement, which, as well known, embodies significant environmental impacts in its production.

A tailing from a mine located in Portugal was used as the base material. It was extensively characterized and treated with AACs produced with different industrial wastes. The best performing mixtures used fly ash from coal power plants and these were further characterized by triaxial testing. Life Cycle Assessment of the mixtures and the calibration of a constitutive model based on the triaxial tests results is ongoing.

To produce AACs, an alumino-silicate source of vitreous structure (the precursor), containing silica and alumina, is necessary. Blast furnace slag and coal fly ash are examples of conventional precursors. To be activated they need a strongly alkaline medium. Sodium silicate (SS) has been widely used for this purpose. However, the manufacturing process of SS involves very significant environmental impacts and costs. A study was carried out to produce waste-based sodium silicate using glass waste from the manufacturing of ophthalmic lenses as a silica source, and an alkaline solution used to clean extrusion rods in the aluminium industry, as the dissolution agent. Comercial sodium hydroxide and sodium silicate solutions were also considered, to establish threshold values.

REEScue-An Integrated process for the recovery of Rare Earth Elements and Scandium from Bauxite Residues
O-43

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Bauxite residue (BR) is a highly alkaline and very fine-grained by-product of the Bayer process. Its huge global annual production, has resulted in BR increasing accumulation, causing deposition and environmental problems. The management and safe disposal of BR are therefore a major issue for bauxite and alumina industries affecting the production cost. The valorisation of BR as a low cost secondary raw material and metal resource, could be a route for its reduction, introducing the waste again in the economic cycle. BR is rich in minerals and metals of high economic interest. It contains oxides and salts of the main elements Fe, Al, Ca, Na, Si, Ti and rare earths - REEs (Sc, Nd, Y, La, Ce, Ds) many of which have been categorised by EU as Critical Metals (CMs).

The present study focused on two different approaches. a) The hydrometallurgical treatment of three different BR samples, as is, and b) the treatment of the same samples after hydrothermal treatment towards the production of magnetite, and the subsequent magnetic separation for the recovery of Fe-rich fraction, suitable for Fe recovery. 70% of the contained Al was leached and could return to the Al plant, whereas the non-magnetic fraction was leached for REE extraction. Recovery techniques such as solvent extraction and ion exchange were evaluated for the REEs recovery from both approaches.

SMART Geopolymers
O-44

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The SMART-G project proposes a valorization approach of Bauxite Residue (BR) and Construction Demolition Waste (CDW) which leads to the production of high added value smart insulation fire-resistant and photocatalytic novel materials for the construction sector. This is being achieved through materials engineering of secondary resources, novel manufacturing technologies such as additive manufacturing and smart manufacturing of building materials, and smart functionalization. The project idea originates from a combination of the existing proprietary knowledge and know-how of the consortium. on: (i) geopolymerization which is an emerging technology with high potentials for the utilization of industrial solid wastes/residues to produce a low carbon cement/concrete replacement for the construction sector; (ii) development of thermal insulating and fire resistant geopolymers; (iii) 3D printing of geopolymeric pastes; (iv) foaming of geopolymers, and (v) integrated photocatalytic coatings with air cleaning functionalities, (vi) demonstrating the final products at an operational environment and testing their performance under real conditions in a demo-building upon project's completion. The involved partners are bringing proprietary know-how and expertise, necessary for this implementation. Aluminium of Greece, is the bauxite residue provider, while the industrial partner, Łęgprzem Sp. z o.o provides the CDW waste. The knowledge and know-how offered by three Universities (University of Aveiro, Portugal; Cracow University, Poland and Vrije Universiteit Brussel, Belgium) and one Research Center (Foundation for Research and Technology-Hellas, Greece) comprise a very important background for the successful implementation of the project. Core asset for this achievement is that in addition, pilot-plant facilities are offered via the SMEs involved in the project (Resourcefull, Belgium; MNLT, Greece), as well as the pilot-scale infrastructure of the FORTH Research Center.

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Tuesday 29 August 2023

ROOM 6

SESSION B3

Energy and CO_2 Storage

Chair: V. Gaganis, Ch. Vasilatos

Carbon dioxide storage in depleted oil fields
O-45

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This paper examines the prospects of carbon dioxide storage in depleted oil wells in the area of Prinos in Kavala, Greece. These are the only oil extraction facilities in Greece, their operation started in the early 1970s and in recent years extraction has decreased dramatically. The need to store this gas arises as a result of measures to minimize carbon emissions into the atmosphere in order to be climate-neutral by 2050 and an economy with net-zero greenhouse gas emissions. Greece as part of the European Green Deal, has adopted the EU strategy in line with the EU's commitment to global climate action under the Paris Agreement. The possibility of reusing the produced carbon dioxide through the oil industry is being investigated, a method that has been the subject of studies worldwide in recent decades.
Incorporating evidence from studies, scientific research and publications, the paper demonstrates that CO2 storage is an affordable and technologically compatible method with existing gas storage methods. It started at the end of the last century, while it has seen particular development in recent years as an auxiliary means for oil extraction in various regions of the world. The resulting economic and environmental benefits are highlighted and reference is also made to the possibility of exploiting similar reservoirs in the wider area. The importance of making such an investment at this particular time period and the environmental and economic benefits for Greece and EU are pointed out.

A unified approach to describe flow dynamics in geothermal energy production systems
O-46

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Geothermal energy is typically produced from a bunch of wells which drain the reservoir. Engineers' experience and reservoir monitoring data are employed to properly determine the wells in operation and their production rate. However, identifying the optimal wells configuration which contributes mostly to the geothermal power produced at the system outlet is very complex since the extracted fluid's energy is attenuated when traveling through the production wells and the surface network towards the delivery point. Un-doubtedly, a reliable optimizer focusing on the unified system would greatly improve its management regarding both energy production and sustainability.
In this work, a mathematical model is proposed, which fully describes flow in the joined production system, by coupling the reservoir, wellbores and ground pipeline network flow dynamics. The reservoir IPR curves are combined to the pipeline network hydrau-lic/thermal behavior, to estimate the geothermal fluid's pressure, flow and temperature at the delivery point. Every design detail, such as well geometry, subsurface heat loss, pres-sure/heat loss along the ground pipeline network is being accounted for. Subsequently, an optimizer identifies the choking that needs to be imposed at each wellhead, so that the ge-othermal fluids produced account for the minimum mass rate, for a given heat load, thus contributing to the sustainability of the geothermal system.
The model can be calibrated using history matching, to further improve estimations ac-curacy. Optimal conditions can be recalculated each time a change takes place in the subsurface system, the surface network or the production constraints.

Energy Transition and Evaporitic formations utilization as potential subsurface storage for H_2 and CO_2
O-47

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Until recently, the role of evaporitic formations in H_2 and CO_2 storage has not been given much attention and it was described as less important in most publications assessing various types of geological storage. Last decade a few countries begun to investigate scenarios of old salt mines as potential store-sites. Although relevant experiments have been made in these countries, this type of geo-subsurface-storage has not been studied in Greece yet.

Despite the absence of salt mines in Greece, a lot of evaporitic formations occur, located mostly in the western and southern part of the country. A few of them show adequate salt bed thicknesses and could be used, given the appropriate requirements, as either, a very good seal or as a potential reservoir. Some of them outcropping due to diapirism, some others due to the Hellenides Fold and Thrust Belt (FTB) tectonic framework. Two types of evaporites are documented; the Triassic ones and the Messinian, both well-known all over the Mediterranean Sea. Among the commonly reported structures are included, well-layered-anhydrites with salt beds, salt-intrusions, diapirs, deformed, thrusted, and collapse breccia bearing peculiar porosities. Each of them may present various risks and a variety of potentiality in commercial-scale which is the question.

In this presentation geologic, and technical data of the various Greek evaporitic formations from onshore and offshore wells are provided, complimented by 2D seismic-lines. The technical challenges and commercial viability are discussed, in order to demonstrate the sustainable potentiality for H_2 and CO_2 geo-storage in terms of Energy Transition.

Sensitivity of CO_2 flow in production/injection wells in CPG (CO_2 Plume Geothermal) systems
O-48

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Geothermal energy is typically produced from underground reservoirs using water as the working fluid to transfer heat energy to surface and eventually to the delivery point. CO_2 has been proposed as an alternative working fluid due to its improved mobility, density and its supercritical phase state, leading thus to the so called CPG (CO_2 Plume Geothermal) systems. As a positive side effect, the injected CO_2 mass circulation in the reservoir can be considered as a CO_2 storage mechanism, which, depending on the size of the porous medium may account for few millions of CO_2 tonnes. Moreover, the thermosiphon effect, owned to the significant change of fluid density between the injection (cold) and the production wells (hot) as well as to its change along the wells, significantly reduces the need for pumping, hence the operating costs.

In this work, we setup a mathematical model, which fully describes flow in the production/injection wells doublet as well as in the geothermal reservoir. Subsequently, the model is used to evaluate the sensitivity of the beneficial effects of circulating CO_2 rather than water. Parameters such as reservoir properties, injection temperature and thermal effects, are tweaked to demonstrate the sensitivity of each one to the system performance. The results can be utilized as a guideline to the design of such systems and to the emphasis needed to be paid by the engineers.

Optimizing Geothermal Energy Extraction in CPG (CO2 Plume Geothermal) systems
O-49

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CPG (CO2 Plume Geothermal) has recently emerged as a promising technology to combine extraction of geothermal energy with underground CO_2 storage, thus achieving double positive results. The idea lies in injecting CO_2 to form a plume and to replace the reservoir brine, which is continuously circulated to transfer heat from the reservoir to surface facilities. Apart from the positive aspects of this technology, such as the reduced energy needs to inject and to lift the working fluid as well as its enhanced mobility in the reservoir and the reduced environmental footprint, there are also negative issues which need to be handled by adequately studying the geological field/reservoir and appropriately designing the production system. For example, wells need to be drilled and perforated to minimize water production and to produce CO_2 solely, thus simplifying the design of the surface heat exchangers. In this work we present the full study of a geothermal reservoir from its geological origin to the dynamic simulation of CO_2 injection and to the estimation of the geothermal energy extraction. It is shown that the system performance is strongly related to the selected schedule and optimizing it, in conjunction to the related cost, is of outmost importance for the Final Investment Decision to be taken and for the viability of such multipurpose-projects under a sustainable future.

Well Control Strategies for Effective CO2 Subsurface Storage: Optimization & Policies
O-50

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Achieving climate goals necessitates an unprecedented transformation of global energy systems in terms of scale, speed, and ambition. Carbon capture, utilization, and storage (CCUS) technologies are recognized as critical components that offer solutions for achieving deep emissions reductions from key industrial processes, including iron/steel production and cement manufacturing, which are essential for modern societies. However, to effectively mitigate the large emissions from these industries, the deployment of CCUS must rapidly scale up from the current level of 45 million tonnes of CO_2 to 2.2 gigatonnes of CO_2 per annum by 2050.

To achieve large-scale deployment of carbon storage, the development of technically sound, safe and cost-effective CO_2 injection and well control strategies is imperative. This requires maintaining a delicate balance of various factors, including subsurface engineering policies, technical constraints and economic trade-offs. Optimization techniques based on the conjunction of reservoir computational models and of mathematical algorithms serve as a valuable tool to address the complexity of the problem and ensure that storage operations are both technically and economically viable, while upholding safety and environmental standards.

This work focuses on the subsurface policies and storage development plans implemented in carbon storage/injection by revealing the strong and weak points of each technology. It also examines the well control strategies and the related optimization techniques in storage options, such as saline aquifers, oil and gas reservoirs and depleted fields. We demonstrate the strengths and limitations of existing optimization approaches which need to be further studied to arrive to the commercial deployment of CCUS.

Tuesday 29 August 2023

ROOM 13

SESSION B4

Greece-specific issues (in Greek)

New raw materials/energy projects in Greece II

Chair: A. Xenidis, P. Tzeferis

Tuesday 29 August 2023

ROOM 5

SESSION B5

ERA-MIN3 at RawMat2023

Chair: F. Beolchini

Battery recycling

Challenges and opportunities for recycling of spent lithium ion batteries – a summary of results of the NEXT-LIB project
O-51

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During 2019-2023, Swerim coordinated an ERAMIN funded project, NEXT-LiB with focus on optimization of the LiB recycling system aiming for substantial improvement of the existing technologies. The project focuses on recovery of Li, graphite, electrolyte and studies on formation of hazardous gases during shredding of spent LiB which is of great importance for the working environment in the battery production and recycling industry.
This paper will highlight the most interesting research results from the project and demonstrate the potentials and possibilities for future improvement of the existing technologies. Possibility and limitations will be discussed

Biotechnological recycling and recovery of metals from waste printed circuit boards & spent Li ion batteries- ERAMIN EU BaCLEM Project O-53

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Waste Printed Circuit Boards (WPCBs) and Spent Li-Ion Batteries (LiBs), obtained from EXITCOM recycling plant in Turkey were processed and subjected to bioleaching and metal biorecovery steps. For LiBs, shake flask bioleaching tests were at first conducted using an adapted mixed culture acidophilic bacterial consortium (lab stock) to optimized the metal recovery, primarily Li and Co from the samples. The optimum conditions were used to perform scale-up bioreactor (1L, 10 L, and 100 L) leaching experiments. In addition, a 2nd set of bioleaching tests involved Gluconobacter oxydans to investigate the bioleaching efficiencies from laboratory-scale to semi-pilot. For PCBs, bioleaching with a pure culture of acidophilic microorganism was done in a two-stage bioleaching processes in a 2L bioreactor. On the other hand, optimization tests using a mixed culture was perfomed in a two-step approach from laboratory-scale to semi-pilot scale (10L). To improve the metal resistance of microorganisms, genetic engineering was undertaken on some strains. Some chemical leaching tests were also investigated from lab-scale to pilot-scale by using H2SO4. The leached residue obtained from the above leaching steps were characterized inorder to understand the metal content and morphology follwing microbial action. The leach solution from bioleaching studies was further treated for metal extraction. Iron was precipitated with NaOH and precipitations for Co and Li were obtained using the ureolytic bacteria Sporosarcina pasteurii. A preliminary overall flowsheet for LIBs processing was provided with the details about each unit operation using a SuperPro Designer program. The works fall within the scope of ERAMIN2 funded collaborative project - BaCLEM.

Magnets and E-Waste

Recovery of valuable metals from Nd-Fe-B magnet leach liquor using antisolvent crystallization and non-aqueous ion exchange
O-54

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To drive the transition to a climate-neutral economy, Europe will need a sustainable and secure supply of key technology metals, such as rare-earth elements (REEs) and cobalt. Urban mining and recycling have been put forward as one key strategy to overcome Europe's dependency on Critical Raw Materials (CRMs), next to primary mining and CRM substitution. The primary objective of the ANTISOLVO ERA-MIN2 project is to take a new concept, antisolvent crystallization, and apply it to the indirect, chemical recycling of End-of-Life (EoL) REE-based permanent magnets that are contained in electric vehicles, direct-drive wind turbines and a multitude of consumer electronics. EoL magnets were characterized by SEM-EDS, XRD and ICP-OES, to support the experimental work. The sulfuric acid leaching of Nd-Fe-B magnets was followed by antisolvent precipitation. By adding an alcohol as antisolvent, e.g. ethanol, the REE can be selectively precipitated as rare-earth sulphate hydrates, while other elements such as Co, Ni, Cu, Fe and Mn are left in the solution. The rare-earth sulphate hydrates can be easily re-dissolved in aqueous solution for further processing. Subsequently, non-aqueous ion exchange (NAIX) was tested ethanolic solutions to recover the non-REE constituents of EoL magnets. While a strong cation exchanger (Amberlyst 15, H+) recovered all metal ions quantitatively without selectivity, a strong anion exchanger (Amberlite IRA-402, Cl-) showed particular selectivity at high ethanol concentrations (>80 vol%). The coordination of Cu and Fe on the latter resin was not conclusive from the XPS studies, yet it indicated that Cu could most likely be recovered from 95 vol% ethanolic feed at elevated temperature as Cu(I). Ongoing studies are also investigating IX and ion chromatography for REE separation and purification from non-aqueous solution.

Siderophores assisted recovery of Ga, In from the end-of-the life product
O-56

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High techs such as communications, renewable energies, displays are heavily dependent on metals such as indium (In) and gallium (Ga). These metals are used in photovoltaics, liquid crystal displays – among others. The supply of these metals is essential for the continuous supply of high-tech devices. However, due to the export control and hoarding, the supply of these metals to the high-tech industry of Europe is not assured and hence, European Commission has listed these metals supply as critical. Recycling of these metals from their end-of-life (EOL) products is a way to overcome the shortage of these metals. However, there are no technologies available for recycling of these metals due to their low concentrations and presence of large number of contaminants. A highly selective and sensitive solvent, ligand or reaction is needed to recover these metals. Siderophores has been shown to bind selectively bind to Ga, and In and Ge even when these metals are present in very low concentrations. Thus, exploiting of siderophores for these metals' recovery can be very interesting. However, no work has been carried out to recovery these metals from their EOL products using siderophores. There are two main challenges in the recovery of metals from their EOL products using siderophores. The challenges are 1) Right selection and production of siderophores, 2) Access of siderophores to the target metals in EOL products.

In the Siderec project, we have demonstrated that selective leaching of In and Ga (>40%) while not leaching contaminants more than 5% from EOL production. Further, we demonstrated that Density Functional Theory (DFT) calculations can be used to identify siderophores that have better binding ability to In and Ge. With these results, we have achieved TRL 3 and the next steps are upscaling of the technology.

Minerals Material Cycles

Evaluation of EOL Materials as SCMs for OPC
O-57

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Various End-of-Life (EOL) materials could become supplementary cementitious materials (SCM) for Ordinary Portland Cement (OPC) depending on their mineralogical composition. We studied 8 different EOL materials from three different countries as potential SCMs. The materials were characterized by location, chemical and mineral composition, their potential for activation, and their (potential) hydraulic reactivity. Various activation procedures were applied to the candidate SCMs depending on their mineralogical makeup. Composite cement blends were generated with potential EOLs with up to 40 wt% EOLs. Pastes prepared from these composite cement blends with EOLs were tested for their strength after hydration durations ranging from 2 days to 365 days. Compressive strength values were compared to the strength of 100 % OPC pastes samples. Durability of the pastes were tested for alkaline and sulfate attacks, separately. Several EOLs in certain mixing ratios gave strength values that matched the one of 100% OP pastes although in blended cement 40 wt% of cement was replaced with these activated EOLs. We developed a systematic mixing scheme for the EOLs that gave the best strength and durability combination.

ReFina - Novel methods for enhanced recovery of metals and minerals from fine incineration ash
O-58

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The fine fraction of municipal solid waste incinerator bottom ash, less than 2 millimeters, represents between 6 and 8 million tons of waste per year in Europe, which is typically disposed of in landfills. However, this fraction has proven to be a secondary source of valuable materials such as copper (1.6 to 3.5 g/kg) or zinc (2.5-6.5 g/kg). In addition, the high content of elemental aluminum in this residue, up to 10 g/kg, is also of interest for the production of the so-called lightweight or aerated concrete. The current ReFina project aims at an integrated treatment of this municipal residue. Our research has succeeded in obtaining, through physical concentration treatments, a concentrated product of dense non-ferrous materials, such as copper, with concentrations higher than 100 g/kg. At the same time, the light mineral fraction obtained has been successfully used as an aggregate to obtain aerated concrete with similar properties to those of market formulations. Finally, the concentrated product of dense non-ferrous metals has been treated with novel hydrometallurgical techniques capable of achieving high recovery values of the target metals. All these studies have been carried out in line with the theory of circular economy, incorporating the mineral fraction of the bottom ash into the construction industry and integrating these valuable metals obtained into the European market, ultimately reducing our dependence on raw materials from third countries.

PROPER: New sustainability metrics to improve refractories recycling performances regarding resource use, environmental impacts and economic benefits
O-59

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About 30 million tonnes of spent refractories are generated every year. Only 7% are recycled in the refractory sector when a larger amount is downcycled in lower value applications. The goal of PROPER is to assess the resource efficiency of closed loops refractories recycling through different lenses: environmentally using life cycle assessment (LCA), economically through a cost-benefits assessment including monetized environmental impacts and regarding resource use by assessing resource losses along the process.
To do that, three different refractory-based products are considered, distinguishing both primary and secondary production routes. Inventory data are drawn from extensive on-site collection regarding secondary production routes directly at the manufacturer site (Extracthive Ceramics Recycling), including in particular measurements of energy consumption, on-site dust emissions, and consistent mass balances. In parallel data for the primary routes were drawn from literature review and specific databases completed with expert judgement.
The LCA is completed with an assessment of resource losses using methods that assess resources dissipation and that were recently developed in the LCA world. Both the JRC-LCI and the average dissipation rate methods are here applied.
LCA results are also included in an economic assessment through monetary valuation. The goal is to look at the economic value of the secondary raw materials based on willingness-to-pay approaches and especially the discount associated to the use of secondary resources against primary ones. Apart from the monetary valuation of the environmental impacts, it includes the negative externalities associated to resource use linked to resource losses.
The combination of information regarding resources losses, environmental impacts and economic benefits allows the development of indicators to measure and improve resource efficiency of raw materials production processes.

Enabling circular economy

RedOx Recycling - A new approach for the recovery of gold from E-waste
O-60

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End-of-Life products containing noble metals, for instance gold in electronic waste, are an invaluable waste stream and often the driving force of the whole recycling cost structure. Beside economical motivations, keeping these resources-streams in a closed-loop is paramount from an environmental point of view and for the establishment of an effective circular economy scheme. Currently, noble metals recycling relies on a centralized collection/ recovery structure hinging on the use of large integrated smelters. This technology is well-established and efficient, although it employs high temperatures (i.e., high energy costs) and dangerous chemicals. Our goal is to develop a hydrometallurgical process to leach noble metals from end-of-life products at much milder and safer conditions than current state-of-the-art processes. This new developed process should be first tested at a lab-scale level and transferred to a small-scale chemical reactor. To close the loop of recovery, the project will investigate the extraction of the leached metals by electrodeposition. As a proof of concept, an electrodeposition module will test the optimal parameters. As initial use-case, the project employs the refuse from BOSCH production sites involved in the manufacturing of electronics and the goal should be the identification of the corresponding technological solutions for disassembly, pre-treatment, and logistics. An economic feasibility verification of the hydrometallurgical process will follow. Finally, to assess the environmental gains of our innovative approach an assessment of the CO_2 footprint of the process compared to state-of-the-art is carried out.

LiCoBAT - LIthium and Cobalt recovery from batteries coming from the reverse logistics chain of WEEE
O-61

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LiCoBat is a cutting-edge initiative aimed at the reverse logistics and recycling of Li-ion batteries, with the building of a pre-industrial scale pilot-plant designed for the safe recovery of Lithium (Li) and Cobalt (Co) elements.

This project is born out of a patent developed at the University of Rome – La Sapienza – by the EcoRecycling spinoff company, and from the technological cooperation between Brazil and Italy. This action is part of the Program for Research and Innovation in Raw Materials for the Promotion of the Circular Economy – ERA-MIN 2 (2016-2022), a global pan-European network represented in Brazil by the Ministry of Science, Technology and Innovation and by Finep, and in Italy by Regione Calabria.

As important as the development of the industrial prototype is the project goal, which is to carry out a mapping of the disposal of Li-ion batteries, as well as of the path such batteries follow until reaching recycling facilities – mainly in Brazil, due to its extensive territory. The objective is to learn the present reverse logistics limitations, and also to identify the actions required to optimize the feeding of a future industrial plant, both in Brazil and in Italy.

In Italy, the LiCoBat project has as its agent the Ecosistem company, located in the Calabria region, while in Brazil the agents are the CTI – Information Technology Center Renato Archer and Biosys Waste Management.

End-of-life Li-ion Battery Management Integration and Technology Evaluation
O-62

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Lithium-ion batteries (LIBs) are increasingly used in consumer electronics and electric vehicles (EVs), resulting in the production of large amounts of end-of-life (EoL) LIBs. These contain valuable metals such as cobalt, nickel, manganese and lithium that can be recycled. The goal of the project was to deliver an implementation framework on the best way to establish EoL LIB recycling facilities, respectively in the European Union (EU) and South Africa (RSA). Alternative hydrometallurgical recycling technologies were evaluated, including established and novel approaches. This was done through 1) Market Analysis and Business Case Development; 2) Life-Cycle Assessment (LCA) to compare the environmental impacts; 3) Material Flow Analysis (MFA) and Reverse Logistics Network (RLN) optimisation; and 4) experimentally testing two novel flowsheets, which incorporated leaching with Methanesulfonic acid (MSA) and the use of Solvent Displacement Crystallization (SDC). Significant differences exist between the projected markets in the EU and RSA, due to growth in the EV market that is expected to be significantly higher in the EU. Nine established hydrometallurgical process flowsheets were evaluated, using H2SO4, HCl and citric acid lixiviants. It was found that H2SO4 leaching, followed by precipitation of Nickel Manganese Cobalt (NMC) material, is the best option. This was the case from an economic and environmental point of view. NMC can directly be used in the production of new cathodes. The two novel technologies were proven experimentally and were then also evaluated in terms of economic and environmental performance. Reverse logistics networks were developed in both regions, specifying the number and locations of recycling facilities, collection centres and transport networks of materials to customers locally and internationally.

Tuesday 29 August 2023

ROOM 6

SESSION B6
Environment and Sustainability I

Chair: N. Kalogerakis, A. Argyraki

Immobilization of Rare Earth Elements and Yttrium (REY) by iron (bio)precipitation in sulphated acid waters from El Bierzo (Spain)
O-63

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Weathering of large dumps of middle Ordovician black shales have led to the occurrence of Acid Rock Drainage (ARD) affecting La Silva stream (El Bierzo, Spain). This ARD is characterized by sulphated acid waters with high concentrations of heavy metals and dissolved thorium (Th), uranium (U), and Rare Earth Elements and Yttrium (REY). To study the mobility of these REY, water, sediment, and precipitate samples were analyzed from La Silva stream and its tributaries. Water samples taken along La Silva stream presented the highest values of REY (4,086 µg/L) at pH 3 and close to the ARD input, suggesting an effective dissolution of these black shales containing phosphate detrital minerals as monazite and xenotime. Further in La Silva downstream, input of natural waters from La Silva tributaries increase pH favoring the hydrolysis of Fe(III) and its precipitation. Sampled iron oxyhydroxy-sulphate (mainly schwertmannite and goethite) presented a great specific surface, promoting the adsorption and therefore immobilization of REY from water such as Ce (max. 39 µg/g), Y (max. 27.3 µg/g), Nd (max. 25.4 µg/g) and La (max. 7.10 µg/g). Furthermore, microbial analysis in some of iron precipitates revealed the participation of microbial microaerophilic iron-oxidizers from the Gallionellaceae family, pointing out the potential role of microorganisms in the immobilization and therefore accumulation of REY in sulphated acid waters.

First study of microbial diversity living at Nisyros volcano extreme environment - Future applications
O-64

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Extremophiles are those organisms which thrive beyond 'normal' environmental parameters. The term of 'Extremes' includes physical extremes (e.g. temperature, pressure or radiation) and geochemical extremes (e.g. pH, salinity, oxygen etc.)
The Hellenic Survey of Geology and Mineral Exploration, has developed a project focusing on the collection, isolation, identification and taxonomical characterization of microorganisms living in extreme environments such as volcanoes and hot springs.
In the present paper we present a first look into the Bacterial Diversity of Nisyros Volcano, Greece. The microbial diversity of Nisyros volcano has never been investigated.
Nisyros is the youngest Hellenic large volcano edifice, defining the easternmost edge of the South Aegean Volcanic Arc (SAVA), whose activity is related to the subduction of the African continental crust beneath the Aegean–Anatolian plate
A collection of samples was carried out during 2020 and 2022. Soil samples were collected aseptically from the surface and in a depth of 20 cm.
The solid samples were chemically analyzed .
Extraction of genetic material from the soil was performed using the PureLink™ Microbiome DNA Purification Kit (ThermoFisher) according to the manufacturer's instructions.
Geochemical analyses of soil, water and gas samples and microbiological analyses-genomic studies of soil samples (16RNA sequencing) were used to investigate the adaptation of the microbial communities at extreme conditions caused by the occurrence of hydrothermal fluids in the volcanic environments.
Genomic studies of thermophilic microbes inhabiting this extreme environment have revealed numerous microbial populations (actinobacteria, cyanobacteria, proteobacteria , etc).

Grain size distribution of rare earth elements in a passive treatment system installed in a legacy polymetallic sulfide mine in Portugal
O-65

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To understand the evolution of the geochemical behavior of rare earth elements (REE) in different compartments of a passive treatment system, soil and sediment samples were collected throughout the system. The samples were first sieved to < 2 mm to obtain the bulk composition and then separated in different size fractions: 2 mm-63 µm, 63 µm-2 µm, and < 2 µm. The REE and trace metals concentration of the bulk composition and size fractions were determined with INAA coupled with ICP-MS. The mineral phases were determined with XRD and SEM-EDS. The iron oxidation state and compounds in the bulk composition were studied by Mössbauer spectroscopy. The results show that in bulk composition, soil from the confined cells and sediment collected in an acidic pond have an enrichment of middle REE (MREE) and light REE (LREE) when compared to heavy REE (HREE). Meanwhile, samples collected in the wetland and in circumneutral water show a flat pattern with a slight enrichment of MREE. The fraction that mostly holds the majority of REE is 63 µm-2 µm and exhibits the same distribution patterns as described for bulk composition. On the other hand, the < 2 µm fraction displays an enrichment of HREE compared to LREE in most of the analyzed samples. The samples are composed mainly of phyllosilicates, quartz, feldspars, and other accessory minerals. Goethite/ferrihydrite are the most abundant Fe oxyhydroxides identified in all the samples, followed by hematite. The presence of jarosite was only identified in one sample.

Long-term assessment of surface cover geochemical characteristics of a treated sulfidic mining waste pile in Lavrion, Greece
O-66

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Sustainable remediation of sulfidic waste piles in historical mining areas can be complex and challenging. Acid mine drainage has been recognized as a serious environmental problem in abandoned sulfidic wastes within the Lavrion urban area. In the sulfidic pile of Kavodokanos, containing about 600000 t of sulfidic tailings, mitigation methods have been proposed and tested in-situ by applying three different dry cover setups with one untreated control by NTUA in the late 1990's. Visual inspection of the pile in November 2019 revealed the borders of treatment quadrants, evidenced by changing vegetation pattern. The aim of this study is to identify important reactions that may have affected the surface cover characteristics in the quadrant plots, almost 25 years after the initial treatment. Combined chemical analysis, X-ray diffraction and scanning electron microscopy were used for the characterization of 40 collected samples. Metal(loid) concentrations in the surface cover vary, reaching > 10000, 12, 4930, 542 and 4010 mg/kg Pb, Cd, Zn, Cu and As respectively in the control plot. The lowest concentrations on average are observed in the compacted clay plot. Mineralogy is dominated by secondary metal bearing hydrous sulfates in all plots. Our results imply that the application of cover-treatments to promote water retention and reduce acidity has led to different degrees of evaporation and infiltration in the long-term. This is evidenced by the geochemistry of the surface material, providing a useful case study on the long-term fate of metal(loid)s under different treatment conditions in the semi-arid environment of Lavrion.

Risk assessment of Metal transportation mechanism from mining source by rainfall runoff as a contribution to the bioaccumulation in seafood
O-67

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Trace metal transport mechanism via rainfall runoff from soil near to mining facility to the water body in the context of the bioaccumulation in seafood was tracked. Soil sampling sites were selected in the region (Windar Valley, Balochistan-Pakistan reported with high trace metal content. This site is quite away from urban anthropogenic activities. Threadfin Sea Catfish and Belanger's Croaker were caught from the adjacent coastal water body. The selection of fish species is based on seafood consumption trends and the abundance of the species near the opening of the windar river to the ocean. The selected metals Pb, Cd, Ni, and Zn in soil samples were high in proportion; the average concentrations were 2793.8, 622.44, 331.33, and 440 in mg kg^{-1}, respectively, as per expectations. The evidence for the bioaccumulation of metal portrays the contribution of the rain runoff to the metal load in the ocean. Using ArcGIS, the soil sample results were extensively illustrated by the spatial distribution in the sampling regions. The Zn>Pb>Ni>Cd was found in pre- and post-rainfall fish flesh samples. Trace metals were higher in post-rain fish flesh samples than pre-rainfall samples, indicating that rainwater runoff could be the significant source for trace metal transport except for Zn. The Pb, Cd, Ni, and Zn elevated results.

Environmental assessment of replacing fossil fuels with hydrogen for motorized equipment in the mining sector
O-68

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For reaching the European milestone of climate neutrality by 2050, the decarbonisation of energy intensive industries is very essential. In 2022, global energy-related CO2 emissions increased by 0.9% or 321 Mt, reaching a peak of over 36.8 Gt. A large amount of these emissions is the result of fossil fuel usage in the motorised equipment used in mining. Heavy diesel vehicles, like excavators, wheel loaders and dozers, are responsible for annual estimated CO2 emissions of 400 Mt of CO2, accounting for around 1.1% of global CO2 emissions. Besides that, exhaust gases of CO2 and NOx endanger the personnel's health in all mining operations, with emphasis to the underground environments. To tackle these environmental concerns and enhance environmental health, extractive industries are oriented in the replacement of fossil fuels with alternative fuels of low or zero CO2 emissions. In mining, the International Council on Mining and Metals has committed to achieve net zero emissions by 2050 or earlier. Of the various alternative fuels, hydrogen (H2) has seen a considerable rise in popularity in recent years, as H2 combustion accounts for zero CO2 emissions, due to the lack of carbon in the burning process. When combusted with pure oxygen, it also accounts for zero NOx formation and near-zero emissions overall. To this end, this study aims to examine the overall environmental performance of H2-powered motorised equipment, compared to the conventional fossil fuels-powered equipment, though Life Cycle Assessment. The results will offer an overview to support decision-makers of the sector.

A scenario-based analysis for the selection of post-mining land uses applying a cellular automata model
O-69

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The vision of the Greek lignite mining industry, entering the coal phase-out era, is sustainable mine closure and land reclamation and, at the same time, the enhancement of safe mining and post-mining activities. During the operation period of continuous surface lignite mines, many areas throughout the years were exposed to flooding causing significant problems both in the operation of the mines and in the reclamation of the mine lands. The main objective of this study is to provide a methodology to detect the areas included in complex surface mining landscapes that are more vulnerable to flooding during extreme weather events using satellite remotely sensed data. This is an important issue for strategic mine closure and reclamation planning. In addition, this research examines whether radar or satellite images perform better in mapping flood areas in such complex areas as continuous surface mining sites. Considering flood detection, several methods can be applied using Synthetic Aperture Radar (SAR). This research uses the change detection method, which requires two images, one during the flood event and the other pre-flood. Furthermore, the Normalized Difference Water Index (NDWI) and the Modified Normalized Difference Water Index (MNDWI) were used to detect surface water delineations after the flood event by employing Automatic Otsu Threshold. Finally, the performance and comparison of the methods were achieved through on-site recordings during heavy rains.

Towards the exploitation of unconventional heavy oils: Electrostatic technologies for the minimization of dehydration cost
O-70

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The growing energy demand have created a large interest towards the vast unconventional oil reserves that include heavy oil, extra heavy oil and bitumen, the exploitation of which is particularly challenging. This type of hydrocarbons exhibits difficulty both in extraction due to the high specific gravity, high viscosity and low mobility as well as in separation and flow assurance due to the high content in asphaltenes, resins, and hetereoatoms.
The study is a comprehensive review of the implemented technologies and the emerging techniques for the dehydration of heavy and extra heavy oils with an °API gravity from 20 to below of 10 and a viscosity between 100 and 10.000 cP. The available options for oil – water separation include mechanical, thermal, chemical and electrostatic treatment or, more often, a combination of them. Special focus is given on the electrostatic treatment, which is an established technology due to its versatility of applications in oil dehydration. Improving dehydration efficiency with the use of this technology is an object of continuous research, either as in the form of a stand-alone electrostatic coalescer or as supplementary internal in existing vessels. The main objective is to mitigate the heating demand of the electrostatic dehydration, to reduce the dosage of chemical demulsifiers and consequently the operating cost.

Tuesday 29 August 2023

ROOM 13

SESSION B7

Mining: Trends and perspectives I

Chair: I. Kapageridis, C. Roumpos

Evaluation methodology of open pit mine overall slope failure risks
O-71

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The geomechanical stability of overall slopes is one of the most sensitive elements of a mining eco-technical system. Slope failure risks and corresponding probabilities and consequences are related to a large number of causes, so their quantification is a complex process.
The proposed risk evaluation methodology includes defining the influence of economic, technical, ecological and geotechnical parameters and analyzing the overall slope stability risk, both in the design phase stage and in the development and closing phases in real-time. Important causes of slope failure can be: the reliability of geological parameters as a basis for the opencast slope design process, degree of implementing planned mining technology and dewatering activities, as well as the occurrence of extreme rainfall and earthquakes for a time-dependent cost of failure consequences. A modified quantitative value method V-FMEA (Value-Failure Mode and Effect Analysis) opens the possibility of risk evaluation with a constant check of acceptable probabilities of overall slope failure and the implementation of detection and preventive activities in function of consequence costs, which include preparatory work, landslide sanation, repair of facilities and equipment, endangerment of health and loss in production. The variable parameters for the overall slope stability risk evaluation are the sanitation costs shown as present value consequences and the probability of stability failure and the possibility of detecting the cause of failure with the accompanying removal or reduction of consequence costs. The opencast mine Field E serves as a good example of this slope failure risk evaluation methodology.

A Glimpse to a Holistic Approach to Environmental Monitoring of the Kolumbo Submarine Volcano with Implications for Deep Seafloor Mining, Ocean Governance and Policy
O-72

Stephanos Kilias[1], Vasilios Pletsas[1], Nikolaos Zegkinoglou[1], Paraskevi Nomikou[1], Theodoros Mertzimekis[1], Paraskevi Polymenakou[2], Andreas Gondikas[1]

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The world's seas and oceans (S&Os) are under intense stress from human activities and from geologic stressors, which are overlooked. The synergistic impact of natural stressors, including deep-sea mining (United Nations Sustainable Development Goals), to S&Os are not yet quantified. The active Hellenic Volcanic Arc is one of the two most volcanically, hydrothermally active and mineralized areas within Exclusive Economic Zones of EU countries. It is perhaps the only place on Earth where the intensity of both anthropogenic and natural stressors is so pronounced, making it the ideal site to study the S&Os ecosystem responses to natural stressors, and potential exploitation of mineral resources. Here we investigate the active Kolumbo Submarine Volcanic-Hydrothermal Ecosystem (SUVHEC), as a role model for a volcanic-hosted deep-sea ecosystem including critical raw materials, for a holistic approach to environmental monitoring. Considering that such research on submarine arc volcanoes is still in its infancy, our aim is to increase knowledge to enable a science-based sustainable management strategy for protection for deep-sea ecosystems and sustainable exploitation of seabed resources. Cutting-edge and innovative deep-sea instrumentation and multidisciplinary research is needed for environmental management of the multi-stressor SUVHEC. SANTORini's sea floor volcanic observatorY, (SANTORY), is developed and installed within the Kolumbo crater to monitor SUVHEC and mitigate potential hazards. SANTORY will establish exchange of information with projects, such as: IODP Drilling Expedition 398, RAMONES, and NEXUS-MONARC. These results will be communicated to governmental officials, and to actions endorsed by the United Nations Decade of Ocean Science for Sustainable Development.

Narrow Reef Mining (NRE) – innovative mining technology for narrow, sub-horizontal PGE ore bodies
O-73

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The platinum-group metals (PGM – Pt, Pd, Ru, Rt, Ir, Os) occur jointly in nature due to their similar physical and chemical properties. PGM deposits differ from any other mineral resource by its: (1) very low grade ore (the average PGM mines contain only 5 – 15 ppm of PGM; (2) very old age (Archean to Proterozoic); (3) specific lithological and geotectonically setting (linked to craton-related layered mafic intrusions), and (4) morphology of the ore (occurring in stratiform layers or lenses, generally below 1m thickness, spreading sub-horizontally for hundreds or meters or kilometres e.g. Platinum or PGM reefs).
Classical underground platinum mining mostly use LP equipment (low profile; 2.2m) and Bord and Pillar mining method. When LP equipment is applied to low-grade, thin, sub-horizontal Platinum reefs is diluting the PGM ore due to inevitable large amount of mined waste-rocks. For that reason, ULP- ultra low profile mining equipment (0.9 - 1.7 m; the NRE fleet) was developed. NRE fleet is composed of NRE Dozer, Drill Rig and Support Rig, each machine operate between 0.9m and 1.7m width at 22° slope (dozer up to 25° slope), are remote-controlled, fully automatic with tracked undercarriage, and are zero-emission due to electric drive. Developed machines are suitable for narrow reef platinum mines worldwide hosted in layered mafic intrusions as well as similar type of thin, subhorizontal layered deposits. The NRE fleet is a unique innovative electric robotic solution for underground mining, aiming to increase safety and productivity while reducing capital and operating costs.
More information on the mining technology is available here: https://dok-ing.hr/underground-mining/

Using force field analysis for examining and managing the stakeholders' perceptions in mining projects
O-74

Francis Pavloudakis, Philip-Mark Spanidis, Christos Roumpos

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The role of the mining industry is undoubtedly vital for global economic growth while, at the same time and under certain conditions, it is decisive to regional and local development. However, the practices applied in the past for the exploitation of mineral resources, which led to significant degradation of the environment, have formed a negative attitude of the parties involved in every mining project. In this context, Corporate Social Responsibility (CSR) and analysis of stakeholders are strategic choices for the mining industry that can contribute to the effective management of a whole project or its components, from the deposit exploration to the mine closure and land reclamation.

This article uses force field analysis (FFA) to examine the role of internal and external stakeholders in the lignite mining project of the Ptolemais basin, Greece, which is entering the closure phase at an accelerated pace due to the energy transition policies. Internal stakeholders are the people working in the mining organization, which, as a public power supply utility, is responsible for the management and execution of the lignite exploitation. In contrast, external stakeholders are entities outside the organization, such as local authorities, NGOs, and the government.

The FFA is applied in four steps: identification of internal and external stakeholders; classification of them into groups according to their interest and influence on the project; assessment of each stakeholder's strength in quantitative terms and graphical representation of it in a force field diagram; management of stakeholders' perceptions. The result of this article is the determination of a specific course of action that balance the benefits and impacts for all stakeholders.

Application of International Standards to Evaluate the Potential of Sustainable Secondary Production of Tin and Tungsten in Portugal O-75

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The ambitious movement towards industry 5.0 technologies and green transition drive the efforts toward securing critical metals' supply chains globally. In Europe, highly economically important Tin and Tungsten are raising concerns regarding supply security due to geographical reserves' uniformness and socio-political reluctance to mining. Nevertheless, mines that have seized operations in Portugal due to not being sustainable in the past are gaining attention again for further exploitation in rising market demand and reclamation efforts due to environmental concerns. Such abandoned resources need to be reassessed for their feasibility from an economic, social, and environmental perspective to ensure sustainable exploitation. Presenting the production criticality of Tin and Tungsten, this study implements the United Nations Framework Classification for Resources (UNFC) to assess the viability of abandoned mines and tailings dumps in Portugal considering the indicators of Sustainable Development Goals (SDGs). The work indicates that Portugal's abandoned Vale das Gatas Tin and Tungsten mine has good potential for further development. Furthermore, social perception towards new and abandoned mining is evaluated by collecting opinions from different parts of the country. It has been identified that sustainable technology and job opportunity are the driving parameters for the social acceptance of mining projects in Portugal.

Machine Learning Techniques to model and predict airflow requirements in underground mining
O-76

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Underground mining exploitations are some of the most challenging working environments, where controlling and maintaining the air quality is of fundamental importance. The main goal of the ventilation systems is to supply fresh air and successfully disperse gaseous pollutants and airborne particulates. Analyzing the conditions, taking into account local or overall requirements while at the same time adjusting and directing the air flow is up to now, in the majority of cases, heavily relied on the manual control of its parameters (man-in-the loop).
This paper analyses the air-flow requirements of underground exploitations and the accurate assessment of the future conditions, so as to effectively adjust the ventilation parameters. More particularly, ML techniques are utilized to capture the patterns or prevailing conditions and to be able to generalize/predict future conditions managed by the ventilation system. The case examined is about an underground bauxite mine, the characteristics and requirements of the mining exploitations have been developed into a digital twin. Through this model several scenarios are developed and evaluated and more importantly data is gathered allowing for the training of the ML algorithms for the assessment of the required airflow, taking into account air-quality data, the number of workers and machine fleet. The ventilation system can be automatically adjusted to the existing conditions development of a ventilation on demand strategy coupled with autonomous capabilities that can achieve both significant improvements in work safety, significant savings on the ventilation energy consumption and a reduced overall environmental footprint of the exploitation.

Tuesday 29 August 2023

ROOM 5

SESSION B8

ERA-MIN3 at RawMat2023

Chair: Pontus Westrin

ERA-MIN SRIA workshop

This workshop aims to collect feedback and expert opinions on the new Strategic Research and Innovation Agenda (SRIA) on raw materials supply for the green and digital transition. The SRIA will serve as a basis for a future international research and innovation partnership within the field of non-energy, non-food raw materials. The workshop discussion will be based on the current draft agenda structure, and focus on identifying technological and structural challenges, as well as research and innovation needs, in six thematic areas:

- Resilient primary and secondary raw materials supply
- Efficient use of raw materials in design and production
- Sustainable use and reuse of products
- Effective policy development and governance
- Maximizing societal benefits
- World-class innovation capacity

See the ERA-MIN website (https://www.era-min.eu/) for more information.

Tuesday 29 August 2023

ROOM 6

SESSION B9
Environment and Sustainability II

Chair: T. Eerola, A. Peppas

Reconciliation conflicting societal objectives: Nature protection vs. raw materials supply resilience
O-77

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The EU is exposed to severe supply risks for certain mineral raw materials, as 1) these minerals are currently known to occur at only few locations, 2) mining is dominated by a small number of countries, 3) politically motivated threats, warfare, or pandemics can disrupt supply-webs, and 4) a fragmented and inconsistent regulatory approach. At the same time, the EU is facing an increasingly perplexing dilemma of having to protect its natural environments and biodiversity while having to ensure a sustained and sustainable supply of minerals. The Green Deal and the Energy Transition require large additional quantities of minerals. Together with the paradigm of economic growth, it will lead to the need to mine in pristine areas.
Mining must take place where the minerals are, but the EU has many protected zones (nature reserves, drinking water, cultural heritage, etc.), where mining is forbidden or only accepted under very strict conditions. To minimise societal conflict potential, inclusive and transparent decision-making is crucial, together with genuine and meaningful participation of all stakeholders. Thus, decision-making process should not just be a token gesture to appease stakeholders, but rather a process where their inputs are actively sought, considered, and incorporated.
The CIRAN project (www.ciranproject.eu) explores innovative options for systemic assessments beyond active mining as a practical bridge from established sectoral methods to ones suited to the economic, environmental, societal, and governance (ESG) challenges of today. It will result in a transparent, system-oriented approach to managing natural resources above and below ground.

Assessment of the environmental behavior of phosphogypsum with the application of lab-scale experimentation
O-78

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Phosphogypsum (PG) is a reject of the phosphoric acid production process in phosphate fertilizer industries. The process results in the production of relatively large quantities of PG that it might cause serious environmental and human health concerns. The data of a laboratory investigation of PG are presented here. Lab-scale experiments with lysimeters were conducted in order to simulate and examine the environmental characteristics and the temporal behavior of PG leachates in terms of physicochemical characteristics and chemical composition. Based on the results, leachates from already deposited for many years PG or its mixture with marble powder, seemed to have better pH and conductivity values and lower elemental concentrations compared to leachates from freshly disposed PG. However, the leachates characteristics improve and stabilize in both cases after four days of irrigation or of 1080 mm - 1240 mm of rain. Most major elements were found to have minimal leachability, and the material satisfied the environmental limits for its disposal at landfills for inert and non-hazardous wastes.

Can We Alleviate the NIMBY Effect?
O-79

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Global raw materials demand is projected to more than double from 79 billion tonnes to 167 billion tonnes in 2060, due to population growth, digitalisation, vehicle electrification, increasing requirements from developing countries, the urgency of climate action, etc. The EU's target of zero emissions by 2050 will require approximately 35% more copper and aluminium than it consumes today. Cobalt and nickel demand could rise by 330% and 100%, while the use of lithium and rare earth elements could grow by 35 and 26 times, respectively.
Given the resistance of local communities to the extraction of mineral resources ("Not in My Back Yard" or NIMBY), the energy transition and the new global economic model represent an opportunity for new approaches to mining. Considering that green-field mines take years to be permitted and developed, such novel attitudes should include the following:

- The support and launch of policies and regulations by the decision-makers and legislators at all levels that can enhance the growth of mining,
- The realistic acceptance by the NGOs, which usually fuel the communities that oppose mining, that everything that backs our current way of life comes from Mother Earth, and
- The responsible and fair dealing with local communities (systematic information from day one, strengthening community partnerships, granting offset benefits, etc.) by the project executives.

BULGCOLD Inc. (TSXV: ZLTO) is committed to having the Social License to Operate at the heart of its sustainable operations to alleviate the NIMBY effect.

Remote Sensing Analysis for Flood Detection in Complex Surface Mining Areas Using Satellite Data
O-80

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The vision of the Greek lignite mining industry, entering the coal phase-out era, is sustainable mine closure and land reclamation and, at the same time, the enhancement of safe mining and post-mining activities. During the operation period of continuous surface lignite mines, many areas throughout the years were exposed to flooding causing significant problems both in the operation of the mines and in the reclamation of the mine lands. The main objective of this study is to provide a methodology to detect the areas included in complex surface mining landscapes that are more vulnerable to flooding during extreme weather events using satellite remotely sensed data. This is an important issue for strategic mine closure and reclamation planning. In addition, this research examines whether radar or satellite images perform better in mapping flood areas in such complex areas as continuous surface mining sites. Considering flood detection, several methods can be applied using Synthetic Aperture Radar (SAR). This research uses the change detection method, which requires two images, one during the flood event and the other pre-flood. Furthermore, the Normalized Difference Water Index (NDWI) and the Modified Normalized Difference Water Index (MNDWI) were used to detect surface water delineations after the flood event by employing Automatic Otsu Threshold. Finally, the performance and comparison of the methods were achieved through on-site recordings during heavy rains.

Durability of red-mud concrete pavement slabs
O-81

Aggeliki Skaropoulou[1], Konstantinos Tsivolas[1], Ioanna Angelou[1], Konstantinos Sakkas[2], Christos Georgopoulos[2], Maria Taxiarchou[1], Efstratios Badogiannis[1]

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Globally, over than 3 billion tons of red mud are stored, making it one of the most abundant industrial wastes on the planet. Aluminium plants generate an additional 150 million tons per year. Considering its alkalinity and content of pollutants, together with the EU directives for a greener environment that promotes the circular economy, its use consists a challenge. This paper proposes the valorization of red mud in concrete contributing to the reduction not only of waste but also of the consumption of primary raw materials for cement production and consequently of CO2 emissions. More specifically, a study of the rheological and mechanical properties, along with the durability of concrete slabs incorporating red mud is presented.

Investigation of thermal behavior of cementitious pastes, mortars and concrete- Effect of Closed Structured Expanded Perlite addition
O-82

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As the Construction sector moves towards buliding decarbonisation and NZEB buildings, the construction materials are required to perform, along with the good structural properties several functions, including providing thermal resistance to the new building. In this paper a study of the evolution of thermal conductivity in relation to the material consisitency in samples of cementitious pastes, mortars and concrete is performed. A significant parameter that is also studied is the effect of the addition of lightweight aggregates to the thermal conductivity of cementitious materials. The lightweight aggregates used to perform this study is Closed Structured Expanded Perlite, produced at a specific Vertical Furnace at NTUA premises.

Integrated mine water management system in mixed sulphide mines
Case study: Kassandra mines
O-83

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The aim of the study is the presentation of an integrated system for the effective management of mine waters draining from mixed sulphide mines. This system ensures the protection and preservation of the qualitative characteristics of water resources, within mining facilities and in their wider area, and full compliance with the legislative environmental quality limits for final effluents and surface water receivers. The proposed collection and treatment system pertains to waters with characteristics representing the entire mine life (from post closure to fully operational mines) and the composition of the drainage (from alkaline with low metal concentrations to highly acidic with very high metal concentrations). As a case study, the mine waters draining from the Kassandra Mines were examined.
Specifically, when the mine is in operation, the system encompasses water treatment using active methods, meaning methods that are effective, entirely controllable, but with high operational and maintenance costs. For compliance with legislative final effluents quality limits, the exclusively proposed stage is primary treatment using the classical method of neutralization with calcium hydroxide, which has been applied effectively for many decades in the Kassandra Mines. In the event that the goal is to attain even further lower concentrations of metals in the final effluents, such as meeting the target values of the EQS for surface receivers, the system is suggested to incorporate, after primary treatment, a supplementary stage of secondary or even tertiary treatment, which were studied through on-site pilot tests for this project. This methodology ensures the quality of surface water receivers even under conditions of extensive drought due to climate change.
On the contrary, when the mine is in a closure and rehabilitation phase, the system recommends the application of passive treatment methods, meaning low-cost methods with limited maintenance and monitoring requirements.

Tuesday 29 August 2023

ROOM 13

SESSION B10

Mining: Trends and perspectives II

Chair: M. Galetakis, I. Kapageridis

Artificial Intelligence Engineering System for a Tailings Storage Facility O-84

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Tailings storage facilities (TSFs) are engineering structures that store mixed waste material from mining processes in liquid or slurry form. Historically, they caused more trouble than water dams. Moreover, they are never past the construction phase because of the constant need for more stor-age, and therefore raising embankments to accommodate tailings during the life of the mine. All these issues lead to TSFs requiring extra careful management. Over recent years, much effort has been put into the development of monitoring systems; however, with the growing number of sen-sors, there is an emerging need to analyze a large amount of data. This paper presents a new en-gineering system based on artificial intelligence (AI) algorithms that help to analyze data from tailings storage facilities. The system has been developed and verified at one of the largest TSFs in Europe called Zelazny Most, located in western Poland. The AI system has been developed as a part of the illuMINEation project, funded by the EU Horizon 2020 research and innovation pro-gram. The core objective of the illuMINEation project was to improve the efficiency, health, and safety of European mining operations and their personnel.

Onsite characterisation of magnesite and laterite mining blocks by using novel sensing technologies – An experimental approach
O-85

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One promising solution for the exploitation of mineral resources in complex geological settings is to use stand-off sensing technologies during excavation. To ensure the wide adaptation of these techniques, extensive testing in mines is mandatory. However, conducting extensive trials in operating mines is expensive and time consuming. Instead, creating and testing physical models of mining blocks in controlled conditions offers reduced research costs and repeatability of the test. In this study, specimens, consisting of ore, waste aggregates and cement as binder, resemble the mineralogical composition and the physical properties (surface roughness, moisture, etc.) of the real mining blocks of a ferro-nickel laterite deposit. These specimens were measured using various sensors on robotic scanners for onsite characterisation, including pLIBS, pXRF, multispectral sensors, a magnetic susceptibility sensor, and a laser profilometer. Results showed that the intensity of the recorded signal is strongly affected by water saturation, surface roughness and porosity of the specimens. Although the cement used in the specimens resulted in a reduced percentage of ore and waste, the elemental composition and magnetic signatures of the aggregates were still distinct.

Risk analysis in underground marble quarries using geotechnical data from monitoring equipment
O-86

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Stone quarrying has been a steadily growing mining activity for the last ten years in Greece, that has not been effectively studied and documented based on scientific data and projects until today.
Most of the marble material used to be exploited using open pit mining with vertical benches. The sustainable development of a marble quarry led the industry to move forward using modern underground excavation procedures. Underground marble quarries based on the room and pillar method pose several potential risks and hazards, including roof instability, pillar failure, and slope instability. Risk assessment models are able to identify and monitor geotechnical risks and lead to recommendations for improving risk management and geotechnical safety in marble quarries.
In this study, data from new technology and specialized monitoring equipment such as sensors and instrumentation as well as data on marble quarry operations and geotechnical conditions is collected and analyzed. The data was recorded automatically and periodically by a specialized state-of-the-art data logger and archived in an autonomous electronic file, syncing at the same time in a dedicated database. The installed sensors were sufficient in quantity and continuously logged data over time, covering as much of the excavated area of the underground openings as possible.
The multifactor evaluation of the above geotechnical data adds substantial scientific value to the geotechnical stability risk analysis of underground marble exploitation and supports the necessity of installing and using geotechnical monitoring equipment in large areas of underground marble openings with intense mining activity.

Applying Model-Based Systems Engineering to Tailings Storage Facility Structures
O-87

Bartłomiej Bursa[1], Paweł Stefaniak[2], Ioannis Kakogiannos[3]

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Model-based systems engineering (MBSE) is a methodology that focuses on creating and exploiting the digital system and engineering domain models as the primary means of exchange of information, feedback, and requirements, as opposed to document-centric systems engineering. The numerical model that encompasses all structural information lies at the heart of the system. Furthermore, this computational model can calculate crucial parameters such as displacements, stresses, and strains. The innovative SEC4TD project, funded by the EIT Raw Materials, proposes an integrated end-to-end (E2E) solution composed of three hardware and software innovative products for mining operators and service providers that will enable multi-scale multi-platform data collection and visualization, events prediction, effective information management, and data traceability. Within this framework, SEC4TD has commenced utilizing the MBSE approach to develop a system specifically for tailings dams. The system integrates all the data from the field, laboratory tests, and monitoring systems to assess the stability of the tailings dam. In the event of unsatisfactory results or the identification of potentially dangerous occurrences, the system immediately notifies the engineering personnel responsible for the tailings storage facility. The MBSE system for tailings dams has been tested at the two tailings storage facilities, one in Poland and another in Bosnia. The article describes the concept, architecture, and data used in the system.

Industry 4.0 roadmap for the mining industry
O-88

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The mining industry is by nature a challenging and demanding sector. Except for extraction; management, processing, and transportation are involved in the mining operations. Mining in-dustries are capital-intensive and often are located in geographically remote and isolated areas, and have substantial environmental and social impacts. The sector is considered traditional and conservative regarding innovation. Nevertheless, its multidimensional nature, combined with the declining ore grades and the increased demand for scarce resources, generates an imperative for innovation and the adaptation of new technologies. In line with Industry 4.0, Mining 4.0 is the framework for integrating technologies such as the Internet of Things (IoT), automated drones, 3D printing, robotics, sensors, data analytics for monitoring and performance evaluation, etc., in the mining industry. The legislation, regulatory, and governance arrangements often create barriers to the absorption of innovative concepts in the mining sector. This study overviews the gaps, barriers, inefficiencies, and enablers in the regulatory framework of the mining sector in relation to new technologies utilization.

Machine Learning Based Domaining of a Porphyry Copper-Gold Deposit
O-89

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Porphyry copper deposits are the main source of copper and other metals mined today to satisfy an ever-increasing global demand. Resource modelling of such deposits can be challenging as they usually present a complex geological environment, difficult to capture using conventional modelling tools. The porphyry deposit in this study contains economic grades of Cu, Au, Mo, and Ag, is hosted by a basalt sequence, intruded by quartz monzonite, and disrupted and bound by faulting. Mineralisation consists of quartz-stockwork veining and alteration is typical of porphyry copper systems.

A multi-step modelling approach has been applied to derive distinct grade estimation domains, after their statistical and spatial identification using drillhole data. It was based on a neural network-based domaining system called Maptek DomainMCF and conventional explicit and implicit modelling techniques. Initially, a block model of alteration was generated by training a DomainMCF machine using alteration information in the drillhole data. A block model of earlier lithology types was then generated by training a DomainMCF machine with drillhole lithology information. Producing these sub-blocked models of alteration and early lithology was a matter of minutes including uploading data, training the machine, estimating blocks, and downloading results. Newer formations were modelled using implicit modelling in Maptek Vulcan. The models of newer lithology types overwritten earlier types produced by DomainMCF where necessary, leading to a complete model of lithology. Alteration and lithology block models were imported to a single regular model and combined to domain the blocks. Explicit modelling of major faults produced models that were used to bound the domains.

The multi-step application of DomainMCF allowed the development of a geologically consistent modelling process incorporating large amounts of data, significantly reducing the time required to produce results.

Transforming decommissioned mines to gravity energy storage system O-90

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The energy transition is driven by renewable sources like wind and solar, but their intermittency requires energy storage systems to balance supply and demand. Batteries which can provide short-term storage solutions and pumped-hydro storage which can provide long-term energy storage with large generation capacities, are the most common used energy storage systems word-wide. Battery based energy storage systems have limited number of cycles and severe environmental footprint (difficulties in recycling lithium-ion batteries). On the other hand, pumped-hydro storage has specific topographical requirements (two large water reservoirs at elevations with a suitable vertical separation) thus building new sites is difficult. A new solution is gravity energy storage (GES), which moves a weight from a lower to an upper elevation using a conveyor belt and bulk granular material. An uphill conveyor belt is used to elevate the material and a downhill regenerative conveyor belt is used for energy harvesting. GES can store energy in stockpiles and generate power by transporting the material downhill, and its storage capacity is limited only by the size and geometry of the stockpiles and elevation difference. Conveyor-belt based GES can be installed in decommissioned open pit mines, which offer suitable topography and available material. This paper investigates the effect of parameters affecting the performance of the conveyor belt-based GES by employing sensitivity/uncertainty analysis. The main parameters considered in the analysis included conveying distances and inclinations, type of conveyed materials, piles heights, and rubber belt and idlers rolling resistances.

Multi-risk assessment in post-mining lignite areas
O-91

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To reduce CO2 emissions and increase the use of renewable energy sources, Europe is moving towards the independence of coal and lignite as the main fuel for energy production (European Green Deal). Huge areas committed to coal mining will be reclaimed and appropriately valorized for the benefit of local communities. The valorization of these “post-mining” areas is a pillar for the just transition to climate neutrality. The content of this paper is directly related to this transition in the era of decarbonization. After the end of mining activity, sustainable reclamation requires quantifying the resilience and safety of mining areas, related infrastructure, and risk and hazard analysis of both the pre-reclamation and post-reclamation eras. The analysis focuses on the soil as a key element in characterizing lignite excavations, processes, areas, and geotechnical engineering. A key element of this paper is the advanced multi-risk assessment through multi-hazard analysis with risks that can occur either one after the other or simultaneously with and without a dependency relationship. The multi-hazard analysis offers a realistic approach to assess risks comprehensively. The three main groups of risks include natural (e.g., earthquake, rainfall), mining (e.g., small-scale landslide, flooding, subsidence, environmental pollution), and technological (e.g., industrial explosion, infrastructure failure) hazards. A semi-quantitative multi-hazard method is being developed to detect the interactions of risks, characterizing the significant non-linear superposition of individual risks. This method analyzes each risk individually, builds interactions between them, and finally quantifies the multi-hazard risk. Each risk will be examined objectively and systematically, with clear assumptions quantifying the likelihood of occurrence, mechanisms, and consequences.

Tuesday 29 August 2023

ROOM 5

SESSION B11

Hydrometallurgical processes for metals recovery from EoL and ores

Chair: S. Riaño, E. Balomenos

Recycling platinum and palladium from autocatalysts: searching for alternative processes combining efficiency with environmental sustainability
O-92

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Platinum-group metals (PGM), such as platinum (Pt) and palladium (Pd), are scarcely available in our planet (≈66 kt) [1] and, in 2018, over 360 t was used in autocatalysts [2], making them considered critical minerals in the EU, US, Japan, Canada and Australia.
In developed countries, recycling PGM from autocatalysts are based on pyro- and/or hydrometallurgical processes. The latter are based in dissolution processes where highly concentrated extracting solutions and long leaching times are used which implies high consumption of reagents and energy requirements. Moreover, current PGM purification processes, which are based in precipitation (PP) and/or solvent extraction (SX), pose several drawbacks: incomplete and difficult separation of each PGM (PP) and inefficient metal recovery at low concentrations (SX). Thus, such procedures presently do not contribute to a clean and efficient handling of waste autocatalysts and to a more sustainable production of PGM.
Following all these thoughts, this work proposes, for the first time, a holistic and integrated approach which combines one microwave-assisted leaching step using a mixture of hydrochloric acid (HCl) and hydrogen peroxide (H_2O_2) followed by two ion-exchange purification (with a strongly basic anion exchanger resin) steps to recover Pt and Pd from a roasted grinded (size ≤1 mm) end-of-life diesel autocatalyst. Our preliminary results point out for a global PGM leaching yield >88 % after microwave-assisted leaching with 2 mol/L HCl and 1 % (v/v) H_2O_2 for 6 minutes at 200 °C. Furthermore, eluates containing Pt or Pd with a purity ranging from 85 % to 90 % can be selectively achieved after synthetic leachates, with a multi-metal composition mimicking the real leachate, are used in continuous ion-exchange purification with a fixed-bed glass column apparatus.

[1] Dong et al. (2015) International Journal of Mineral Processing, 145, pp. 108-113
[2] Wei et al. (2020) Journal of Cleaner Production, 239, paper 11803

Gold recovery from integrated circuits: proposal of an innovative and greener hybrid process
O-93

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Integrated Circuits (ICs), a major electric component of printed circuit boards, have multiple functions, such as amplifier, computer memory, micro-controller, or microprocessor. Due to its important function, its constitution has to be resistant to high temperatures; so ICs are made of silicon dioxide reinforced with brominated epoxy resin and a metallic fraction. Each IC contains in average 0.65, 41.95, 29.65 and 16.91 %wt of Au, Cu, Fe and Ni, respectively, among other metals. This metallic constitution turns ICs in a very good opportunity to recover Au.
However, the non-metallic fraction is very hard to remove without environmental damage. The methods applied until now have several disadvantages, such as, the emission of toxic gases and high energy consumption [1]. Furthermore, a relevant loss of Au is reported [1].
Hence, in this work, we propose a different approach that combines, firstly, a sequence of mechanical, (by pressing the ICs sample at 400 bars) and physical (sieving and magnetic separation) processes that allows to separate a fraction enriched in Au from another fraction mainly constituted by base-metals, and, then, followed by a chemical process to recover gold from the fraction enriched in Au. The sequence of mechanic-physical processes allowed to concentrate 80% of the gold in the non-magnetic fraction with a low percentage of other base (Fe and Ni) metals. From the non-magnetic fraction, Au was leached using KI-H2O2-H2SO4 system where several parameters were optimized: temperature range from 30°C-60°C, KI concentration from 0.5M-1.5M and H2O2-H2SO4 concentrations that varies according to KI concentration, S/L ratio 15%-5% and time 30 minutes - 3 hours.

Leaching and recovery of gold from ores using alternative lixiviants to cyanide
O-94

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In the recent years many research publications appear in the technical literature related to the application of alternative lixiviants to cyanide for gold leaching. The driving force for these research studies arises from the environmental hazards potentially caused by cyanide's toxicity and the ban on its use posed in various countries in the world.

The present work is based on a detailed review of the relevant literature. The advantages, disadvantages and restrictions of the alternative technological solutions were assessed and compared with the currently applied technology of cyanidation. The chemistry of the available cyanide-free processes, the typical operating conditions and their performance regarding gold extraction and recovery, were examined in detail. Health and safety issues, environmental aspects, the development stage and the technological restrictions and challenges of the examined processes were also taken into consideration for evaluating their potential.

Solvent extraction for iron removal and HCl recovery from Ni/Co pregnant leach solutions: flowsheet optimization and thermodynamic modelling
O-95

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To secure future supply of battery materials in Europe, the valorization of domestic European nickel and cobalt resources will become inevitable. With a focus on responsible mining, the Horizon Europe project ENICON (https://enicon-horizon.eu/) develops an HCl-based flowsheet to convert Europe's Ni/Co ores and tailings into battery-grade metal salts. This HCl-route applies the principles of "Circular Hydrometallurgy" and will use industry-appropriate, inexpensive chemicals. This includes the recovery of HCl and iron by solvent extraction instead of neutralization or precipitation, respectively. Starting from a synthetic solution, containing Co, Ni, Fe, Mn, Zn, Cu, Mg and Ca, a three-step solvent extraction (SX) process is proposed for the purification of Ni/Co. First, iron is quantitatively removed by undiluted tri-n-butyl phosphate (TBP) in one contact. HCl can be recovered from the FeCl3 stripped from the loaded organic phase by hydrolytic distillation. Second, excess HCl, which originates from the leaching operation, is efficiently removed by tris(ethylhexyl)amine (TEHA) at elevated temperature (60°C) or with the addition of a diluent (10 – 20 vol% Shellsol GS190) to reduce viscosity. Stripping with water at elevated temperature (≥ 60 °C) and O/A ratios between 1/2 and 1/3 allow to recover > 60 % of HCl, with 94% recovery at O/A = 1/5 and 100 °C. In the final step, Versatic Acid 10 is used to extract Ni and Co selectively. To support the experimental research, a thermodynamic model for calculating liquid-liquid equilibria with TBP was developed using the semi-empirical OLI Mixed-Solvent Electrolyte framework, and this model will be extended to TEHA.

Gold recovery from refractory auriferous sulphides applying the Platsol Process
O-96

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The conventional cyanide leaching process has been used for many decades to extract gold and other precious metals from auriferous ores and concentrates. Although cyanidation has given excellent results throughout these years, its negative environmental impact due to cyanide's toxicity and the ban of its use in various countries in the world has led scientists to search for alternative methods that can bring similar results. The Platsol process has proven to be a promising one for the treatment of refractory gold ores, as it minimizes the environmental impact as well as the overall cost of gold extraction. The method combines in one treatment stage the oxidation of gold bearing sulphides and the extraction of liberated gold in the aqueous phase. This is obtained by conducting the pressure oxidation treatment in the presence of a limited amount of chloride anions in the aqueous phase.
In the present work the Platsol process was evaluated for gold recovery from a concentrate, where the main gold bearing phases were pyrite and arsenopyrite and gold content was close to 20 g/t. The experiments were conducted in a laboratory autoclave of 1 liter and the investigated parameters were the operating temperature (200-220oC), the O2 pressure partial pressure (200-700 kPa), NaCl concentration (5-15 g/L) and S/L mixing ratio (10-20%). The results of the experimental work demonstrated that the Platsol method can be very efficient for the treatment of this refractory gold bearing concentrate. Namely it was possible to obtain in one step the oxidation of sulfides and a high percentage of gold recovery in the aqueous phase (92-93%) applying relatively mild operating conditions, i.e. S/L=100 g/L, T= 210oC, pO2=200 kPa and NaCl=5 g/L.

An innovative approach for the crystallization of battery grade cobalt sulfate
O-97

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The rapid and ongoing electrification of the world's vehicle fleet, which is necessary to enable the transition to a civilization based on renewable energy, is only possible owing to the lithium-ion batteries. Cathode active materials with diverse chemistries and properties can be produced by various compositions of critical metals like lithium (Li), nickel (Ni), cobalt (Co), and manganese (Mn).
Different hydrometallurgical processes are investigated to recover cobalt sulfate (CoSO4) from end-of-life electrical vehicles' NMC batteries, which is crucial to the industry for achieving the goals of the new European regulatory framework for batteries. For the recovery of high-grade CoSO4 from strip liquor of solvent extraction operation antisolvent crystallization, often referred to as salting out crystallization, is investigated as an alternative to conventional processes.
Cobalt was separated using solvent extraction and the commercial extractant cyanex 272. On a batch scale, solvent extraction experiments were carried out to optimize the extractant concentration, equilibration time, organic-to-aqueous phase ratio (O/A), scrubbing, and stripping conditions. The process was validated in continuous mode using a battery of mixer-settlers MSU 0.5 by MEAB. Furthermore, preliminary experiments were carried out for the antisolvent crystallization of cobalt sulfate. CoSO4 was successfully obtained through antisolvent crystallization. High cobalt recovery rates with low co-extraction were achieved. The specifics, benefits, and challenges of operating of liquid-liquid extraction as well as anti-solvent crystallization were discussed further.

Recovery of antimony from alkaline sulphide leaching solutions
O-98

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Antimony is classified as a Critical Raw Material (CRMs) by the European Commission. In the case of the Olympias mine in Chalkidiki, where there is exploitation of mixed sulfide minerals, antimony is collected along with galena. Its presence in galena concentrates is considered an impurity by customers, leading to penalties when its concentration in the concentrate exceeds limit values. This study examines the recovery of antimony from Olympias galena concentrates through leaching in strong alkaline sodium sulfide solution, oxidation of the pregnant solution with elemental sulfur (to oxidize trivalent antimony content to pentavalent antimony), and its subsequent precipitation as sodium thioantimonate after cooling.

The extraction, oxidation, and precipitation experiments were initially conducted using synthetic antimony sulfide (Sb2S3) solution, and then, under common experimental conditions, the behavior of antimony was investigated when it is not derived from solid antimony sulfide but is contained in galena concentrates. Successive leachings of galena were carried out using the pregnant solution as a leaching agent for further galena leaching, aiming to enrich the solution. During the experimental process, cooling temperatures and time were varied to find the optimal conditions. The antimony recovery results were independent of its origin, with extraction rates from the alkaline sulfide leaching being 90-97%, and precipitation rates as sodium thioantimonate being 75-80%, for both solid antimony sulfide and galena concentrates

Tuesday 29 August 2023

ROOM 6

SESSION B12

OSH and EPD Reporting

Chair: G. Barakos, K. Adam

The experience on the implementation of Risk Management in OSH and environmental issues in the extractive companies
O-99

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Risk Management (RM) as a management technique has developed significantly over the past 20 years globally to address risks. RM is often linked to financial, reputational, and quality risks. The purpose of this article is to shed light on the environmental and Occupational Safety and Health (OSH) risks associated with the extractive industry, as well as how they are managed. A number of interviews with extractive industries were held as part of the European Commission project "Elaboration of Guidelines for Best Risk Management Approaches in the Extractive Sector" in order to investigate and identify the sector-specific approach to the Risk Management processes concerning environmental and OSH risks. The extractive sector believes that society's acceptance is a key element to being licensed to operate. So, the management of risks under the perspective of providing high OSH standards and, at the same time, achieving the lowest impact on the environment are the keys to a productive operation. The interviews showed that most extractive companies used custom-made risk management practices, predominantly for internal use and not for licensing. Only the Environmental Impact Assessment acts as a vehicle to summarize the key findings from the RM concerning the environmental issues, and to communicate these to regulators and the interested public alike. Members of the Environmental and OSH departments state that when complex risks arise up, both teams through brainstorming sessions use RM to find common solutions. Companies also believe that there were no contradictory risks when assessing the perspective of OSH and the environment.

Piloting the establishment of soil geochemical baselines for Potentially Toxic Elements (PTEs) in Greece- Preliminary results from Attica and Boeotia
O-100

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Geochemical baselines offer critical information for sustainable development because they provide a reference point for understanding the natural background levels of various elements and compounds in the environment. By establishing such baselines, we can better detect and assess the impact of human activities on the environment, including the extraction and use of natural resources, as well as pollution and other forms of environmental degradation. In Greece, national scale soil geochemical baselines are yet to be established. The present study serves as a pilot project on establishing the soil geochemical baselines with the ultimate aim of publishing the first Soil Geochemical Atlas of Greece, and create a rich, publicly available, database of soil geochemical data. A total of 164 samples were collected from 117 locations on a 5 km x 5 km grid within the pilot area of about 2500 km2 extending in Attica and Boeotia. Both surface (0-20 cm) and depth (20-50 cm) soil samples have been collected and a full quality control program has been deployed for the estimation of measurement uncertainty from sampling and analysis. The historical mining area of Lavrion is part of the study area providing a useful example of elevated concentrations of PTEs in soil. Preliminary results and research challenges of the pilot project are presented along with the preliminary interpretation for PTEs distribution and potential sources, in soil of the pilot area.
Acknowledgements: This project is conducted by HSGME, and financed by the National Funds Programme, project no. 2020ΣΕ06100004 (HSGME no 22204).

Evaluation of occupational health and safety issues in coal mining Industry
O-101

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This paper presents the necessity to analyze and evaluate occupational health and safety issues in the coal mining industry, as well as employee training programs in order to eliminate occupational accidents. Open pit mining is work that carries a high level of risk. According to the EU directives and the National legislation: All efforts must be made to increase occupational safety and health, in accordance with the Vision Zero approach. In order to achieve these standards, it is important to assess and evaluate occupational risk based on the recording of the main causes of accidents in the coal mining sector. Interviews with working staff were conducted and recorded training data were evaluated. Our analysis shows that in order to minimize work accidents, it is necessary to adopt training activities where the staff has active participation. Rigorous standards must be maintained and at the same time low vibration and noise levels should be managed. Prevention measures during rock burst should be implemented and the possibility of slip and falls should be considered. The goal is to recognize unsafe situations, risks or symptoms and indications in order to prevent accidents and health problems due to exposure to dangerous risk factors at work. This can be achieved by training, creating a prevention mentality and increasing their level of their awareness.

Understanding the Social License to Operate from a Cultural Perspective: The case studies of Australia, Greece, and India
O-102

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A reliable, sustainable, and transparent supply of critical raw materials is vital for developing future technologies and transitioning to a carbon emission-free world. However, extracting them from the ground can generate social, economic, and environmental impacts, compromising the mining industry's public perception and jeopardising operations' social acceptance. In various contexts, the social impacts of mining are assessed with different sets of indexes and targets. This study investigates cultural indicators of societal acceptance for mining critical raw materials in Australia, Greece, and India. Comparing the perception of mining in the three countries points out the difference in every society's behaviour based on their culture. A comprehensive literature review is conducted, followed by discussions with experts on the sustainable supply of critical raw materials, and the application of established cultural models. The scope of this work is to discuss the status quo of the social license to operate (SLO) in Australia, Greece, and India from the perspective of cultural differences. By evaluating these differences, the authors aim to highlight the significance of cultural factors in the mining industry and the communities affected. Secondly, show pathways to include cultural dimensions in corporate activities and vital negotiations between industry and community stakeholders to increase the public's awareness, improve their perception of the purpose of mining and prepare the road for gaining the social license to operate.

EPD reporting in the metal and mineral sector
O-103

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In an increasingly globalized and environmentally conscious market, the environmental attributes of products are of primary importance for the sustainable development of manufacturing companies.
The aim of the paper is to statistically analyze the Environmental Product Declaration (EPD) reports, that have pawned from Life Cycle Analysis (LCA), in the metal and mineral products industry based on two parameters: (i) the geographical scope and (ii) the category of the product. During the recent years EPD has been developed as a tool for the carbon footprint assessment of products, however, it is not yet that widely applied in companies and requested by key stakeholders as customers. In addition, in the Metals and Minerals industry, the use of EPD reports is not yet as widespread as in other industrial segments such as plastics.
The present article is based on the EPD Library of the official website of the International EPD System. Data was extracted and relevant information gathered by using the available filters of the EPD library, such as the geographical scope and the product category. Then from the database created, tables and graphs were made, regarding the number of EPD reports by manufacturing companies, based on the country of origin and product category. This research offers insight regarding the benefits stemming from the adoption of EPD tool and the preparation of the corresponding reports by companies in the metal and mineral industry, emphasis placed on the countries and product categories for which EPD reports have not been published.

Sustainability Reporting in the Raw Materials Industry
O-104

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The purpose of this paper is to study and compare the Global Reporting Initiative (GRI) standard widely used in the Sustainability Reporting of the Raw Material (RM) Industry with the recently emerged European Sustainability Reporting Standards (ESRS). The Non-Financial Reporting Directive (NFRD), 2014, that initially set the requirements for NFR to companies with more than 500 employees, will be replaced by the new European Corporate Sustainability Reporting Directive (CSRD), 2023. As of 2024 large undertakings, as well as small and medium-sized undertakings which are public-interest entities will be required to publish reports on their environmental and social impacts, replacing the NFRD.

Within this framework, this paper aims to review and compare the two standards, GRI and ESRS, since due to the forthcoming directive, a significantly higher number of companies, as compared to companies subject to NFRD, including companies of the RM Sector will have to prepare the procedures for the implementation of the new standards. Taking into account, the widely implemented set of GRI indicators, the article will highlight both the similarities and differences of the first set of 12 draft ESRS.

These results are expected to be of interest for the public interest, as well as Large and SMEs companies of the RM sector regarding their corporate sustainability reporting. Moreover, these results may be also of interest to EFRAG-GRI organizations, that have started planning the new standard update. One of the main conclusions of this study is that the two sustainability reporting standards have several similarities, so for companies that were already using GRI there should be no difficulties in adapting to the new standard.

Tuesday 29 August 2023

ROOM 16

POSTER SESSION 2

Mining

Energy Environment and Sustainability

Hydrometallurgical Processes

P2-01
Geochemical and limnological characterization of the Corta Atalaya pit lake (Riotinto mines, Spain)

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Corta Atalaya (CA) open pit mine is known for its large size and for being one of the most important exploitations of copper in Europe. Despite its historical importance, little is known about the lake formed in this open pit.
During this study, the lake presented a surface area of 16 ha and a maximum depth of 106 meters, representing a high volume of acid and metal-enriched water.
CA pit lake has shown permanent chemical stratification (meromictic lake), where three layers with different density and chemical composition can be differentiated: (i) a superficial layer of 5±2m depth, with electric conductivity (EC) between 5.4-6.64 mS/cm, oxygenated and Fe(III)-rich mixolimnion, (ii) an intermediate layer (between 5 and 30 m, chemocline) exhibiting strong vertical changes of parameters as temperature (T) and EC showing an increase with depth and (iii) a thick bottom layer from 30 m to 106 m depth, anoxic, elevate EC (47 mS/cm) and T (32°C) values, and concentration of Fe as Fe(II) (monimolimnion).
As far as we know, there is no other mining lake in the world, where its monimolimnion presents similar concentrations, reaching values of up to 112 g/L sulfate, 41 g/L Fe, 2.8 g/L Al, 5.5 g/L Zn, 405 mg/L Cu, 437 mg/L Mn, 52 mg/L As, 27 mg/L Co, 14 mg/L Cd and 6 mg/L Ni.
This characterization is essential to start considering this pit lake as a model and laboratory in the Iberian Pyrite Belt, potential source of strategic and critical raw materials, activating a Circular Economy.

P2-02
Preliminary Environmental Assessment of Carbonated Slags as a CCUS in Agricultural Applications

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P2-03
Evolution of alluvial gold mining technologies

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This work examines alluvial gold deposits mining and processing methods from the Argonautic expedition until the Renaissance. According to Greek mythology, the mountain rivers of Colchis (Georgia) carried coarse sand and gold particles, which were washed in special wooden sluice boxes. The finer fractions were held in the lower part of the device, which was lined with sheepskin. Using a sheepskin to extract gold from riverbeds gave rise to the myth of the Golden Fleece. Afterwards, during the Roman Empire period, the mining of alluvial gold was done manually until the discovery of hydraulic mining, a technique that contributed to a massive increase in production. At the same time, the Romans employed various techniques to separate the metals from the total mass of the ore. Gold refining was carried out through cupellation and the mercury amalgamation process. During the Renaissance, Georgius Bauer Agricola wrote "De Re Metallica," one of the essential machinery books in mining in the 16th century. He developed a new type of pump to remove water, the uncontrolled flow of which caused significant problems in the underground mining process. The bucket chain pump, the "pater noster" pump, and the piston pump are some of the most innovative devices he presented in his work. Also, Agricola extensively references the recovery techniques for gold and other precious metals during the Archaic period that helped preserve the myth of the Argonautic expedition and the Golden Fleece.

P2-04
Capacity of Nerium oleander to phytoremediate mining spoils assisted by air nanobubbles and biochar

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The main objective of this study is to investigate the capacity of N. oleander to phytoremediate toxic metal spoils and improve the fertility of poor soils assisted by soil amendments; biochar, fertilizer and air nanobubbles (NBs). The substrate (soil) used in the present study was provided by the General Mining and Metallurgical S. A. LARCO and was produced by mixing soils from areas close to laterite (Ni containing ores) mines, which are unsuitable substrates for plant growth, due to the high concentration of metals such as As, Cd, Cu, Mn, Pb and Zn and low nutrient availability, and low water holding capacity. Proper amendments were applied to achieve optimal growth of plants and ameliorate the heavy metal extraction. One option is the addition of biochar to soil, which increases the nutrient availability through the nutrients contained in biochar and decreases the bioavailability and mobility of heavy metals present in soil. Furthermore, the effect of irrigation with air nanobubbles supplemented water was evaluated in toxic metal spoils' remediation. Nanobubbles (NBs) sized at <1 μm diameter exhibit long lifetime in aqueous solution and high specific area thanks to the small size. Water containing NBs show higher germination rates in seeds and also have a beneficial effect on plant growth. The pot experiment of N. oleander was analyzed in terms of heavy metals content in soil and plant tissues. Moreover, the plants' condition in the aspect of antioxidant enzymes activity was investigated.

P2-05
Extractive waste management in coal surface mining projects - A circular economy approach

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Coal surface mines usually occupy large areas for the development of mining activities and affect and change the landscape and the land cover in various ways. After completing the exploitation of a specific mine section, the sustainable reclamation of mining land is directly associated with the optimal exploitation of the waste dumping sites since these areas have larger acreage than the corresponding mine pits. This study investigates the main issues related to the progressive development of dumping sites in continuous surface mining projects, from the initial excavations to the completion of mining operations and the post-mining utilization, considering both basic geospatial parameters and the circular economy principles. In this framework, the waste dumping areas of the exhausted Amynteon lignite mine in North Greece are examined. The analysis focuses on the following research issues:
(a) The strategy of waste dumping in complex surface coal mining operations based on a circular economy approach.
(b) Critical factors of the reclamation of the mining areas related to the environmental permits and the planning of new land uses within the Just Transition Plan.
(c) The main technical, environmental, social and economic parameters affecting the suitability of mining land to specific objectives regarding the transition to post-mining activities.
The results of the spatiotemporal analysis of the waste dumping areas indicate the main geotechnical, geochemical, and environmental critical parameters related to the long-term sustainability of the examined areas and the suitability of mining land to the transition to a new post-mining model.

P2-06
Dynamic adsorption of Pb by Fe-Mg clay–quartz beds using micro-columns

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Clays are versatile materials with various industrial applications. Their natural abundance, low cost and physicochemical properties make them highly desirable in environmental applications, especially for the treatment of contaminated soil, water and wastewater by potentially toxic elements, such as lead (Pb). The sorption efficiency of clays regarding Pb has been usually studied by static experimental procedures, which are easy-to-use but labour-intensive. In this study, dynamic adsorption experiments were performed using micro-columns to assess the adsorption behaviour of natural Fe-Mg-rich clays interacting with Pb ions. The experimental parameters tested were the inlet solution pH, Pb concentration, and the flow rate. The studied clays consist of varying amounts of palygorskite and Fe-smectite, originating from NW Greece. The micro-column beds were assembled by diluting a specified amount of clay with quartz (Qz) sand to enhance permeability. Based on the results, the mixed palygorskite/Fe-smectite-rich clay beds exhibited the greatest adsorption capacity (45.2 ± 0.01 mg Pb/g) followed by the Fe-smectite-rich (35.7 ± 0.07 mg Pb/g) and palygorskite-rich (20.0 ± 0.03 mg Pb/g) clay beds, at inlet solution pH=3.5, 100 mg/L Pb and flow rate 0.7 ml/min. The results indicated that the greater adsorption efficiency of palygorskite/Fe-smectite-rich clays could be attributed to synergistic effects due to the coexistence of palygorskite and Fe-smectite clay phases, which have distinct physicochemical characteristics. Moreover, the results obtained showed good agreement with the static experiments, implying that the use of micro-columns could describe adsorption adequately over shorter experimental times.

P2-07

Potential use of leaching gravel as a raw material to the preparation of geopolymeric material as an alternative to conventional cement materials

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Mining waste – based geopolymers are a sustainable alternative to conventional cement materials due to contribute to the valorization of mining wastes as well as to the new constructions materials with reduced fingerprint. The objective of this study was to determine the potential of leaching gravel (LG) from hydrometallurgical copper processing to be used as a raw material in the manufacture of geopolymer.

NaOH, Na2SiO3 (modulus 1.5), and LG were mixed and then wetted with an appropriate amount of tap water, then stirred until a homogenous paste was obtained. A liquid/solid ratio of 0.3 was used for preparing mixtures. The paste was then cast in cubic moulds of 50 mm for the determination of compressive strengths. The samples were left to dry for 24 h at room temperature, then unmoulded before analysis after 28 days curing time. The compressive test were conducted in a compression machine (15/300 kN). According the laser diffraction spectroscopy (LDS) analysis the 90% of LG particles were below 500 µm. The X ray diffraction (XRD) analysis identified crystalline phases of albite (30 %), Quartz (16%), Anorthite (16 %), and Phillipsite (14%). The X-ray fluorescence (XRF) determinations showed mainly a 55% of SiO2, 13 % of Al2O3, and 9% of CaO. ICP (OES) concentrations of Fe, Ca, Cu, Al, As, V, Zn, Mo, and Ni were 49.545; 24.735; 6.172; 14.152, 239,5; 129,6; 41,1;15,1, and 13,1 mgkg-1, respectively. The geopolymer samples showed resistance ranged between 2 and 10 MPa. In comparison with the raw material composition, the amorphous percentage of materials in the geopolymer was 35 %, whereas the crystalline percentage of main mineral phases decreased. Further studies are needed to find the optimal combinations of materials to produce a more resistant and environmentally safe geopolymer. Particularly are necessary compressive resistance higher than 15 MPa are necessary to be used as construction unit such as bricks.

P2-08
Alluvial gold mining from Argonauts to Agricola

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This work provides historical information and examines changes in the methods and equipment used in gold recovery and processing operations. Alluvial gold recovery methods, mainly based on gravity separation combined with the use of mercury (amalgamation), have been applied since the early days of mining. Historically mining gold extraction from the river beds was first implemented in Ancient Anatolia (also called "Asia Minor") and Ancient Greece, as well. As a first attempt to recover gold, the traditional immersion of sheepskin in the river water to trap alluvial gold was developed. This technique has been considered as a milestone in the famous myth of the Golden Fleece (also known as "Chrysomallon Deras"). Since then, gold extraction and processing technologies evolve over time. In this respect, Emperor Augustus developed hydraulic gold mining during the period of Roman Empire. Subsequently, the innovative machines of Georgius Bauer (Agricola) were widely used during the Renaissance, while Spanish colonialists in America improved their techniques by observing the efficient methods of the natives. Finally, the "American gold rush" era was perhaps the most important period of the alluvial gold mining process. It took place in the rivers of America during the 18th-19th century. Today, in the technologically-advanced society, there exist a variety of gold mining machines, including spiral and jig concentrators that provide higher production rates and less harm to the environment.

P2-09

A Review about the methods and techniques for evaluating the waters and soils in mining regions.

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Mining activities are a severe anthropogenic stress to the water environment and the soils of a mining region. The crucial issue about water resources is the probable deterioration of their quality, as it affects human consumption. Also soil contamination draws interest in farming and soil fertility, but also because its interaction with surface water or groundwater causes deterioration of water resources. Monitoring and evaluation of the environmental conditions is essential for mining industries and local authorities, by using different techniques and methods. Regarding mine water evaluation, the applied methods and techniques are mostly:
- Biomonitoring using bioindicators that can accumulate metals, tolerate in extreme conditions but be sensitive to changes.
- Indices: Water Quality Index (WQI), Trophic State Index (TSI), Heavy Metal Pollution Index (HPI), Ecological Risk Index (ERI), considering quality parameters.
- Stable isotope analysis and Bayesian mixing model.
- Factor analysis, Principal component analysis and Cluster analysis, Spatial analysis (Moran's I, etc) as statistical tools, supporting the methods above.

Regarding soils, based on Food and Agriculture Organization of the United Nations (FAO) and the Dutch List, the concerning inorganic metals and metalloids in soil environment are As, Cd, Co, Cr, Cu, Pb, Zn, Mo, Hg, Sn, Ni, Sb and Se etc, that can be estimated by:
- Biomarkers: Earthworm Eisenia fetida, C/N Soil biomass ratio, Phytochelatin (PC), Structural index (SI) of Nematode community, accumulation patterns of lichens Cladonia rei and Diploschistes muscorum.
- Indices: Contamination Factor (CF), Enrichment Factor (EF), Potential Ecological Risk Index(RERI), Nemerow Pollution Index (PI), Available phosphorus(P2O5), Nitrogen content, Geoaccumulation Index (Igeo).

This paper compares and highlights the advantages and disadvantages of every method and technique and suggests the proper one for the environmental management of mining areas.

P2-10
Groundwater monitoring system based on Arduino platform and IIoT platform

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Presentation of the possibilities of using widely available development platforms and sensors designed for them to monitor the quality of groundwater and air. The data collected in this way can be transferred remotely for further analysis, processing and presentation of results in an automatic manner on a dedicated IIoT platform. This solution is part of the illuMINEation project funded under the Horizon 2020 programme

P2-11
Face Mapping in Open Pit Mines-A new approach

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In a surface lignite mine, face mapping is an important task, necessary for assessing lignite mining seams. Nowadays, geologists can take advantage of innovative technology to carry out mapping quickly and more precisely. In the South Field Mine located in the Lignite Center of Western Macedonia, Northern Greece, the method of photogrammetry has been successfully used. A small Phantom4Pro helicopter is flying so that the entire face is covered. The drone flies along the entire bench, which is about 2 kilometers, trying to take plenty of photos at an appropriate angle, covering mainly vertically the entire face from the roof to the toe. The data is downloaded to the Pix4d program and processed. The important information that was not available with the conventional way of sampling, is that the photos are georeferenced and now the exact position of each sample x, y, and z as well as the thickness of the mineable coal seam, are known. This is a powerful tool for coal deposit exploitation and can certainly be applied to any other surface mine. Another major advantage of using this methodology concerns the spatial accuracy of the lignite-quality data collected after sampling. This information is very important, because it may be used as input in a database that can be integrated into drilling, survey, and other data, and improve the geological and reserves model of the exploitation area.

P2-12
Potential benefits from Carbon Capture Utilisation and methanol production in magnesite processing line

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Magnesite (MgCO3) is a carbonate mineral, which is calcinated and further processed to generate magnesia (MgO) refractory materials and other products. MgCO3 products are mainly used in the iron and steel industry, in cement manufacture as a refractory material and as raw material in the chemical industry, in agriculture, etc. The MgO refractory industry is linked with carbon dioxide (CO2) emissions released not only from the fuel combustion in the production process of MgCO3, but also from its decomposition. Even though the exact amount of CO2 eq. depends on the specific product, there is the urge to minimize the CO2 emitted from MgO3 processing. Carbon Capture and Utilization (CCU) technology has gained ground the recent years in the industry. The incorpora-tion of CCU systems for the processing of fuel-gases is investigated as a mean that can contribute further to the extractive industries decarbonization. The CO2 captured through this process can be converted into a value-added chemical or liquid fuel. This study aims to overview the impact of the application of CCU technologies in MgCO3 processing line and the conversion of the captured CO2 to methanol (MeOH). In this regard, the strengths (S), the weaknesses (W), the opportunities (O) and the threats (T) of the proposed concept will be discussed in a SWOT analysis coupled with the environmental and techno-economic aspects.

P2-13
Potential application of RES and underground H2 storage in abandoned mines

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Mining operations, as all industrial operations, have a significant impact on the environment both through the generation of wastes and through the landscape change. In view of this, pioneering and sustainable post-mining technologies are demanded to reduce environmental impact. Clean energy can be part of the solution, with emphasis to the penetration of renewable energy sources (RES) for the mitigation of greenhouse gases. RES production is inherently fluctuating, at times being insufficient while others creating energy surpluses. By converting a mining site to a parallel renewable energy generation facility can provide new job opportunities and economic value, as well as contributing to a more secure energy supply. Abandoned mines present a viable option for the installation of such systems, exploiting their underground facilities for safe storage. In this regard, the underground facilities can be exploited for green hydrogen (H2) energy storage systems. Underground H2 storage has many advantages over surface storage, including safer storage, smaller footprints, larger storage capacity, and lower cost. The reuse of pre-existent infrastructure and land availability for deploying solar parks also offers innovative ways to generate clean energy. This study examines the potential of repurposing abandoned mines in the form of renewable energy generation facilities in order to improve their environmental impact and move quickly towards sustainable and innovative mining throughout Europe.

P2-14
Prediction of hydrate dissociation conditions in natural/acid/flue gas streams in the presence and absence of inhibitors

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Computational modeling is crucial for estimating hydrates dissociation pressure of various gas streams including natural, acid and flue gas. They are related to the optimization of mitigation actions, such as selection and dosage of the appropriate thermodynamic inhibitor to minimize operating costs and reduce environmental footprint as well as the development of innovative applications in energy storage, gas separation and carbon capture and storage.

Commercial PVT software packages like MultiFlash, HydraFLASH, CSMGem, and CSMHyd are widely used for these purposes. However, they differ in their computational approach including hydrate modeling framework, EoS models, thermodynamic models for salts and inhibitors and phase models for coexisting hydrate phases. Moreover, the fitted parameters in each package are customized by their respective developers based on experimental data and expertise applied during model calibration.

To address this variability, we evaluate the performance of these leading-edge commercial software packages using a diverse set of systems, ranging from single-component to highly inhibited cases. Our evaluation is based on an extensive database of 400 experimental dissociation pressure data points published recently. Our findings reveal that each software package exhibits unique strengths and weaknesses in predicting hydrate dissociation conditions for different characteristics of gas mixture systems forming hydrates. Therefore, this work acts as viable guideline for industry practitioners and researchers interested in obtaining accurate predictions of hydrate dissociation conditions for both mitigation actions and technological solutions.

P2-15
Evaluation of an iron nanocomposite material for heavy metals removal under flow conditions

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A novel nanocomposite material, consisting of zero valent iron nanoparticles (nZVI) incorporated in the matrix of a chelating cation exchange resin, was evaluated for the selective removal of heavy metals from the typical effluent of a wastewater treatment plant. The resin selected as host matrix for the incorporation of nZVI possesses iminodiacetic acid functional groups, which are characterized by high selectivity for heavy metal cations over the alkali metals. The performance of the nanocomposite was evaluated by conducting column experiments and using as feed solution the tertiary effluents of a wastewater treatment plant. The solution was spiked with a mixture of heavy metals, i.e. Cr(VI), Ni, Pb, Cu, Cd, Zn and As, at levels approximately 10 times higher than the limits established by the Greek legislation for recycling the wastewater effluents in other uses.

The experiments were carried out in three columns operating with different contact times, τ=2.4, 4.8 and 6 min, and the total amount of the supplied solution was equivalent to 6600, 3300 and 2500 bed volumes (BV), respectively. The nanocomposite was found to be efficient for Cu, Cr(VI) and Pb, and to a lesser extent for Ni. The concentration of Cu in the effluent remained constantly below detection limit in the three columns and during the whole operation. Hexavalent chromium Cr(VI) was detected only in column with τ=2.4 min and after the supply of 2400 bed volumes. The breakthrough of Pb appeared after the supply of approximately 2000 BVs in columns with τ=2.4 and 4.8 min and the breakthrough of Ni took place in the three columns after the supply of approximately 450 BVs. The nanocomposite was not found to be efficient for Cd, Zn and As, in this multicomponent solution.

P2-16
Manganese Recovery from Nickel and Cobalt Production Facility MHP Leach Waste

Fırat Tekmanlı, Bengi Yağmurlu, Hüseyin Eren Obuz

The aim of this study is to convert the high amount of manganese which remains inert and concentrated in the intermediate product of the plant. Efforts were made to recover the manganese remaining in the leaching solid during the production of Ni and Co-containing end products from the MHP solid, which is the concentrated intermediate product of the plant, and finally to convert it into a salable $MnSO_4$ product. First, the manganese in the MHP leach residue was transferred to the liquid phase by leaching, and solvent extraction (SX) and ion exchanger (IX) processes were applied to remove other metals be impurities other than Mn from the liquid phase. In this study, according to the metal content of the obtained PLS, Optimization studies were carried out to determine the appropriate organic solution selection and working conditions in the SX step. Similarly, the effect of resin types in step IX was investigated. The knowledge and experience gained at this stage will shed light on future studies and contribute significantly to obtaining high-purity products.

P2-17
An innovative approach for the recovery of cobalt sulfate from battery leach solutions by anti solvent crystallization

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The rapid and ongoing electrification of the world's vehicle fleet, which is necessary to enable the transition to a civilization based on renewable energy, is only possible owing to the lithium-ion batteries. Cathode active materials with diverse chemistries and properties can be produced by various compositions of critical metals like lithium (Li), nickel (Ni), cobalt (Co), and manganese (Mn).

Different hydrometallurgical processes are investigated to recover cobalt sulfate (CoSO4) from end-of-life electrical vehicles' NMC batteries, which is crucial to the industry for achieving the goals of the new European regulatory framework for batteries. For the recovery of high-grade $CoSO_4$ from strip liquor of solvent extraction operation antisolvent crystallization, often referred to as salting out crystallization, is investigated as an alternative to conventional processes.

Cobalt was separated using solvent extraction and the commercial extractant cyanex 272. On a batch scale, solvent extraction experiments were carried out to optimize the extractant concentration, equilibration time, organic-to-aqueous phase ratio (O/A), scrubbing, and stripping conditions. The process was validated in continuous mode using a battery of mixer-settlers MSU 0.5 by MEAB. Furthermore, preliminary experiments were carried out for the antisolvent crystallization of cobalt sulfate. CoSO4 was successfully obtained through antisolvent crystallization. High cobalt recovery rates with low co-extraction were achieved. The specifics, benefits, and challenges of operating of liquid-liquid extraction as well as anti-solvent crystallization were discussed further.

P2-18
Raw materials and circular economy: bioelectrochemical copper removal and recovery from wastewater

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The raw materials industry has been inevitably overtaken by the modern demands for sustainability. This is not a priority only in terms of environmental and human health protection but also a matter of efficient and expedient use of the mined raw materials and resources. This specific objectives are in the core of the new technological culture, which aims to minimize or even eliminate waste by recycling, reusing and recovering resources from it.
The mining and metallurgical industries are no exception and in this study recovering copper from waste streams is presented as case to demonstrate demonstrate some new technological possibilities related to the so-called Bio-bioelectrochemical processes which enable simultaneous waste water treatment, energy recovery and reduction of waste streams copper losses during its production and processing.
The concept is based on the cathodic reduction of Cu2+ to elemental copper Cu0 in Microbial Fuel Cell (MFC) type of reactor where the main source of electrons is the biological oxidation of organic wastes. Both model solution and real metallurgical effluent rich in copper ions were tested. During the experiments, copper was successfully removed from the treated model solution with 99.42 % efficiency (initial concentration of 250 mg/dm3). Solid copper particles with size of about 1 µm were obtained and detected. In the experiments with real wastewater samples it was found out that the process efficiency is in strong dependence with the pH and the presence of other reducible compounds with higher standard electrode potential than copper.

P2-19
Evaluation of thiosulphate for gold recovery from pressure oxidation residues

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Considering the toxicity and environmental problems created by the use of cyanide in industrial applications of gold extraction, intensive research has been developed during the decades for identifying new effective reagents able to replace cyanide in gold extraction operations. A wide variety of reagents have been thoroughly investigated with laboratory and pilot scale tests, but thiosulphates is the only one that has recently found industrial application. For this reason, thiosulfates were selected for evaluation in the framework of the present work, as a promising non-cyanide reagent for obtaining the recovery of gold from the pressure oxidation (POX) residue of gold bearing sulfide concentrates.

The investigated parameters included the solid-liquid mixing ratio (S/L), the temperature (T), the initial pH and the initial thiosulphate concentration. The maximum gold extraction achieved using calcium thiosulphate was 70%, with CaTS=0.15 M, initial pH 7, temperature 50oC and treatment duration 6 hours.

P2-20
Hydrometallurgical recovery of EoL LFP batteries using oxalic acid as lixivient

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This work explored the efficiency of recycling lithium batteries from lithium-iron-phosphate (LFP) electric vehicle type using hydrometallurgical methods with the purpose of extracting the metal contents such as Li, Fe, Al, Cu. Specifically, samples from LFP batteries of the Beev vehicle were used in the study. Following battery disassembly, an overall pretreatment method was applied, involving various stages of shredding, crushing/grinding, sieving, and washing to reduce the size and recover the valuable materials of the batteries, known as black mass, which primarily includes the valuable constituents of the anode (graphite) and cathode ($LiFePO4$), as well as aluminum and copper used as current collectors. The black mass treatment was conducted through leaching with an aqueous solution of oxalic acid, which dissolves the lithium content, leaving most other metal contents in the solid residue of the leaching. Leaching tests were performed by varying the concentration of oxalic acid, temperature, and leaching time. The Li extraction reached 100% at higher oxalic acid concentrations, decreasing over time, while remained almost unaffected by temperature variations. Overall, the method proves to be satisfactory for lithium extraction, its separation from the solid phase, and recovery from the solution in a subsequent process, using oxalic acid concentrations of 0.5 or 0.7M. Under these conditions, aluminum dissolves in high percentages (70-100%), while the dissolution of iron and copper remains at relatively low levels (3-5% and <2%, respectively).

P2-21
Leaching of Bauxite Residues from Turkish, Greek and Romanian Plants Using Concentrated Sulphuric and Hydrochloric Acids for Potential Application in an Industrial Recovery Plant

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Bauxite residue is a major industrial waste from the Bayer process. It contains rare earth elements that are crucial to the development of new technologies. The profile of scandium and rare earth elements within bauxite residues depends on ore sources and process parameters. Acid leaching is a common recovery method for extracting elements from oxides, such as those present in bauxite residues. The main goal of this work is to optimize the acid leaching process in order to recover as much as possible the whole rare element present in the bauxite residue from ETI (Turkey), MYTILINEOS (Greece) and ALUM (Romania) plants. In order to adapt this process to industrial work volume, it was aimed to work with solid/liquid ratio lower than 25% involving highly acid concentrations. To reduce costs, hydrochloric and sulphuric acids, which are widely used in industrial processes, were selected. The risk of corrosion was not taken into account, as polymeric materials such as resins, polyethylene and polypropylene can be used as containers in these highly acidic environments. The results confirm the scandium selectivity of sulphuric acid, which can extract almost 60% of the quantity present in the Turkish residue via a 3h treatment with an 8M concentration. Hydrochloric acid is less selective and can extract more than 90% of the cerium and lanthanum present in the Turkish residue, and more than 60% of the scandium present in both the Turkish and Greek residues. In addition, the leaching process can be reduced to 30 minutes using hydrochloric acid. These processes can be implemented quickly and cost-effectively across different companies.

P2-23
Acid Leaching of Cu/Fe polymetallic alloy: Process alternatives & Challenges

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Copper (Cu) slags are potential alternative sources for the production of Cu and other metals (e.g., Ni, Co). A Cu-slag underwent reductive smelting and a polymetallic Cu/Fe alloy was produced. Two process alternatives were initially examined for the hydrometallurgical extraction of Cu: (a) leaching with H2SO4 and (b) leaching with HCl. O2(g) was used as an oxidant in both routes. The purpose of the study was to determine the efficiency of each acid in extracting Cu and to highlight any challenges during the leaching process. The HCl route appears to be more efficient, with % wt. Cu extraction over 85%. On the other hand, %wt. Cu extraction in the H2SO4 route is below 30% and some of the challenges responsible for this phenomenon are discussed.

Wednesday 30 August 2023

ROOM 13

PLENARY LECTURES

Chair: A. Xenidis, P. Koutsovitis, S. Kalaitzidis

Plenary lecture 9
From List of Critical Raw Materials to List of critical projects

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Criticality assessment of raw materials is the procedure of demonstrating possible supply risks and their sensitivity of contribution to national and regional economies. The methodologies behind criticality assessments vary at country or regional levels, and even at global levels.
Additionally, criticality studies depend on a wide range of indicators to underline the various challenges in terms of technological factors, geology and geopolitical, as well as social and environmental considerations.
Building on the EU's experience in performing periodic criticality assessments and updating the EU list of Critical Raw Materials every three years, the talk will provide a brief overview of what critical materials are, why they are so important in the context of the European Green Deal and more generally for the energy and digital transitions, who is assessing criticality in the international framework, how and for what purposes.
The discussion will touch on possible causes of critical materials supply crises and possible mitigation countermeasures, including the role of circular economy strategies.
The talk targets all who are looking to expand their knowledge on critical raw materials and the methodology
behind their identification. The lecture will discuss on how to move from criticality assessments and prioritise actions towards lists of critical projects.

Plenary lecture 10
The Application of United Nations Framework Classification for Resources (UNFC) to European Mineral Deposits

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United Nations Economic Commission for Europe (UNECE) Sustainable Energy Division

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Delivering the goals of the European Green Deal and achieving sustainable resource management within the circular economy in Europe starts with a comprehensive and standardized approach for the effective management of European mineral deposits that are at the beginning of the value chain. Accurate, relevant, and timely data and information are essential for the classification of mineral deposits in accordance with ensuring sustainable development. Against this background, the most suitable classification scheme that considers all elements of sustainable development with a shared, principles-based, integrated, and sustainable resource management approach is the United Nations Framework Classification for Resources (UNFC).

UNFC is a globally recognized framework for the classification and ultimately the sustainable management of energy and raw material projects, based on three fundamental criteria, including the project's environmental-socio-economic viability (E axis), its technical feasibility (F axis), and degree of confidence in the product's estimate (G). Applying UNFC to mineral deposits contributes to responsible extraction practices, minimizing environmental impacts, and ensuring long-term mineral resources availability.

European mineral deposits encompass a wide range of resources, many of which are critical raw materials. The application of UNFC to these deposits enables a much-needed harmony for resource classification and data collection across the European Union (EU). The use of UNFC in Europe facilitates meaningful comparisons between different deposits, areas, regions, and countries, which contributes to a more informed decision-making process on different levels. UNFC provides a clear framework for assessing the environmental-socio-economic viability of a mineral project, allowing policymakers and stakeholders to make sustainable decisions. UNFC serves as a fundamental tool to achieve sustainable development, efficient resource utilization, and enhanced economic growth across Europe.

On the other note, especially considering the EU Critical Raw Materials Act (EU CRM-Act), applying UNFC in Europe also promotes transparency and mobilizes sustainable investments to scale-up production of mineral deposits in the EU. A harmonized classification system increases the confidence of investors, ensuring a common understanding of resource potential and thereby attracting more investment in the mining sector. Additionally, the transparency reflected in UNFC fosters trust between EU Member States, encourages cooperation, and streamlines cross-border trading of minerals. Thus, the application of UNFC to European mineral deposits suitably caters to the objectives laid in the EU CRM-Act.

However, implementing UNFC in EU poses certain challenges. The diversity of mineral deposits across EU Member States requires tailored adaptation and harmonization within regional, national contexts. Each Member State will need to either integrate UNFC principles into their existing resource classification systems or bridge between UNFC and their national resource classification systems. In both cases this should be done while acknowledging their national regulations.

Wednesday 30 August 2023

ROOM 13

SESSION C1

Critical metals recovery from mining/metallurgical waste

Chair: A. Lopez-Buendia, D. Panias

Efficient Use of Sulfuric Acid in Bauxite Residue Leaching
O-105

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Bauxite residue (BR), an alkaline industrial waste, is a major by-product of the alumina production process known as the Bayer process. The Bayer process generates a byproduct known as bauxite residue (red mud). This residue was leached with sulfuric acid in a pilot plant of Mytilineos S.A to recover scandium. Scandium was selectively recovered in pilot-scale experiments using ion exchange. This process generated a raffinate solution containing various dissolved impurities such as aluminium, sodium, calcium, iron and mainly sulfate ions. Regeneration of the raffinate solution can reduce the cost of the process and minimize the use of H2SO4. The potential of raffinate recycling as a technology for reducing the usage of H2SO4 in the leaching process was evaluated by neutralizing bauxite residue with the raffinate solution before the leaching step. The study aimed to investigate the feasibility of using the raffinate solution for the neutralization of BR, enabling its reuse and improving the process's environmental sustainability. The neutralization process de-creases pH value of BR pulp with 50% w/v p.d. from 11 to 6. Experimental investigations were carried out to assess the leaching behaviour of bauxite residue compared to neutralized bauxite residue (NBR) using sulfuric acid. The obtained results were compared to evaluate the effectiveness of NBR as a substitute for bauxite residue in the leaching process. The consumption of acid during the leaching of neutralized BR was three times less than the BR leaching. X-ray diffraction (XRD) analysis of BR and NBR was conducted to determine the mineralogical phases of the materials. The results of the study provide valuable insights into potential ways to reduce the cost of the BR leaching process while also improving its environmental impact by recycling valuable materials.

HCl- based leaching method for extracting Ni/Co from ore deposits and tailings
O-106

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The rapid decline in grades and depletion of reserves has sparked interest in Ni and Co sources on a global scale. The Horizon Europe ENICON project suggests a HCl-based flowsheet as an environment-friendlier alternative to high-pressure acid leaching (HPAL) to convert Europe's Ni/Co ore deposits and tailings into battery-grade metal salts and to enhance the sustainability of the Ni/Co supply chain. FeNi (Class-II Ni) generated from laterites, Mixed (Ni/Co) Sulphide/Hydroxide Precipitate (MSP/MHP) from the bioleaching of Co-rich pyrite tailings, and Ni/Co-containing silicate tailings can all be processed to downstream products using this HCl-based approach. In order to completely extract Ni and Co from these resources, the impact of different variables involved in the acid leaching processes, i.e. temperature, liquid/solid ratio, and HCl (or HCl + H2O2) concentration was investigated and optimal conditions were identified. The preliminary experimental results demonstrate quantitative Ni and Co extraction from the feed materials and provide a lixiviant that can be employed in the following step using solvent extraction to purify these metals into battery-grade.

Microwave roasting of bauxite residues
O-107

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Bauxite residue (BR) is the solid resultant from the extraction process of the aluminium hydroxides for aluminium or alumina production. BR has the potential to be used as iron-bearing ore that, in the case of the plant of Aluminium of Greece it is higher than 40% referred to Fe2O3. Although it still far from the standard 63% fines iron ore commodity, it had fine mill pre-treatments. Efficient technologies for iron extraction are demanded to transform the residue into a valuable material.

Microwave roasting appear as powerful system for iron recovery, with relevant advantages, such as electrical efficient energy, volumetric and quick heating, or the low thermal energy loss. The transformation during microwave heating was monitored by x-ray diffraction and dielectric properties, identifying the main transformation events and the mineral phases obtained using coke as main reductant agent. Initial tests were made in static microwave resonant cavity, controlling the raising temperature by software, to have a predefined ramp at temperatures higher than 1300 °C.

A microwave BR roasting pilot in continuous operation was installed in Aluminium of Greece plant, using several mixture formulations to evaluate the processed products, as well as the flowability during processing. A monitoring and control system including microwave power reflectometry, pyrometry and other complementary sensors, was used to control the parameters of process, such as mass flow, temperature of the reaction, power consumption, gases liberated. Trials performed identified the best conditions the efficiency of the system to be transformed in a promising technology for BR treatment for valorization.

Alumina and iron recovery from the BR-Ca reduced pellets by simultaneous magnetic separation and alkali leaching
O-108

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Iron and alumina can be separated from hydrogen-reduced Bauxite residue-calcite pellets simultaneously through magnetic alkali leaching experimentally. Self-hardened pellets were made from bauxite residue, limestone, and calcined lime mixtures and after self-hardening they were reduced non-isothermally by hydrogen gas, and then they were milled. The grounded reduced pellets were leached with fixed Na2CO3 concentration, leaching time, and temperature with simultaneous separation by a magnetic fraction by a magnetic stirrer. X-ray diffraction, scanning electron microscopy, and inductively coupled plasma were used to measure phase analysis, microstructural analysis, and elemental analysis of the leaching solution. It was found that there is a significant increase in iron content of the magnetic fraction as compared to a nonmagnetic fraction, and the alumina recovery into the solution goes above 85%. The recovery of alumina depends upon the amount of formation of mayenite and gehlenite during the hydrogen reduction step. The more amount of mayenite and less gehlenite more will be the alumina recovery. Simultaneous leaching and magnetic separation lead to more unlocking of the reduced matrix and more iron and alumina recovery in comparison with applied dry separation techniques. Magnetic and nonmagnetic products are mostly composed of iron and CaCO3; however, metallic iron is high and CaCO3 is low in the magnetic fractions.

Recovery of copper and zinc from ash from incinerated municipal waste
O-109

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EU's 2023 list of critical raw materials comprises more than 40 elements and EU's CRM act sets a goal of 10% of each of these materials to be produced in Europe. Ashes from incinerated municipal waste are known to contain critical metals such as copper and antimony, in addition to important base metals like zinc and tin. Our work has shown that the potential recovery of copper and zinc may be in the same order of magnitude as virgin ores. Such source materials are ready to be treated hydrometallurgically compared to primary production. Costly mining, grinding, milling and beneficiation operations of ores are avoided. However, the heterogeneity of the contents in municipal waste to be incinerated is great since it will vary with factors like time and consumer trends, the site where the waste is collected, and the incineration technology that is used.

We have tested possible processes for using ashes from incinerators, both fly ashes and bottom ashes, and included old processes like the Schnabel process in our evaluation. The possibilities for selective leaching with ammonia and ammonium carbonate are utilized as well as recycling of the ammonia. Fly ash and bottom ash may be treated similarly, but with some specific differences. Our conclusion is that recovery from incinerated municipal waste ash is an economical viable source for copper and zinc. Such a process will also reduce the amount of waste to handle and also make it more chemically stable due to the alkalinity of the residue.

Unlocking the Potential of Bauxite Residue: A Comparative Exergy Analysis of Emerging Valorization Techniques
O-110

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The excessive generation of bauxite residue (BR) in the Bayer process is one of the main issues alumina manufacturers are facing. Over the past few years, significant effort has been made to maximize the use of BR by valorizing its valuable constituents. This paper describes a comparative exergy analysis of different technologies for BR utilization, demonstrated in pilot scale. In particular, the processes studied include sodium recovery through hydrothermal dealkalisation technique, pig iron production with EAF smelting, alkaline leaching for aluminum recovery and acidic leaching for scandium recovery. Exergy analysis is used to quantify the thermodynamic limits as well as the resource efficiency (of materials and energy) for their transformation into valuable products, highlighting the sustainability potential of the new processes under development. These processes are demonstrated in a combined flowsheet and the holistic exploitation of BR is analyzed and discussed.

Wednesday 30 August 2023

ROOM 5

SESSION C2
Substitution and Recycling of Critical Raw Materials in the Automotive Sector - The Industrial Perspective

Chair: I. Yakoumis

Universal Hydrometallurgical Up-Scaled Process for Recovering Critical and Strategic Materials from Automotive EoL Streams
O-117

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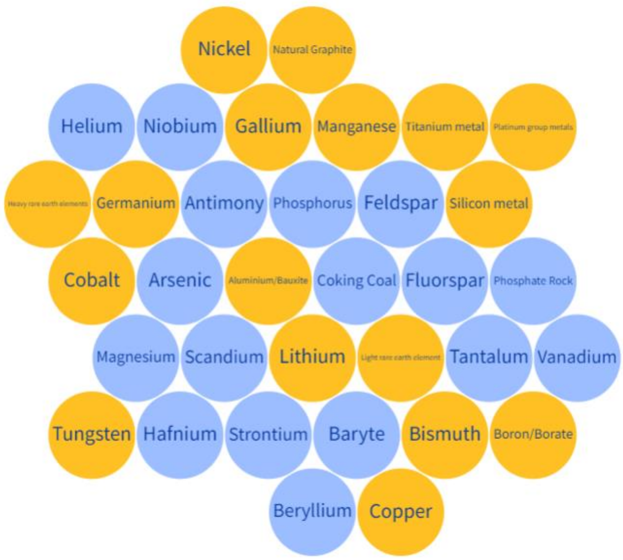

Thirty four 34 critical raw materials CRMs identified in EU in 2023 (**trategic raw materials** SRMs identified as blue

The EU's demand for base metals, battery materials, rare earths and more are set to increase exponentially as the EU divests from fossil fuels and turns to clean energy systems which necessitate more minerals.

The **EU green transition** require the build-up of local production of batteries, solar panels, permanent magnets, and other clean tech. Abundant access to a range of raw materials will be needed to address the corresponding demand. In order to decouple Europe from Critical and Strategic Raw Materials dependency from third countries and imports, sustainable and feasible methods of recycling End of Life devices and recovery methods for these materials should be designed and developed. **MONOLITHOS** has developed an integrated innovative hydrometallurgical method for waste valorization by pre-processing and recalling CRMs and SRMs from EoL permanent magnents, automotive catalysts and electrocatalysts, batteries and mining tailings, creating a new supply chain for the production of new products. The low acidity hydrometallurgical method, is applied on low temperature <70^{o}C, for short processing time (3hrs), producing low waste volumes, by treating large amounts of EoL feedstock. This recycling method has been integrated with suitable sorting and preprocessing technologies, in order to implement a complete recycling system in industrial scale, capable of extracting and reusing the valuable elements contained in the secondary feedstock from automotive parts, looping the automotive sector.

Characterization methods of the intermediate products, side products and by-products in each processing stage, performance and environmental evaluation of the materials used and CRM and SRM recalled and life cycle analysis on the overall process are also considered dominant tools for the realization, demonstration and commercialization of the scaled up process in industrial scale.

Wednesday 30 August 2023

ROOM 6

SESSION C3

Industrial minerals and Waste reuse – valorization I

Chair: Ch. Vasilatos, K. Komnitsas

Pathways towards Sustainability and Decarbonisation in the Construction Industry: The Role of Industrial Minerals and Geopolymers
KN-09

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EU has already set the ambitious target to become "climate-neutral by 2050 – an economy with net-zero greenhouse gas emissions". To achieve this strategic goal intense Decarbonisation in all economic and social sectors is required coupled with the transformation from a linear "brown" to circular green economy.
It is well known that the Building Sector is one of the sectors with the most significant environmental footprint accounting for 38% of the total GHG emissions . According to UN Environment program, "Meeting the Paris Agreement goal to limit global warming to well below 2°C, preferably to 1.5°C, above pre-industrial levels, requires global decarbonization of the building and construction sector . In this respect, Buildings decarbonisation is expected to play a significant role, requiring deep interventions in existing and new structures in relation to 4 pillars: energy efficiency, electrification, use of RES and efficient management of electricity loads.
For the Building materials, this means that they should be improved towards energy efficiency as much as possible and as fast as possible. Therefore, they must consume less energy during their manufacturing, demand less energy for their transportation, acquire additional functionalities and be of top performance, demand less energy for their installation.
Industrial minerals both as primary and as recycled materials can play an important role in the new generation of construction materials since they can i) give to conventional building materials additional functionalities ii) lead to less energy intensive manufacturing processes and iii) result in more energy efficient final products. In this presentation, the role of industrial minerals in the future of construction materials is discussed, along with all the trends for sustainability and energy efficiency.

Factors affecting the properties of slag-based alkali activated materials O-118

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This study, carried out in the frame of Horizon Europe ENICON project, "Sustainable processing of Europe's low grade sulphidic and lateritic Ni/Co ores and tailings into battery grade metals", https://enicon-horizon.eu/, evaluates the properties of alkali-activated materials (AAMs) produced from slag obtained from the Euronickel ferronickel plant at Kavadarci, Republic of N. Macedonia. The activating solution consists of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) solutions. The effect of various operating parameters, i.e. molarity of the activating so-lution (6-10 mol/L), pre-curing period (24-96 h), curing temperature (20-80 ^oC), and aging period (7-96 days) on the compressive strength, density, porosity and water absorption of the produced AAMs, was initially assessed. The first experimental results indicate that the produced AAMs acquired compressive strength exceeding 40 MPa after curing at 80 oC and aging of 7 days. This value increases to higher than 55 and 70 MPa when the aging period is 28 and 96 days respectively.

Composite lightweight materials with upgraded physicochemical functionality and improved economic feasibility
O-119

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In recent years, research has been focused on materials with superior physicochemical functionality. Although the research results are particularly encouraging, their use in commercial products is limited mainly due to the high production cost. Indicatively, nanomaterials form aggregates that limit their activity and therefore the economics of the innovative proposition.

One solution is the creation of composites which exhibit improved physicochemical functionality and therefore economics. In these materials, the substrate must be mechanically durable, have good adhesion to the coating and promote its performance. The coating technique should ensure uniform distribution of the multifunctional material to the substrate without agglomerates, good adhesion over time and the economy of the whole process in terms of time, raw materials and energy consumption.

In the present work, expanded perlite substrates were coated or impregnated by materials with a variety of physicochemical characteristics, e.g. inorganic and / or organic, photocatalytic, nano-materials, etc. The influence of the substrate's physical properties (bulk density, size distribution, open/closed porosity etc.) on the performance of the produced composite materials was studied. Value-to-Client Analysis and extraction of conclusions regarding the performance and economy of the best finished products were performed.

Creating public acceptance in building products made from metallurgical wastes
O-120

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Under the Removal project a demonstration for the potential of using Bauxite Residue (BR) in building products was conceived in the form of a small informational pavilion. The pavilion is located in the Aspra Spitia settlement, next to MYTILINEOS Alumina and Aluminium plant in Ag.Nikolaos Greece. Using MYTILINEOS BR, BR pavement tiles and BR geopolymerized brick slips were used respectively in the floor and the walls of the pavilion, while high strength BR hybrid binders were used in producing benches and tables. The goal of pavilion is to serve as an informational center, showcasing BR reuse technologies and boosting public acceptance for use of BR in commercial applications.

The pavilion is situated at the beach front of the historic modernist settlement by prominent 1960's architect and planner Constantinos A. Doxiadis, himself one of the early figures demonstrating the need and the methods towards a more sustainable turn regarding the science of Ekistics. This presented the project with an important challenge regarding the adaptation of this experimental structure in the overall urban and natural environment of Aspra Spitia. Additionally, the pavilion serves as a continuous testing ground for the functional, aesthetic and technical behaviour of BR materials used, if considering their future commercial development.

Crystalline and Amorphous Phases in Fe-Rich Slags: Implications for As and Sb leaching Behaviour
O-122

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Non-ferrous metal production generates a substantial volume of slag that holds potential for valorization. However, the leaching of toxic metals, resulting from the presence of metal(loid)s in the slag, remains a significant environmental concern, impeding its utilization in various high-value applications. To ensure the safe reuse of slags in such applications, it is crucial to understand the leachability of major/minor/ hazardous elements that dissolve from crystalline or amorphous phases within the slag, considering the 1) chemical composition; 2) mineralogy, and 3) microstructure. This study investigates (a) the crystalline or amorphous phases within the slag that contain hazardous metalloids (b) the processing conditions and parameters (e.g., slag composition, atmosphere, and cooling rates) under which these phases are formed, and (c) the leaching of hazardous metalloids in relation to (a) and (b) With an emphasis on evaluating both synthetic and industrial slags, this research focuses on studying the distribution of hazardous metalloids such as As and Sb among different (crystalline and amorphous) phases. Fe-Si-Al type slags with varying chemical compositions (doped with small amounts of As, Mo, Sb, Cu, Cr, and S), atmospheres (pO2), and cooling rates were produced. The correlation between leachability and the presence of different phases was investigated using solid-phase characterization (XRF, ICP-OES, QXRD, SEM/EDX, EPMA), as well as leaching tests (EN 12457-2, toxicity characteristics leaching procedure (TCLP), and pH-dependent tests). Results showed that As was effectively immobilized by the amorphous phases formed during fast slag solidification (water-quenched). Conversely, Sb was immobilized by the minerals (fayalite) formed during slower slag solidification (air-dried). This data provide a foundation for developing a model to predict leaching behavior, enabling more efficient slag modifications aimed at limiting leaching.

Eco-friendly composites – environmental assessment of mine tailings based geopolymers
O-123

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Resource efficiency is one of the basic principles for a Circular Economy (CE). It could be achieved by finding replacement for natural raw materials by anthropogenic raw materials, including by-products from industrial processes and waste materials. In case of the Polish economy, one of the possible sources are mine tailings from hard coal exploration and also the waste from post-mining heaps. The main objective of this work is to present the results of environmental analysis for mine tailing-based geopolymers. Two geopolymer materials were compared using life cycle assessment (LCA) methodology principles. One of them was based on metakaolin and the second on industrial waste, mainly from coal shale as a waste from hard coal mining. The results show that replacing the original material, such as metakaolin in mining tailings reduces environmental impact, including CO2 emissions. The main findings can be helpful in the implementation of CE, especially the development of sustainable materials, which is one of the crucial elements to introduce closed loops into practice.

Wednesday 30 August 2023

ROOM 13

SESSION C4

Magnets and REEs

Chair: K. Forsberg, S. Kalaitzidis

High-performance solid phase extraction chromatography for recycling of NdFeB magnet waste.
O-124

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Exponentially increasing use of rare earth elements (REEs) in green technologies such as electric vehicles, wind turbines, and electronic equipment is driving a rapid rise in economic importance. In addition, complementing the supply of REEs from primary sources through recycling of waste streams is becoming increasingly significant due to the high supply risk. Chromatography has the potential to be an efficient and environmentally friendly alternative to current go-to technologies for REE separation. In this work, we have investigated separating REEs (Nd, Pr, Sm and Dy) from Fe, Co and B using high-performance solid phase extraction chromatography.
In addition to REEs, spent NdFeB magnets contain large amounts of Fe. The REE were extracted from a Fe-rich sulfate-based leach liquor using solvent extraction. More than 99% Dy, 81% Pr, 76% Nd, and 33% Sm was extracted in single-stage using 34.7 vol.% D2EHPA in kerosene and O/A ratio 1. Under these conditions the co-extraction was limited to 2.3% Fe, 0.5% Co, and 1.5% B. After stripping with dilute acid, REE separation into pure fractions by extraction chromatography was investigated, using a D2EHPA-impregnated column and elution with H2SO4 gradients. It is shown that in a single stage it is possible to separate the light REEs (Nd and Pr) in a high-purity fraction from Sm and Dy in separate fractions, with the co-extracted impurities separated in an early-eluting fraction.

Advancing sustainable magnets for electric mobility and renewable energy: Innovating processing and recycling routes for Nd-Fe-B permanent magnets
O-125

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Rare-earth-element (REE) based permanent magnets (PMs), i.e., Nd–Fe–B, hold the highest maximum energy product (BH)max of more than 400 kJm-3. As such, they are in high demand for critical applications in electric mobility (e-vehicles), and wind turbines. Nd-Fe-B PMs are vital for fulfilling "Green Deal" and "Critical raw materials act" commitments and enabling future energy technologies. Nd-Fe-B technologies in the industry are mature, so incremental improvements are now the norm. However, the potential is enormous, as we currently reach only 20% of the potential coercivity in these magnets. Furthermore, REEs are on the EU's list of critical raw materials, which require holistic measures, including recycling to accompany their future development. Our recycling and reprocessing strategies for end-of-life Nd-Fe-B magnets include hydrogen processing techniques and chemical leaching. With exploring the possibilities of re-engineering, the Nd-Fe-B magnets starting from pre-obtained single crystalline Nd2Fe14B phase, new intergranular recourse efficient phases were designed and consolidated via fast consolidation technique - spark plasma sintering. The inclusion of Nd-Cu in the Nd2Fe14B single crystalline powder was investigated. The coercivity increased from 16 kA/m for the sample without Nd-Cu to 492 kA/m for the sample with a 10 wt.% Nd-Cu addition. Furthermore, the remanent magnetization increased from 0.20 T to 1.04 T. First upcycled magnets were successfully prepared, and the results achieved high coercivity and remanence that are further optimized. For that, it is crucial to detect and understand the underlying chemical and physical mechanisms for magnetization at a high spatial and analytical resolution using transmission electron microscopy (TEM). The effects of our work are multifaceted, as it is aimed at recycling and upgrading the Nd-Fe-B magnets with improved performance and resource efficiency.

Process mineralogy applied to mineral processing for the development of REE deposits
O-126

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REE are complex deposits displaying a high degree of inherent variability that has an impact on their beneficiation, and consequently their economic evaluation. Automated mineralogy (AMIN) has become an integral part in geology, geometallurgy, and mineral processing industry in the evaluation of REE deposits and down stream processes. Ore characterization includes mineral and textural quantification, grain size, and mineral liberation analysis in relation to beneficiation such as grinding, flotation, gravity and hydrometallurgical processes. AMIN is heavily used in flowsheet development, process design, and optimization. Mineralogical analyses, coupled with mineral chemistry such as EPMA and LA-ICP-MS analyses are further used to understand the deportment of REE among multiple REE mineral hosts. Case studies of REE deposits from alkaline and carbonatite deposits are presented to demonstrate the strong dependence between quantitative mineralogy and mineral recovery in relation to the type of REE minerals, and their mass, grain size, and liberation attributes. Mineralogically limited (predicted) grades and recoveries can be used as a proxy for beneficiation (e.g., flotation) characterization. Furthermore, AMIN analysis of hydrometallurgical products, i.e., leached residues, aims to evaluate the metallurgical performance of REE extraction from their hosts. Thus, the AMIN data can be linked to metallurgical response, and used to explain test results, and guide the flowsheet development.

Investigation and Optimization of the Chemical and Operational Parameters of the Stripping Process Using Oxalic Acid to Recycle REEs from Permanent Magnets
O-127

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The NEW RE project has been defined to introduce a comprehensive method with economic and environmental benefits to recover rare earth elements (REEs), Iron, and Boron from the spent PMs. The BOX-Behnken design was used to determine the effects of several operational and chemical parameters, i.e.: the stripping reagent to loaded organic phase volume ratio; oxalic acid concentration; the stirring rate; stripping time on the efficiency of stripping process of loaded DEHPA by oxalic acid. The PMs swarf resulted from manufacturing these were used as raw material for the leaching with citric acid. At the optimum conditions, more than 85% of light REEs and 80% of heavy REEs were recovered in the overall recycling processes. It could be concluded that using oxalic acid is a simple and efficient method for stripping the loaded organic phase in recycling PMs.

Potential application of modified diglycolamide resin For Rare Earth Element extraction
O-128

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Rare earth elements (REE) play a vital role in technological advancement due to their unique physical and chemical properties essential for various renewable energy applications. However, this increasing demand represents a challenging task for sustainability that corresponds to various research interests relating to the development of various extraction techniques, particularly on the extractant being used. In this study, TK221 (a modified diglycolamide polymer resin containing, carbamoyl methyl phosphine oxide (CMPO) and diglycolamide (DGA-N)) has been investigated as a conjugate extractant. FTIR and SEM analysis results confirmed the presence of CMPO and DGA-N being coated onto the PS-DVB support of TK221. Moreover, the kinetic rate law and adsorption isotherm batch test was investigated to understand the corresponding adsorption mechanism. The results show that REEs' (Nd, Y, Ce, and Er) obtained pseudo-second-order kinetics and Langmuir isotherm, suggesting that the adsorption mechanism undergoes a single monolayer adsorption site via a chemisorption process. The Qmax values of Nd, Ce, Er, Y, and Fe were 45.249 mg/g, 43.103 mg/g, 35.088 mg/g, 15.552 mg/g, and 12.315 mg/g, respectively. This research further suggests that TK221 polymer resin can be used as an alternative absorbent material for an effective REE extraction.

Recovery of Scandium from industrial acidic solutions through ion-exchange
O-129

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Scandium is a critical metal with increasing demand in modern technologies, like 5G thin films, oxide fuel cells, light-weight Al-Sc alloys and it is present at considerably high concentrations in various metallurgical by-products, including the ones of titanium oxide production industry. Its limited availability presents significant challenges for extraction. In this study, we focused on developing an efficient ion exchange technique for scandium extraction, aiming to overcome these challenges.
Ion exchange, renowned for its high selectivity, emerged as a promising approach to selectively capture scandium ions from complex solutions containing diverse metals. To optimize extraction efficiency and selectivity, careful selection of the appropriate resin, investigation of the initial feed solution and elution of the resins are considered crucial factors. In this study, two different cases for scandium extraction from industrial by-products through ion-exchange technique are presented: extraction from by-products from TiO2 industry and extraction from Bauxite Residue. The results of our work indicate that resins impregnated in dis(2-ethylhexyl) phosphate (D2EHPA) show selective extraction of Sc in complex aqueous solution. Moreover, the adjustment of the initials feed solution can enhance extraction and selectivity of Sc.

Utilization of graphite industrial wastes for the sustainable production of silicon carbide
O-130

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This work investigates the utilization of industrial graphite wastes for the sustainable production of silicon carbide (SiC). The sourced graphite wastes are generated in the machining process of synthetic graphite to produce casting molds of non-ferrous metals. Currently, SiC is produced according to the Acheson method, in which pure silica sand reacts with fine carbon in an electric furnace at temperatures in the range of 2200 - 2500 °C. Acheson process has a quite low efficiency, since only about 20% of the charge is converted into SiC, while the high operating temperature results in significant environmental and energy issues. In this work, an innovative approach for the production of SiC at temperatures below 1000 °C was investigated, using graphite wastes and silica sand with the addition of magnesium powder (Mg), as a reducing agent.
The main process parameters affecting the yield and purity of SiC were studied and the obtained materials were characterized by XRD, FT-IR and SEM. According to the experimental results, the temperature, retention time and molar ratios of SiO2 to graphite and SiO2 to Mg affected strongly the process yield and the quality of the obtained SiC. The mechanism of the process has been also discussed.
Acknowledgements: This work was funded by the research project GRAPHITE / ATTP4-0358649 that has been co-funded by Greece and the European Union, through the framework program ATTIKH 2014-2020 of the Greek General Secretariat of Research and Innovation.

Securing the supply chain for rare earth polymer-bonded magnets by recycling
O-131

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The development of new technologies for the sustainable and efficient recycling of rare earth (RE) permanent magnets (based on Nd-Fe-B) is a very important task to secure the supply of European industry with the required raw materials. Permanent magnets are not only a key functional material in the mobility and energy sectors, in particular magnets for e-mobility and wind energy, but are also used in various other applications (communication technology, pumps, sensors, magnetic holding systems, etc.). Although permanent magnets are used in a wide range of technologies important for future applications, the supply of rare earths is dominated by China and, to a lesser extent, Australia. Recycling of scrap magnets from end-of-life products is one way to secure Europe's rare earth supply chain. Recycling also improves the environmental footprint of REE magnets in a circular economy, as the environmental impact of primary REE mining can be reduced by using material that is already circulating in the technosphere. With a market share of around 85%, sintered magnets are the dominant type of magnet when using rare earths. However, polymer bonded magnets are used in a wide range of applications due to their much lower production costs and ease of processing into complex shapes. Polymer bonded magnets are more difficult to recycle as the composite materials need to be separated without degrading the material properties.

In the framework of the EU-funded ERA-MIN 2 project SupplyPBM we investigated the supply chain for polymer bonded RE magnets in terms of a circular economy by detailed Life Cycle Analysis. Further we developed and tested on a lab scale methods production of recycled polymer bonded magnets.
Based on our LCA data we used two different types of EoL magnets: sintered magnets, recycled by rapid quenching (in particular melt-spinning) and polymer bonded magnets, recycled by high pressure high temperature batch reactor system for chemical recycling.

Wednesday 30 August 2023

ROOM 5

SESSION C5

Energy transition metals –
ENICON & EXCEED HE projects

Chair: K. Komnitsas

Energy transition metals: Future demand and low carbon processing technologies
O-132

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This paper discusses the importance of the energy transition metals Ni, Co and Li, towards building Europe's clean technology value chains and meeting the 2050 climate-neutrality goal. Some emerging metal extraction technologies, investigated in the frame of Horizon Europe projects, ENICON, https://enicon-horizon.eu/, and EXCEED, https://exceed-horizon.eu/, in order to de-crease the carbon footprint of the production of energy transition metals are also discussed.

Exploring barriers to the implementation of circular economy processes for batteries
O-134

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The batteries sector is expected to play a key role in the energy transition and will need to cope with soaring material demand in the future. Implementing circularity approaches for batteries that enter the EU market is considered to be among the key options for mitigating the impacts of increased resource use, but also for securing future access to raw materials needed for decarbonization technologies. Using a muti-case study method, this paper aims to identify key challenges that hinder the adoption of circularity and resource efficiency practices by companies in the battery sector. The analysis is based on qualitative data collected from a sample of 10 companies. To support the cat-egorisation of data, a conceptual framework of existing barriers faced by businesses implementing circularity models is developed through a literature review. The paper concludes by identifying areas where EU policy intervention is needed.

Preliminary assessment of the social license to operate in four European lithium projects
O-135

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Lithium is needed for green energy transition, and it is produced outside of European Union (EU). However, EU has promising lithium projects, but their local acceptance may be important for their viability. Four lithium projects are preliminary assessed using data from literature and media regarding their acceptance. They are case studies of the Horizon 2020 Project EXCEED (Grant Agreements no. 101091543). They aim for lithium production from pegmatites/granites/kaolin.

The Rapasaari project owned by Stillwater-Siboney Keliber Oy is in Kaustinen, western Finland. The company aims to start production from pegmatites in 2024. The region has no mining-related disputes, but the project is close to Natura 2000 area.

The Mina do Barroso project is owned by Savannah Resources in northern Portugal. Feasibility study and environmental impact assessment are on the way and production would be from granite.

The Trevalour project in St. Austell, Cornwall, UK, is operated by Cornish Lithium plc. It is in an old mining heritage area and the project is in exploration stage. The company aims to produce lithium from granite/kaolin and thermal water.

The Emili project in Beauvoir (Allier), western France is owned by Imerys Minerals Ltd. It is planned to start production from granite in 2028.

All companies practice stakeholder engagement and communication. Except of the Mina do Barroso, there seems to not have any open resistance towards the projects and quite positive picture is given for all other projects in the media. Mina do Barroso is also the only project with critical academic articles on it.

Strategic and critical raw materials in the battery supply chain - skills, education and training
O-136

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In European Critical Raw Materials Act underlined that by 2030,15% of the EU's annual consumption for strategic raw materials should be produced from recycling, and the recycling processes for lithium-ion batteries should achieve a yield of 95% for Co, Cu, Ni, 70% yield for Li till 2030. It will require new skills and competence, therefore, the EIT InnoEnergy created the European Battery Academy offering courses and lectures for over 800 partners of which from Poland, only 11 industrial partners.
Poland is one of the EU leaders in Li-ion batteries with a manufacturing capacity of 73 GWh (export of EUR 8.25 billion, 2022). Currently operating in Poland: LG Energy, Northvolt, Umicore, SK hi-tech, Capchem, Guotai Huarong, BMZ and Mercedes-Benz Manufacturing Poland, Clean Power Technology. Moreover, the EBRD has committed more than €500 million to the EV manufacturing sector, of which the most recent project was to invest in a new EV battery recycling facility (Elemental Holding). As the production of batteries is an activity that relies heavily on raw materials and has a great potential for recycling and recovery an education programme is also needed. Nowadays, most technical universities offer education in the field of electromobility, producing highly skilled engineers, but there is a lack of education about battery recycling. To fill the gap the BattValue project supported by EIT Raw Materials was developed to provide courses with professional-level knowledge of existing and future battery concepts, focusing also on circular economy and raw materials flows and security. The aim of the paper is to assess and review the existing offer of the different educational content of courses and training in Poland and the EU focusing on the recovery of critical and strategic raw materials from batteries. It would be compared with country policy and planning investments to identify a gap in education and skill and to propose missing content and solutions.

Wednesday 30 August 2023

ROOM 6

SESSION C6

Reuse-Recycling and Valorisation II

Chair: C. Mitchell, V. Melfos

Fuelling the Foundation Industries: discovering the hidden value of mineral waste in the UK
O-137

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The Foundation Industries, which include the chemicals, cement, ceramics, glass, metals and paper sectors, are worth £52 billion to the UK economy, produce 75% of its materials and 10% of its total CO_2 emissions. The UK extractive industry is integral to the foundation industry value chain and annually supplies millions of tonnes of mineral products used in its manufacturing processes.

Mineral extraction and processing results in a wide range of mineral waste materials including over- and inter-burden, scalpings, oversize, fines, tailings, slimes and dust. Although the exact amount, and its composition, is unclear due to a lack of data, it is estimated that over 50 million tonnes of mineral waste were produced in the UK in 2020.

Driven by the imperatives to achieve resource efficiency, circular economy, sustainable development and industrial decarbonisation, the British Geological Survey (since 2021), has been visiting UK mineral operations to improve the understanding of mineral waste production, composition and its potential for use. This has enabled sharing of data and information on previously poorly understood stocks and flows of waste materials between different industries and led to potential new applications in novel polymer coatings and investment casting.

This ongoing research is being carried out as part of the TransFIRe (Transforming the Foundation Industries Research and Innovation Hub) project funded by UK Research & Innovation as part of the Industrial Strategy Challenge Fund Transforming Foundation Industries challenge.

EcoGlassFab: Eco-Glass-Fabrication from the assembly of secondary precursors
O-138

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A calculation tool to formulate Eco-designed glasses is being developed within the Institute of Sciences and Technologies for a Circular Economy of Low Carbon Energies. The objective is to develop an "EcoGlassFab" application that will allow the calculation of the best available secondary materials assemblies (bio-sourced materials, specific cullet, PV glass, industrial mineral materials to be valorized, fumes, dusts) and to elaborate glasses considering the compositions and technical specifications of glass manufacturers. In addition to the scientific and technical challenges (reactivity at high temperature, optimal thermal flows and glass quality), this tool will take into account economic and environmental aspects through a systemic approach. Its development was initiated by a Life Cycle Analysis as well as a technical-economic analysis based on a given glass formulation with low impurity tolerance. The scope of the study extended from the extraction of raw materials in the mine to the production of the glass at the end of the glass furnace. Data from the so-called "conventional" process, which includes 100% primary raw materials, and the "EcoGlassFab" process, which includes a proportion of secondary precursors to replace certain raw materials, were compared. The results show that the substitution of raw materials by secondary materials in the selected case study allows to reduce the environmental impacts by about -15%, on all the 16 classes of the life cycle analysis, considering a substitution of raw material of 25%. This study must be completed by chemical reactivity studies as well as heat flow measurements to determine the technological feasibility of this type of Eco-designed glass. This approach will be transposed to many glass compositions for various applications (flat glass, hollow glass, glass fiber, glass frit, colored glass,...)

Valorizing mineral wool ash as a supplementary cementitious materials O-139

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Fulfilling the ambition for maintaining global carbon neutrality, utilizing alternative zero-carbon resources is becoming more essential in the design of building materials. Among efforts to develop alternative supplementary cementitious materials are becoming popular due to their low environmental impact in reducing CO2 emissions. The mineral wool waste collected from construction debris could be valorized as a potential pozzolanic material for Portland cement concrete. However, a completely circular production can only be obtained through a "zero-waste" production route. The ashes collected from the coke-fired hot blast kiln are a significant portion of the waste stream generated from mineral wool production. To achieve a sustainable circular production for mineral wools,
valorizing the waste stream obtained during production is becoming more essential for the producer. The main goal of this study is to validate a circular
production route utilizing the waste ash generated during mineral (stone) wool production in cementitious binders. To achieve this goal, 2 different types of waste ash having different composition and particle size were used. The ashes were classified as W10 is calcite based ash having an average particle size of 75 microns and W20 is a silicate based ash with an average particle size of 22 microns. The performance evaluation was done on cement-based samples where 20% of the cement was replaced with waste ash. The results showed that W20 exhibits a puzzolanic behavior and can improve the strength of the mortar even at early ages while W10 does not contribute to strength and acts as a filler material. Both ashes increased the initial setting time and reduced the workability of the mortar. The outcomes of this study creates an economic value for large volumes of material
of previously zero value, while proposing a new cementitious composite product for the mineral wool producers.

Microwave chemistry for enhanced carbon capture by serpentine quarry waste
O-140

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Mineral Carbonation (MC) is included among the most promising potential solutions for long-term carbon capture and storage (CCS). This mineral treatment consists in the water-mediated reaction of the CaO and MgO components of minerals with carbon dioxide, with formation of stable and insoluble Ca- and Mg-carbonates and/or hydroxy-carbonate hydrates. Noteworthy, these latter compounds constitute also valuable secondary raw materials employed, e.g., in the construction sector. Despite the carbonation reaction is spontaneous under a wide range of conditions, kinetic barriers pose sever limitations for its practical exploitation.
High fractions of MgO are available in serpentine minerals, characterized by alternated layers of silica [SiO2] and brucite [Mg(OH)2], quarried in a number of sites in Europe, with a relevant role played by Italy. This industrial activity is characterized by the production of a fraction as large as 50% of waste in the form of serpentine pebble and powder, representing potential reservoirs for fixing a quantity as large as 20 ktons of CO2 per site/per year in the form of re-utilizable Mg-carbonates.
With the scope to contribute in making this possibility a reality, we show here the application of microwave (MW)-assisted processes for the in-depth study of the carbonation of brucite, representing a model systems for the reactive component of serpentine. MW reactors allow for a fine tuning of the temperature, pressure and irradiation energy, enabling us to infer the mechanism, kinetics, and energy costs of the reaction and to identify the chemical characteristics of the products.

Effect of by-pass filter dust on durability of self-compacting concrete O-141

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By-pass filter dust (BPD) constitutes one of the main by-products produced and collected during cement production process, being a potential atmosphere and subsoil pollutant. In this paper, the utilization of BPD by partially replacing a conventional filler such as marble powder in terms of durability and transport properties of Self-Compacting Concrete (SCC) is thoroughly investigated. More specifically, BPD incorporation effect was evaluated after conducting a series of tests related to SCCs' water absorption, sorptivity, water permeability, chloride diffusion coefficient, carbonation and freeze and thaw resistance. The above-mentioned test results demonstrated that BPD, thanks to its high pozzolanic reactivity in conjunction with its filler effect, contributed to the production of SCC of denser cementitious matrix which in turn leads to improved durability.

How to convert your waste into a resource?
O-142

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In today's circular economy the conversion of a waste to a potential resource is very favourable in today's markets. However, you need more than just a process to take things forward into a full-scale commercial project.
Mures Magnesium Srl have developed a process to recover magnesium, chromium oxide and calcium chloride from an historical chromium oxide process residue and have chosen to follow the mining industry reporting standards in the evaluation of their project, namely the JORC Code, in order to pursue funding for the commercial project. The JORC Code is produced by the Australasian Joint Ore Reserves Committee and is for the Independent reporting of Exploration Results, Mineral Resources and Ore Reserves. It is a professional code of practice that sets minimum standards for the Public Reporting and provides a mandatory system for the classification of minerals Exploration Results, Mineral Resources and Ore Reserves according to the levels of confidence in geological knowledge and technical and economic considerations. The National Instrument 43-101 is a similar code utilised in North American.
Within these codes the classification of the Resource is well defined to ensure a degree of confidence in results presented and similar rules are applied to the excavation and processing, plus environmental and social impacts that ultimately permit the final conversion of the project to a Reserve, thereby giving further independent confidence in the project as a whole. This paper presents and discusses the issues encountered and how Mures Magnesium have overcome them.

Valorization of aplite in alkali-activated materials
O-143

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Geopolymers belong to the broad family of alkali-activated materials that are considered to have much smaller carbon dioxide (CO2) footprint than traditional Portland cements. A wide range of metallurgical wastes are utilized as silicious sources to produce geopolymer components with a prospect of numerous applications in the construction field. At the same time, efforts have been also made to the valorization of aplite rock, which is found to be abundant in Finnvolldalen of Norway and consists mainly of quartz and alkali feldspar, resembling the composition of Na-rich pozzolans. In this framework, the current study focuses on the synthesis of inorganic polymers made of aplite and metakaolin as precursors. In addition, the production of synthetic Na-waterglass is also tested as candidate soluble silica donor in geopolymer systems, through the hydrothermal treatment of aplite. The obtained results confirm that inorganic polymers produced by hydrothermally treated aplite (HTA) and metakaolin (MK) lead to materials with enhanced compressive strength values compared to specimens produced by untreated aplite and MK. At the same time, sodium silicate solution from aplite and commercially available waterglass present similar properties, indicating that aplite can be used as alternative raw material in the production of sodium silicates.

Optimization of the demolition waste incorporation to cement mortar by response surface methodology
O-144

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Building construction and demolition waste constitutes one of the largest waste deposits in the world. Major actions for valorzation must be implemented.
In this context, the recycling of demolition waste represents a considerable challenge in the building sector.
On the other hand, Tunisia has recorded in recent years a strong urbanization which results in an excessive increase in construction sites and therefore in the number of anarchic dumps and large quantities of demolition waste, resulting in increased pressure on ecosystems and excessive exploitation of natural resources. This is why it is imperative to reduce the consumption of materials, and to use natural resources efficiently through waste recycling. As a result, the recovery of demolition waste, their exploitation and their reintegration into a new life cycle requires detailed studies of the properties of this waste.
In this context, this work focuses on other possible applications of these types of waste through their integration as an additive to cement. Six types of demolition waste are then selected, namely concrete, brick, tiles, plaster, earthenware and marble, with different proportions.
This work concerns the use of experimental design methodology to optimize the effect of addition of those different demolition wastes on mechanical and chemical properties for new developed cement.

Wednesday 30 August 2023

ROOM 13

SESSION C7

Advanced metallurgical processes

Chair: C. van der Eijk, D. Panias

The possibilities and limitations of the use of hydrogen in different metallurgical sectors
KN-10

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The metallurgical sector is vital to a sustainable future as vast amounts of metals, such as steel, aluminium, and copper are required for solar panels, wind turbines, electrification of transport and upgrading of the electricity grid. However, the metallurgical industry is also one of the largest CO2 emitting sectors.

Hydrogen is considered the key enabler to make the metallurgical industry less carbon intensive. The use of hydrogen in the steel industry is getting well established with several high TRL initiatives ongoing. Hydrogen can, however, also play a role in the production of other metals. The presentation will highlight some of the other metallurgical sectors in which hydrogen is now explored. That is:

- For the processing of bauxite residue. In this case the iron in the bauxite residue is partially reduced to magnetite or even completely reduced to iron after which this iron rich fraction is separated. The alumina is afterwards recovered through leaching.
- For the pre-reduction of manganese ore which can also be performed using hydrogen instead of fossil carbon. The Manganese metal can then be produced with an aluminothermic reaction afterwards to warranting a fully CO2 free processes.
- For the recovery of copper from copper slags which is well suited to do with hydrogen because it results in a selective reduction of the copper without reducing the iron.
- Hydrogen as fuel for heating in the steel and aluminium industry, replacing oxyfuel burners that run on fossil fuels.

Isothermal Pre-reduction behaviour of Nchwaning Manganese Ore in H2 atmosphere
O-145

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The application of hydrogen to pre-reduce manganese ores is a sustainable approach to do decarbonization in the ferroalloy industry. The process is extensively studied and tested in lab to pilot scale in the HAlMan EU project. This work presents the results of an experimental study that was conducted in a lab scale vertical thermogravimetric furnace for the pre-reduction of a manganese ore by hydrogen under isothermal condition at 500℃, 600℃, 700℃, and 800℃. The ore and reduced samples were characterized by XRF, XRD, BET and SEM techniques to outline the hydrogen reduction behavior of the ore from mineralogical, microstructural, and chemical points of view. The rate and extent of reduction were studied using the continuous mass changes during the reduction. It was found that pre-reduction at temperature 700℃ and 800℃ yields metallic iron formation from Fe_2O_3 and MnO formation from MnO_2/Mn_2O_3. However, the pre-reduction at lower temparatures within did not show complete reduction to Fe and MnO reduction products. The pore structure of the ore was affected by pre-reduction temperature, and significant porosity evolution was observed.

Optimization of Fe, Al, and Na recovery from H2 Reduced Bauxite Residue (Red mud) using Response surface methodology (RSM)
O-146

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Bauxite Residue (BR), a solid waste generated during the Bayer process for alumina production is a polymetallic source. This study aims to investigate the recovery of Fe, Al, and Na from H_2-reduced BR pellets (under 5 vol% H_2 + 95 vol% N_2 with 45 L/h flowrate) after water leaching and magnetic separation and further optimize the recovery process through response surface methodology (RSM). RSM with a full factorial design was employed to evaluate the effect of process variables such as temperature (400 - 700 °C), time (30 - 12 min), and NaOH addition (10 - 25 wt%) for recovery of these metals from reduced pellets. From the analysis of variance (ANOVA), the significant factors on response were identified. The Fe, Al, and Na recovery was primarily influenced by the temperature and NaOH, then the reduction time. The optimum parameters for concurrent recovery of Fe, Al, and Na recovery were predicted to be 600 °C for 2 h with 20 wt% NaOH addition, resulting in Fe, Al, and Na recovery of 75.8 %, 84 %, and 90 % respectively. The actual experimental Fe, Al, and Na recovery rates are 73.4 %, 80.1 %, and 87.9 %, respectively. The predicted recovery rates at optimal process parameters are sufficiently accurate and within the allowable variance (< 5 %).

Contribution to the optimization of the smelting reduction of nickeliferous laterites, based on the recent industrial experience. O-147

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The Greek Ferronickel Industry faces the challenge of restructuring and reoperation in the future, given that privatization is in progress, including the acquisition of the company's assets to a joint venture enterprise. Within this framework, the current paper aims to contribute to the discussion for developing a new management strategy for the optimization of pyrometallurgical process, focusing on the critical step of smelting reduction. Based mainly on industrial experience, factors which critically affect the safety and cost-effectiveness of smelting reduction are detected and presented, also by means of case studies, being classified as following: i) Optimal raw materials' feed management, including laterite ores (domestic or not), solid fuels and electrode paste, ii) Focus on preventive maintenance management. Substantial increase of the facilities' operational index and cost saving is obtained, iii) Modern human resources management strategy, enhancing evaluation indicators' use, education culture, process standardization and tacit - explicit knowledge management. Their economical footprint is further discussed.

Exploring the leaching potential of lemonitic laterites with nitrate solutions
O-148

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In the current paper, the recovery of nickel and cobalt from a lemonitic laterite sample, derived from a mine area in the Greek island of Euboea, was studied via an acid agitation leach process with nitric acid as the leaching agent, to determine the optimal conditions at which the highest possible extractions of nickel and cobalt were obtained in the pregnant solution.
Pretreatment of about 10kg of the ore, by crushing and grinding, was followed by sampling of a representative 0.5kg sample. The sample was characterized chemically, using XRF, as well as by acid digestion with ICP-OES, and mineralogically by XRD and SEM analysis. Three series of experiments were carried out. In the first series, the extractability of metals was studied by varying the pulp density at values of 10%, 20% and 30%, in the second the temperature at values of 60oC, 80oC and 100oC. For the last series of tests, the metals extraction at different values of initial nitric acid concentrations of 1M, 2M and 4M, was examined. For the analysis and characterization of the final extraction products, FAAS and ICP-OES were used for pregnant solutions as well as XRF and solids acid digestion with ICP-OES method for solid residues obtained.
Based on the results, pulp density is a parameter that affects to a small extent the extractability of selected metals. The effect of temperature is characterized as particularly significant as with its increase, the final percentages of nickel and cobalt were particularly high. The variation in acid concentration had a significant effect but not like that of temperature. For extraction conditions of pulp density 20%, temperature 100oC, and 2M HNO_3 concentration, the highest recoveries of nickel and cobalt were obtained, namely 94.4% and 83.6% respectively. Iron in all tests did not exceed dissolutions of more than 7.2% in the pregnant solution.

Aluminothermic reduction of iron and titanium from metallurgical wastes
O-149

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Bauxite is an important ore that is used to produce metallurgical-grade alumina through the Bayer process. During this process, a byproduct is formed, known as bauxite residue (BR). The production of 1 ton of alumina generates around 1 ton of residue which handling is a major challenge for the alumina industry due to its large volume and high alkalinity. Titanium oxide is a major component of BR with a high value but it is often an unwanted element in common BR reuse options such as cement or iron production. Conventional carbothermic reduction smelting of BR produces a slag still containing a large amount of Ti. This study investigates an aluminothermic process for producing a FeTi alloy by combining BR, ilmenite ore, and fluxes. Based on thermodynamic calculations and batch experiments, the aluminum(reductant) and the fluxes amounts were investigated to achieve the optimum alloy production in parallel with a slag that could be further valorized in the cement industry. The mineralogical and chemical analysis of the metallic and slag phase agreed with the thermodynamic calculations. The results obtained by this study can lead to developing a new process for the complete valorization of BR and paving the way for scaling up aluminothermic processes for producing ferroalloys from all iron-rich residues.

Wastes from olive oil production as a perspective component for biocoke production
O-150

Małgorzata Wojtaszek-Kalaitzidi[1], Michał Rejdak[1], Michał Książek[2], Sten Yngve Larsen[3], Stavros Kalaitzidis[4]

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Norwegian ferroalloys industry produces 1Mt/y of different kind of ferroalloys (e.g. FeMn/SiMn, FeSi/Si). One of the basic components used in ferroalloys production are iron ore reductants. For this purpose, raw fossil materials like coal and coke are used thereby making the Norwegian ferroalloys industry one of the greatest CO2 emitters. Recently EU adopted the plan for 40% CO2 emission reduction till 2030 and to achieve this target the replacement of fossil originated reductants with “zero” emission substrates like biomass is necessary. The main objective of the project is to develop an innovative and economically viable technology for bio-coke production for the ferroalloys industry. Bio-coke can be produced on the basis of coal with the addition of substances of biomass origin. Blends for the production of bio-coke should have appropriate coke-making properties to ensure the quality of bio-coke.
Various types of biomass were tested in the project, among others the wastes from the olive oil production from the Greek company Eleourgia Prevezis S.A. Three types of olive wastes were tested: olive exhausted cake, pellets from olive exhausted cake, olive kernels. Due to the chemical and physical properties, only the olive kernels presented the desired quality to be used as a bio component in coking blend. As it is well known, the addition of biomass to the coal blend always deteriorates the coking properties and the coke quality. The biomass can be added to the blend only in rational share dependent on the biomass properties, coal blend properties, coking conditions. To reduce the negative effect of the biomass addition on the coke quality, the olive kernels were tested also in form of biochar (carbonization T= 600°C). In comparison to the other biomass components, the olive wastes in both raw and biochar form together with wood charcoal presented the most promising effect in obtaining biocokes.

Wednesday 30 August 2023

ROOM 5

SESSION C8

Experts Panel Discussion
How can EU Critical Raw Materials extraction from waste or low-grade ore compete with Asian production?

Moderators: T. Balomenos, B. Orberger

The Sulphate Process and its role in a Chemical Production Network
O-151

Maurits Van den Berg

Venator

In mainland Europe, Titanium Dioxide is produced predominantly via the Sulphate Process. The plants operate as large separation devices, with the main product TiO_2, as a white pigment unsurpassed for its brightness and refractive index, containing only trace levels of foreign elements. The foreign elements accumulate in the co-products, which have been successfully integrated in existing large-scale industrial processes. Examples are additives that reduce hazardous chromium levels in cement or additives that aide in purifying water.
Going forward, critical materials such as valuable metals can be gained from co-products. Further, co-products from the Sulphate Process may constitute a viable raw material to produce metals and alloys in metallurgical processes. Finally, the energy transition could benefit greatly from what the Sulphate Process has to offer in its co-product portfolio.
Europe stands at a crossroads: will it prove to be possible to strategically secure these critical raw materials from the Sulphate Process?

Industrial Minerals: The sleeping giant of European CRM resources? O-152

Anastasios Kladis

AdMiRIS

CRM and other strategic metals, are highly sought after in Europe and European Commission is putting more and more effort and resources to mobilize companies, research, academia and society. Beyond the traditional sources, i.e. metallic deposits and their byproducts or tailings, an alternative, promising, yet underutilized source is industrial minerals (IM). Europe has leading positon in several IM which could be converted into sources of valuable metals. However, metals production requires totally different skills (financial, technical, and social) which are not fully available yet in IM companies. Special attention needs to be given in preparing/assisting IM companies to valorize the metals in their resources. And this is happening now…

While Europe is deficient in many (if not most) of metals (several of which are deemed as CRM), it has abundant resources of industrial minerals and rocks (IM): dolomite, bentonite, perlite, kaolin, feldspar, nepheline syenite, non-metallurgical bauxite. Several of those contain significant quantities of CRM, e.g. Al, Sc, Ga in bauxite. Due to large scale operations, IM extraction produces tailings, which also contain CRM. Already several EU funded projects are focusing on IM as a source of metals. Would the conversion of IMs into sources of metals including CRMs offer some support to European's Industry effort to reduce dependency from imports?

Waste to resource - secondary resourcing from waste
O-153

Duane Runciman

Mures Magnesium Srl.

Europe has failed to recognize the trapped value in its stored wastes generally treating waste mineral piles as exactly that. We believe the EU needs to start to consider that such waste is potentially semi processed stored resources that should be given opportunity to give again. A leaf should be taken out of Australia's book where they have recently completed a survey of the countries waste / tailings piles. Further work needs to be done to catalogue Europe's waste mineral piles, rate those that should be given a second look and then do initial surveys to include or eliminate these from reprocessing consideration. This will never be industry driven, but rather perhaps EIT RM / Horizon should be mandated to start this. A catalogue of these mineral wastes may well crystalize reprocessing thought processes.

Gallium Supply Chain - EU Resilience
O-154

Stefan Eichler

Freiberger Compound Materials

Gallium is a critical raw material to produce GaAs - base for high frequency/optoelectronics. The gallium supply chain is analyzed from an EU resilience perspective. Strategies to improve the current situation are considered with respect to technological and economic aspects:
- Circulation/recycling
- stockpiling
- EU production capability

A European Stockpile Organization is a must have for Europe to reduce its supply disruptions for Critical Materials
O-155

Henk Van der Laan

VIC

Today, around 25% of the metals mined Worldwide are used in Europe, however, just around 2 - 3% of the World metal production is currently mined in Europe, resulting in a huge imbalance.
Is Europe aware of its necessity to expend its metal production?
This is a legitimate question, because the recent energy crisis has reduced Europe's metal production capacity even further.
Metals are indispensable in the green transition for producing renewable energy. Metals are not only needed in products like wind turbines, solar panels, electric cars, or hydrogen technology, they are needed too in the expansion of the electric grid. Basic metals like aluminium and copper are needed to double the grid in the next 10 years to coop with the enormous growth of renewable energy.
The Green transition requires more critical metals like Li, Mo, Nb, V, Sr, Si, Ti, Mg, REE metals and Sc. Most of these critical metals (Mg, Nb, Sc, Sr, Ti and REE) are not at all produced in Europe and must be imported for 100%. The dependence on imports can lead to supply disruptions and lead to unacceptable high prices.
New sustainable mines are needed for the long term to solve the metal supply imbalance. Another option for Europe is to focus more on Industrial Symbiosis (IS) projects. In an Industrial Symbiosis project, waste streams from one industry are used as a feedstock for other industries.
However, developing new mines and starting new IS projects in Europe will not solve the imbalance of metals in Europe in the short term.
In order to avoid future supply disruptions, like the 2021 Mg crisis, Europe needs to set up a European organized critical metals stockpile.

Wednesday 8 September 2021

ROOM 6

SESSION C9:
Education

Chair: G. Barakos, M. Menegaki

European Universities and New Tools in the Raw Materials Education KN-11

Katerina Adam

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As amply documented in EU policy documents, such as Green Deal, Circular Economy Action Plan and Digital Agenda, Raw Materials play a pivotal role towards the Transition of Europe into a sustainable economy. To secure the supply of critical and other strategic raw materials needed for green and digital transition, major emphasis is placed in the development of innovative solutions along the whole value chain, achieved with the cooperation of HEIs, Industry and RTOs.

Despite the Strengths and Opportunities available for the EU Raw Materials sector, threats that often prevent its sustainable development include inter alia, the lack of its acceptance from the public as well as the shortage of skilled graduates and engineering professionals necessary to implement Digital Transformation and Industry 4.0. To circumvent the above, systematic efforts are paid during the last decades to update the education of the Raw Materials professionals in EU.

The present article presents the overarching role of European University Initiative, EUI, and the Educational Projects of EIT Raw Materials towards the education of professionals with the skills to deal with the major environmental and social challenges encountered, while ensuring economic competitiveness. Along these lines the objectives of the Alliance of European Universities linking Society with Technology, EULiST, recently recognized by the EU as a European University Alliance, where NTUA participates as a partner, will be presented as a case study.

TIMREX – an EIT labelled master programme in innovative mineral exploration
O-156

Sibila Borojević Šoštarić[1], Ferenc Madai[2], Gabriela Paszkowska[3], Nils Jansson[4]

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Nordic and West Balkan countries are major investments regions in Europe for greenfield and brownfield mineral exploration, however, availability of qualified technical, scientific and managerial personnel involved in the whole mineral cycle is limited, especially in West Balkan countries. The partners of the TIMREX EIT RawMaterials labelled MSc programme have developed a joint curriculum focused on innovative raw materials prospecting and exploration methods with strong innovation and entrepreneurial components. The programme incorporates new exploration techniques and methodologies, portable and higher sensitive equipment, robotized exploration equipment, and consequently processing and interpreting of large, multidimensional datasets. The TIMREX curriculum was built around the ideal mineral exploration programme, suggested by raw materials stakeholders, orientated to field geology, exploration techniques and data processing, including also elements of sustainability, transversal societal and regulatory aspects. Programme also focuses on EIT Overarching Learning Outcomes (OLO-s) embedded as core elements of the curriculum courses (innovation, entrepreneurship, sustainability, creativity, leadership and intercultural competences). Significant contribution to the OLO-s also arise from cross-organizational programme elements, including Exploration entrepreneurship course, summer field camp, Internship and Social and civic internship.

Integrated Mine Planning Education for the Modern Engineer
O-157

Ioannis Kapageridis, Kyros Koios

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Mining has been at the forefront of new technology for decades. The constant need for improved efficiency, safety and profitability has always been the driving force for the development and implementation of the latest technological advances in mining. Mine planning has been an area that traditionally attracted new algorithms and methods to address old and new problems. The importance of having trained professionals that can effectively use such sophisticated software tools is largely recognised by the mining industry.
It has been 23 years since Maptek Vulcan, a sophisticated mine planning software package, was first installed at the Laboratory of Mining Informatics and Machine Learning Applications and used to teach computerised mine planning to undergraduate students. A dedicated course was developed and is taught to fourth-year Mineral Resources Engineering students covering all aspects of mine planning with computer software, from exploration data processing to production scheduling. A series of hands-on lab exercises combined with supporting short theoretical lectures, allow students to experience all major steps of the mine planning process in as real terms as possible and, at the same time, learn how to use one of the top mine planning packages world-wide. The course also allows students to apply the theoretical knowledge gained in other courses of the Mineral Resources Engineering study programme and better understand how geological and engineering parameters are combined in an integrated mine planning project. This paper discusses the structure, scope, challenges, and results of the mine planning course and how it addresses the current knowledge and skills requirements of the industry.

The interactive advancement of the Australian Mining Industry and Academia toward the sustainable supply of critical raw materials
O-158

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The supply of critical raw materials (CRM) essential for high-tech and clean energy technologies must pick up sharply over the coming decades to meet the constantly growing demand. The global mining industry is reaching a historical and challenging turning point to transforming from a so-called polluting business to a recognised contributor to the broader clean energy transition. Along with the industry sector comes the academia shifting towards industry-driven research and education, offering job-ready skills and experience to the students, applying lifelong learning schemes for professionals, and driving commercialisation outcomes. This paper discusses how the Australian mining sector and academic community build new interactive educational and research capabilities and focus on engaging students more, them being the future ambassadors of mining. The discussions evolve around three cornerstones. The first one is the Trailblazer Program, an innovative, highly collaborative, industry-facing, and community-minded initiative for the sustainable supply of CRM. Trailblazer aims to change how research is conducted and how future engineers are educated. The second pillar discusses a Continuous Professional Development Program for mining industry stakeholders offering lifelong learning opportunities and pathways in a shifting industrial environment. The third keystone relates to Curtin University's Work Integrated Learning (WIL) Activities, an industry-engaging pedagogical practice designed to provide students with much-needed diverse experiences that help them understand how their accumulating knowledge applies in the real world and prepare them for their future as mining and metallurgical professionals. Finally, this work addresses the opportunities and challenges of applying similar practices in the European educational system.

Program for achieving progress in transfer the science to business developed within teaching project for staff at Eastern and Southeastern European universities
O-159

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The successful commercialization of the results of scientific works, R&D projects and inventions as well as cooperation between research centres, industry and business is becoming commonplace and crucially in regions development. Regardless of the scientific level of the results of scientific and research works, the functionality of these results and the adopted business model for their implementation are the key factors determining the market success. Currently recognized skills and competencies of academic staff at Eastern and Southeastern European universities in the field of implementation and commercialization the scientific research results, do not seem still sufficient. The article presents the methodology, development and results of the tailor-made Science to Business transfer program implemented within the TrainESEE v.2 'Training the trainers in East and Southeast Europe' project.

Discussion on Knowledge Gaps in Mining Operations: Empirical Evidence from the Greek Mining Industry
O-160

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Mining operations are long-term projects of high complexity, involving qualified personnel, various types of heavy equipment and extended site infrastructures. To achieve their production and business targets, mining organisations make intensive efforts to develop scientific and technological knowledge, which is collected during, and because of the execution of mining projects. Practice, however, shows that developing a knowledge body pertinent to mining systems and frameworks presents dysfunctions, discontinuities and performance limitations, known as 'knowledge gaps' (KGs). KGs describe, in various forms and structures, the difference between the knowledge required for a particular project or decision-making process and the knowledge that a specific mining company maintains for this purpose. KGs are becoming crucial, especially when technological improvements or changes in existing mining systems for the transition of ageing/closing mines to sustainable post-mining uses are necessary and must be determined as the fundamental and critical part of post-mining initiatives and plans. The objectives of this paper are (a) to provide an introductory discussion on the nature of KGs in mining organizations and projects; (b) to conduct empirical research through semi-structured interviews with experts involved with the scientific, technical and socioenvironmental aspects of the mining industry in Greece, aiming to identify and taxonomize the KGs appearing in mining and/or post-mining frameworks to sustainability, and (c) to advise a methodology appropriate for the qualitative and quantitative investigation of the current situation of Knowledge Management (KM) in Greek mining organizations, with proposals for the dissemination and integration of KM in mining industry and science.

Wednesday 30 August 2023

ROOM 16

POSTER SESSION 3

Industrial Minerals

Reuse and Valorization

Advances in Metallurgy

Education

P3-01
RIS Internship – sustainable and structured internship programme for RawMaterials master students and organization from RIS regions

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The deficit of graduates working in core Raw Materials sectors will significantly impact Raw-Materials organization from European RIS regions. The RIS Internship programme aims to im-prove professional opportunities for RIS RawMaterials students, familiarize the future young professionals with work environment and real-life challenges and trigger their intrinsic interest for development of future career in the sector. Overall objectives of the programme are to increase students' entrepreneurial and business skills, boost the employment of the RM graduates within the hosting organizations and leverage the regional brain drain. Eligible students and organizations are coming from core Raw Materials professions: mining, geo-sciences and geotechnology, geo-sciences, material science, extractive waste management, and metallurgy and recycling, all belonging to STEM area. The territorial coverage includes European RIS countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Italy (southern part) Latvia, Lithuania, Montenegro, North Macedonia, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Turkey, Ukraine. Programme was implemented via recorded pre-training webinars of students and supervisors, development of RIS Internship guide for suc-cessful RIS Internship implementation and on-line matchmaking platform, making it structured and sustainable with minimum future investment.

P3-02
Thermal treatment of serpentinized olivine wastes, obtained from chromite mineral enrichment operations, as an example of circular economy in the mining sector

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Chromite ore occurs mainly in ophiolitic mineral complexes and within ultrabasic rocks. Therefore, during the mining and beneficiation processes applied for this ore, significant amounts of solid waste materials can be usually produced. These ultrabasic rocks are mainly various structures of olivine and serpentine (i.e. hydrous structures of olivine). Although the main product of the respective enrichment process (mineral dressing) is the chromite ore, the ultrabasic rocks can be also considered as potentially useful by-products, rather than waste. Their utilization in other processes complies with the principles of circular economy, as applied in mining activities and it has already attracted the interest of scientific community.
This study was carried out with samples collected from the Vourinos area in Kozani region (Western Macedonia, Greece), where chromite mines and the enrichment mineral plant are located. The aim of this study was initially the detailed physicochemical characterization of these wastes and subsequently, the increase of olivine/serpentine ratio by the application of proper thermal treatment in order to be able to find alternative applications. E.g. the neutralization of acidic mine effluents, or as additional material to ceramics aiming in enhanced properties. However, the presence of a large percentage of serpentine may reduce the performance, when attempting to apply the ultrabasic rocks in the aforementioned processes. According to the obtained results, the application of thermal treatment is possible to limit the presence of serpentine, making it more attractive/suitable for use in the aforementioned (or other) potential applications.
Acknowledgment: This research has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code:T2EDK-02206).

P3-03
Recovery of Critical Raw Materials from abandoned mine waste, some potential case studies in North-Western Italy

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Critical and Strategic Raw Materials European Union's policies are targeting the production of fundamental raw materials from internal sources, fostering the recovery of relevant quantities of materials from existing mining facilities in Europe, achieving Climate Neutrality, and the ambitious goals of the European Green Deal. North-Western Italy had been an important mining area until the mid-1900s, as reported by ISPRA in its 2017 report, updated in 2022, containing the Italian inventory of closed mining waste storage facilities, referring to 92 localities. Three sites were chosen to better define their historical and bibliographic framework, actual conditions to evaluate the effective volume of extractive wastes and the technical feasibility of recovering valuable minerals. The selected sites are the Traversella-Brosso mine, Piedmont, the Libiola mine, Liguria, and the Herin mine, Aosta Valley. Traversella-Brosso district has been active until the late 1960s, producing at that time more than 100 tons per day of Fe, Cu, W, Ni, Pb, and Ag ore; the Libiola mine produced 1 Mt of Fe-Cu ore between 1864 and 1962, while the Herin mine had a peak production of 11.000 ton per year of Cu-Fe, Ni, and Zn ore in the1920s. At the moment, in the surrounding areas of these sites, there are relevant amounts of abandoned mining waste causing environmental problems. The potential recovery of the residual valuable fraction of materials could be crucial for both CRM and environmental recovery of the involved territories.

P3-04
Electric Arc Furnace Dust vitrification via soda-lime recycled glass

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The present research work focusses on the characterization and leachability evaluation of electric arc furnace dust (EAFD) and its vitreous outgrowths, produced during vitrification with soda lime recycled glass (SLRG). EAFD is a hazardous industrial waste generated in the collection of partic-ulate material during steelmaking process via electric arc furnace. Glasses of various syntheses were obtained during EAFD vitrification with various amounts of silica scrap (50, 60 and 70 wt%). The characterization of the as-received dust was carried out by using granulometry analysis, chemical analysis, X-ray diffraction (XRD), and scanning electron microscopy (SEM), in conjunction with Energy Dispersive X-ray Spectroscopy (EDS). The produced glasses during vitrification were studied by means of chemical and mineralogical analysis, whereas their microstructure in polished sections was examined by SEM/EDS. Their behavior during leaching was determined by the EN 12457-2 compliance leaching test and according to the results the trace elements detected in the leachates were well below the corresponding regulatory limits.

P3-05
Using natural and synthetic zeolites for polluted soils clean-up

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Mining activities have traditionally sustained human livelihood but impacted adversely the ecosystems causing erosion, sinkholes, soil and aquatic contamination and loss of biodiversity. Soil health is crucial in supporting multifariously the ecosystems, i.e., physically (pH, electrical conductivity), chemically (soil organic matter, nutrients) and biologically (microorganisms).

This study aims to examine the effectiveness of natural and synthetic zeolitic materials as potential soil amendments for the rehabilitation of Lavrion mine degraded areas. Two natural zeolite tuffs, clinoptilolite- and mordenite-rich, from Samos Island were used as low-cost modifiers. A synthetic Na-P1-rich zeolite derived from Meliti coal fly ash, was also employed. For this purpose, the concentrations of six heavy metals, i.e., Pb, Zn, Cu, Mn, Fe, Cd, were determined in both water and EDTA extracts of Lavrion soils prior and after the zeolites addition. The mineralogical composition and structural properties of the materials were determined via XRD and SEM, respectively. The results demonstrated that, using these aluminosilicates, not only the regulation of soil pH and CEC were feasible but, also, the potential bioavailability and water-leaching of all six heavy metals studied were considerably reduced. These findings constitute the first step towards mitigating mine soil erosion accelerating the natural restoration processes and seem very promising towards reversing the environmental damage caused by abandoned mine soils.

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P3-06
Optimization of the demolition waste incorporation to cement mortar by response surface methodology

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Building construction and demolition waste constitutes one of the largest waste deposits in the world. Major actions for valorzation must be implemented.
In this context, the recycling of demolition waste represents a considerable challenge in the building sector.
On the other hand, Tunisia has recorded in recent years a strong urbanization which results in an excessive increase in construction sites and therefore in the number of anarchic dumps and large quantities of demolition waste, resulting in increased pressure on ecosystems and excessive exploitation of natural resources. This is why it is imperative to reduce the consumption of materials, and to use natural resources efficiently through waste recycling. As a result, the recovery of demolition waste, their exploitation and their reintegration into a new life cycle requires detailed studies of the properties of this waste.
In this context, this work focuses on other possible applications of these types of waste through their integration as an additive to cement. Six types of demolition waste are then selected, namely concrete, brick, tiles, plaster, earthenware and marble, with different proportions.
This work concerns the use of experimental design methodology to optimize the effect of addition of those different demolition wastes on mechanical and chemical properties for new developed cement.

P3-07
Recovery of stainless steel from end-of-use dishwashers

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Wastes of Electrical and Electronic Equipment (WEEE) include a variety of products, from house appliances to spacecraft equipment, turning them into a significant source of secondary raw materials. Stainless steel is one of the most useful and valuable product of WEEE. Large quantities of stainless steel can be recovered from dishwashers. In this research project, the preparation of the samples includes their separation to their components, according to the following successive procedure: the dishwashers get through a magnetic separator to hold the magnetic ferrous pieces, an eddy current separator to separate the non-ferrous metals and an induction sorting sensor to detect and separate the remaining metallic fractions. From this procedure, two outgoing streams are produced, the stainless steel stream with some impurities, and the impurity stream. Thereinafter, the stainless steel stream passes through a high intensity magnetic separator, in order to eliminate the containing impurities. The result of this high intensity magnetic separation is a magnetic stream, containing the stainless steel pieces and a non-magnetic stream, which contains the impurities. The final step of this procedure is hand sorting, so that any remaining impurities in the magnetic stream to get removed.

P3-08
ARTeMIS – A European training-through-research program for exploration geologists

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The ERASMUS+ ARTeMIS (Action for Research and Teaching Mineral exploration Inclusive School) program is a training-through-research project for mineral exploration that brings together Master students from four partner universities (Univ. Lorraine, FAU Erlangen-Nürnberg, Aristotle University of Thessaloniki and NKUA Athens) and the mining company Hellas Gold. The program includes training for lecturers and students on portable spectroscopic tools (pXRF, pLIBS, pVNIR-SWIR and pRAMAN), and classroom instruction in mineral resource geochemistry. The course is supplemented by a two-week field school in NE Greece (Central Macedonia and Thrace regions) dedicated to the application of portable spectroscopic tools in demanding field work environments. The field training is combined with mapping of porphyry-epithermal type deposits metallogenic systems, which are exploration targets for various base, critical and precious metals (e.g. Cu, Fe, Pb, Zn, Au, Ag, Pb, In, Ge, Ga, Sb, Bi, ...) on the European continent.

The expected results of this training work are:
(1) Creation of complementary teaching units for lecturers and graduate students in the context of mineral exploration and resources in Europe
(2) Use and development of portable spectroscopic tools during field work adapted to mineral exploration
(3) Publication of an educational field guide dedicated to the mineral resources of northeastern Greece
(4) Creation of a methodology for logistical preparation of an international field school for teaching in exploration geology

Another aspect of the ARTeMIS program aims to offer new opportunities to students with disabilities by making training courses accessible. To this end, a collaboration with occupational therapists permits to identify ways of improvement by bringing together lecturers, students, Earth Sciences professionals and therapists.

P3-09
Utilization of an industrial waste for the development of fire resistant geopolymers

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This paper deals with the production of fire resistant materials for tunnel applications based on the technology of the geopolymerization, utilizing a transformed industrial waste (bauxite residue from the Aluminium Production) which has been treated (calcined) to be a proper precursor for inorganic polymers. Although the structural elements of a tunnel or a building and generally a structure are considered inflammable in a real fire situation the concrete lining can be spalled largely, sometimes perhaps entirely, with very serious consequences on cost and safety of people. The existing methods are efficient; however, their high price render their application usually unaffordable.

The targets of the developed materials are a) to retain their structural integrity b) to avoid spalling of the concrete c) follow the requirements of the RWS curve.

Within the specific research a fire resistant material was developed utilizing the treated (bauxite residue) with small additions of other elements to achieve a fire resistant material that can withstand under the most severe fire scenario. The developed material was upscaled and produced in dimensions 1x1m to be validated in real scale fire scenarios. The test took place using a custom made furnace for large scale specimens and the results showed that the material passed the RWS curve criteria, and it is promising material for application as fire resistant panel in tunnel applications. Materials are also assessed for their resistance under the ISO-834 fire curve. From the results is concluded that these geopolymers can resist the specific fire scenario that may occur during a fire either in a building or in a tunnel without yielding or spalling. Also, these materials are very low-cost materials concerning that the basic raw material is a waste which currently is (landfilled).

P3-10
Empowering Students for the Future: Enhancing Soft Skills through non-formal educational paths

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The job market is undoubtedly subject to constant change, with the skills required being equally affected. Multiple organizations have highlighted the imminent need for certain skills, with soft skills in high demand. Moreover, the impact of soft skills on employees' career success has been a topic of research in the relevant literature. Today's students will need to acquire these skills to successfully respond to future challenges. To achieve this, in recent years, significant emphasis has been put on modern didactics, pedagogy, and educational approaches in general. Seminars, webinars, workshops, etc., provided by volunteer groups are seeking to contribute to this educational transition. This, along with various personal experiences, inspired Mi.M.E.C. (Mining & Metallurgical Engineering Community) to offer a number of educational events on soft skills to Greek, mostly undergraduate, students. This work aims to showcase the perceived need by the students for a more in-depth understanding of the topic based on our recent experience.

P3-11
Preliminary study of low cost raw materials for new syntheses of geopolymers targeting environmental applications.

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This study deals with the preliminary characterization of sterile materials and by-products in order to be used in geopolymer syntheses for environmental applications. Specifically, the new low cost syntheses of geopolymers, will be used as filters in waste water treatment. The utilization of alternative raw materials can contribute significantly not only to the sustainability but also to the circular economy. The samples derived from the industrial-mining-agricultural activity and were collected by companies operating in Greece. The bulk mineralogical compositions of samples were conducted using XRD, while semi-quantitive mineralogical analyses were also performed. Additionally, in the present work are presented the geochemical (XFR) analyses of the studied samples.

The preliminary results indicate that the tested samples have geochemical and microstructural characteristics suitable for the production of appropriate mixtures with: 1) desired proportions of silica /aluminum and 2) ability for geopolimarization targeting to heavy metals adsorbion. The syntheses of geopolymers from sterile materials and by- products lead to the development of improved competitive products and low energy footprint technologies.

P3-12
Sustainable Valorization of Quarry Waste from Granite Ornamental Rocks for Extracting Critical Raw Materials

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Critical Raw Materials (CRM) are a pivotal concern for the digital industry and the European Green Deal. European Union is undertaking actions to identify new ore deposits and engage in their cultivation, diversify the sources of CRM supply, and enhance recycling efforts.

These objectives can be synergistically promoted by leveraging the materials discarded in landfills from granitoid rock quarries. For example, in leucogranites quarries the presence of pegmatite veins and masses represent an aesthetic defects, so a great quantity of material is discarded. However, these waste materials can represent an important source of economically interesting minerals.

In Italy, the Sardinia Region is the main producer and exporter of ornamental granite and, over the years, granite waste dumps have accumulated throughout the island, spoiling the landscape, occupying valuable land space, and posing potential risks to the biosphere.

Within this context, this study focuses on a leucogranite quarry located in the town of Buddusò in Northern Sardinia, with the aim of testing a processing methodology for granite waste recycling through physical methods (gravity and magnetic separations). The purpose is to obtain products enriched in critical raw material minerals from the initial waste. Through these processes, it was possible to increase the concentration of highly desirable minerals (such as Spodumene and Allanite). Thus, the results of the geochemical and mineralogical investigations conducted on the obtained products are presented.

P3-13
Techno-environmental assessment of novel pathways of red mud waste use to improve extraction efficiency of valuable metals

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Red mud waste from primary aluminium production contains several metal oxides, mainly those of aluminium and iron, with minor amounts of Ti, Zn, Ga, V, Y, REEs and possibly many others. According to the circular economy concept, red mud waste is a potentially valuable secondary resource of several critical metals.

The study aims to identify the potential techno-environmental impacts/benefits of implementing the novel pathways of red mud waste treatment into primary aluminium plant. One of the novel treatment aims to extract Fe from red mud through the gasification process and to extract REEs, Sc, Ti, Fe, V and alkali metals from the after gasification red mud residue. The red mud samples from the ETI Aluminium plant in Seydişehir, Türkey were used in this study as input materials. The XRD analysis of input red mud identified around 30% of the weight as Hematite (Fe2O3) and more less the same percentage as Quartz (SiO2), around 15% of weight as Calcite (CaCO3) and similar content of Alumina (Al2O3).

The second pathway tests the waste materials for production of coagulants, sorbents and catalysts for water and flue gas treatments.

The environmental assessments are determined using the life cycle assessment method (LCA) with the implementation of the European methodology, PEF 3.1, i.e. Product Environmental Footprint. The evaluation will be performed by the Expert for LCA software with specific databases (Sphera – 2023, Ecoinvent 3.9, ILCD, EF).

The treaments are developed and experimentally verified within the ERA-MIN3 call 2021 project ‘Utilization of Aluminium-Bearing Raw Materials for the Production of Aluminium Metal, Other Metals and Compounds (ABTOMAT)’.

P3-14
Environmental Footprints of Bauxite alternatives for Alumina production - regional characteristics in Central Europe and Turkey,

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The paper aims to identify and assess the potential environmental impacts or benefit of selected alumina compound production pathways from Bauxite alternatives considering the regional characteristics of Central Europe and Turkey. The diaspore, black and white drosses (as regional Turkey materials), clay, fly ash and topaz (as regional Czech materials) will be presented in the study.

The novel concepts and improvements are developed based on implementati pre-treatment processes and hydro- and pyrometalurgy processes within the ERA-MIN3 call 2021 project 'Utilization of Aluminium-Bearing Raw Materials for the Production of Aluminium Metal, Other Metals and Compounds (ABTOMAT)'.

The analyses are determined using the life cycle assessment method (LCA) with the implementation of the European methodology, PEF 3.1, i.e. Product Environmental Footprint. The PEF 3.1 indicator determines the overall environmental impact of technology, considering different categories of impact, e.g. carbon footprint/climate change, acidification, consumption of fossil resources, land use, human toxicity, etc. The assessment was conducted in the Expert for LCA software using the Gabi 2023, ILCD and Ecoinvent 3.8 databases, focusing on the systems' operational phase.

P3-15
Re-use of historical thermal plant ash deposits as supplementary cementing materials

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The use of historical deposits of ash from power thermal such as the Turceni thermal power plant - located on the outskirts of Turceni, Gorj County, and Termoficare Oradea SA- located on the outskirts of Oradea, Bihor County is an aspect that covers some ecological usages for removing the deposits as well as reducing pollution through CO2 decrease in cement producing factories. These ashes, used in pastes and mortars were made thermally activated at a temperature of 700°C and inactivated.
In order to be able to observe the phases formed at different hydration times of the cement pastes consisted of 20%, 25%, 30% and 40% respectively of thermal power plant ashes activated and inactivated, XRD, DSC and SEM were made at 1 day, 7 days, 28 days and 356 days.
Following the obtained data, from XRD: C3A, C2S, C2F, C3S, bassanite (CaSO4 0.67H2O), portlandite (Ca (OH)2), hillebrandite (Ca2SiO3(OH)2), kuzelite (Ca2Al(SO4)0.5(OH)6 (H2O)3), etringite (Ca6Al2 (SO4)3(OH)12(H2O)26) and afwillite (Ca3(SiO3OH)2 2H2O) were obtained.
The addition of power plant ash induces changes in both initial and final setting time for all samples (especially for samples containing 20% ash).
Sustainability through the reuse of accessible economic and social resources is a way to achieve environmental balance while ensuring long-term development. The study proves that the ash from the thermal power plant Turceni deposit can be used as is or activated as SCM material in order to replace ordinary Portland cement up to 40% depending of applications.

P3-16
BR valorization with enhanced Al extraction by hydrothermal conversion of hematite to magnetite

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Bauxite residue (BS) is the major by-product of the Bayer process for the aluminum production. 150 million tones .is produced annually, while due to the high alkalinity and fineness the material disposal is restricted leading on accumulation causing deposition problems of potential environmental risk.
The REEScue project concept (https://reescue.com/) and the proposed technical solutions are based on the smart combination of physical and hydrometallurgical processes that will enable the recovery of valuable marketable products and the reduction of the quantity of BR to be disposed. The study focuses on two main processing stages of the technology; the hydrothermal treatment of BR towards the production of magnetite, a and the subsequent magnetic separation for the recovery of Fe-rich fraction. The sufficient transformation of the majority of hematite to magnetite, the recovery of high Fe-grade concentrates with magnetic separation and the enlightening of limitations related to the material, like limited hematite liberation, are the most important findings that are presented and discussed.

P3-17
Limonitic laterite reduction with hydrogen

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The application of hydrogen in extractive metallurgy industry is crucial to Europe's transition into a climate-neutral continent by 2050. The initial steps in this direction comprise the construction of direct reduced iron furnaces for steel industry which consists the major contributor of anthropogenic CO_2 emissions. However, attention should be given to other sectors of metallurgy industry too, such as the extractive nickel sector. Recent research studies indicate that production of ferronickel from laterite ore, by involving the use of hydrogen, is possible either through a complex pyrometallurgical/hydrometallurgical process, or through a direct pyrometallurgical process using sodium thiosulfate as an additive. The current study focuses on the pre-reduction, at low temperatures, of a Greek hematitic nickeliferous laterite of the LARCO GMMSA Company aiming to the production of an intermediate product that can be further hydrometallurgically treated for the production of nickel and cobalt. Reduction tests were performed in the temperature range of 300-500 °C into a horizontal tube furnace using a H_2/N_2 mixture (10 v/v. % H_2). The reduction progress in terms of iron reduction degree was identified using a combination of XRD-Rietveld and Mössbauer spectroscopy methodologies. The results show that hematite phase (Fe^{+3}) is progressively transformed to magnetite (Fe^{+3}/Fe^{+2}) and wustite (Fe^{+2}) over 350 °C, while a minor metallic iron phase begins to be formed at 450 °C. The iron reduction degree reaches 98% at 500 °C. The quantitative mineralogical composition of iron phases after the reduction at that temperature is: magnetite (79 w/w.%), wustite (12 w/w.%), metallic iron (7 w/w.%) and hematite (2 w/w.%).

P3-18

Limonitic laterite reduction wit Use of aluminium scrap for the production of high-quality recycled aluminum products. Design and production control criteria -The project DeReAL

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Today global demand for aluminium is increasing, while the use of aluminium scrap is widely used by businesses for producing several aluminium products, from car parts to food packaging. Considering that the energy required to melt aluminum scrap is about 5% of that needed for ore reduction and that the available aluminum scrap is estimated to double by 2050, increased use of recycled aluminum provides an opportunity for the metallurgical sector to shift to a circular economy with more-sustainable materials use.
The DeReAL project aims to develop a methodology for controlling and evaluating the impact of adding aluminum scrap to the production of primary aluminum products, thus decreasing the need of energy consumption, and contributing to environmental footprint reduction of a smelter. The effect of scrap addition in the microstructure of several types of aluminum alloys, taking into account customers' specifications, is thoroughly studied by combining optical microscopy and SEM/EDX analysis, as well as mechanical testing. Overall evaluation of the microstructural variables revealed a path for determining the final properties of the as-cast products and identifying the critical process steps that enable maximum utilization of scrap.

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