

Dubrovnik International ESEE Mining School – DIM ESEE 2

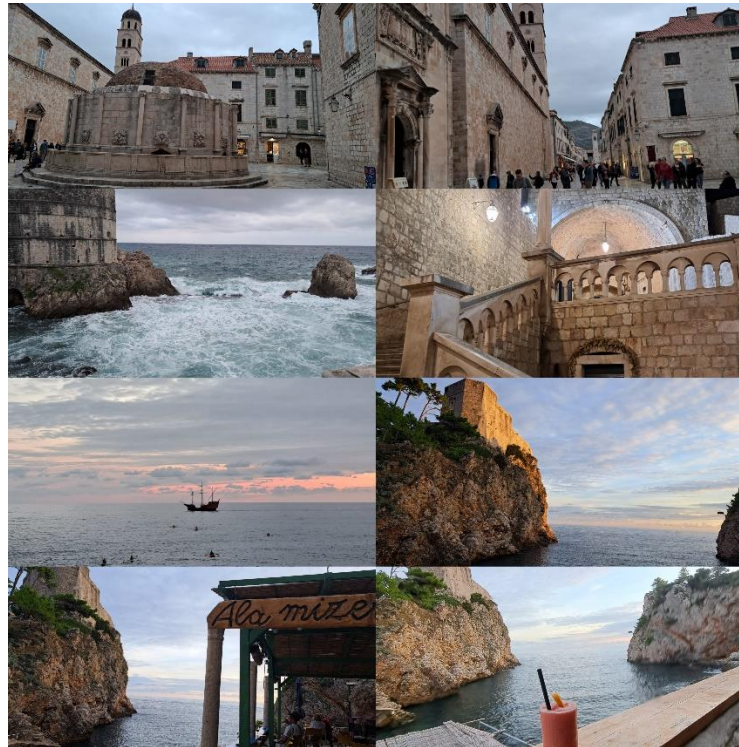
INNOVATIONS IN ORE PROCESSING

16th – 18th October 2024

Hybrid: online and on-site (IUC Dubrovnik)

2024 PROMOTIONAL BOOKLET

Technical description of the workshop, description of lectures and lecturers' short biographies



REGISTRATIONS: <https://dim-esee.eu/registration-and-fees/>

CONTACT INFORMATION: info@dim-esse.eu



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Abstract

Nowadays mineral deposits are generally becoming lower grade and mineralogically more complex. The mining industry has responded to this challenge by innovating and developing technologies that have increased efficiency and productivity, some through the increase in scale and capacity, some by challenging the norms of processing some by introducing secondary processing, and by investing in a circular economy.

The current focus of innovation in mineral processing is towards increasing production rates (with the same equipment), reducing capital and unit operating costs as well as minimising energy, water, and environmental impact while aligning with the legislative framework. Pre-concentration technologies, more energy-efficient comminution technologies and circuits, coarse particle recovery, and storage of dry-stacked tailings are examples of areas where significant fundamental innovation impacts process plant design.

The DIM-ESEE 2: Innovations in Ore Processing Course will include lectures from academic staff and industry experts along with hands-on learning challenges faced by the RM sector in the processing of ore and waste materials for the sustainable recovery of the contained mineral values. The course shall provide insights on various aspects related to innovation in the sector and highlight the importance of such innovations for the sustainability of the RM Sector. Participants will be given a unique opportunity to interact with some of the leading specialists and innovators in the field.

Prerequisites

Raw materials professionals with good command of English language and basic knowledge related to the Workshop topic, working in one of the following fields: Ore processing, Metallurgical Engineering, Mining Engineering, Environmental Engineering, Applied Earth Sciences, and similar.

We particularly encourage applications of professionals from the following countries: Armenia, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Georgia, Greece, Hungary, Italy, Kosovo, Latvia, Lithuania, Malta, Moldova, Montenegro, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Turkey, Ukraine.

Needs for the development of this module

This three-day course, organized in a hybrid form, will focus on the technological innovations applied in the processing of primary and secondary raw materials as well as the environmental and economic aspects of these process schemes through an integrated approach. The course will include lectures from academic staff and industry experts along with hands-on learning challenges faced by the RM sector in the processing of ore and waste materials for the sustainable recovery of the contained mineral values.

The trainees will work in teams to address the challenges set by the lecturers/mentors in order to develop their critical thinking skills and take an active role in their learning. Every day will provide a balance of theoretical presentations by the lecturers and technical challenges for the participants. Three lectures will be delivered online.

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Learning Outcomes

A. Knowledge-based Outcomes

- Understand the importance of critical and strategic raw materials
- Get familiar with the various processing techniques for primary and secondary raw materials to produce marketable products
- Obtain an overview of the content of the regulatory EIA and ESIA studies, Environmental Auditing and Environmental and Social Management Plans (ESMPs)
- Understand the core principles of scaling up a process from laboratory to industrial scale
- Get familiar with the characterization and disposal systems of mine waste
- Be able to select the most appropriate mine waste treatment scheme
- Articulate the fundamental principles of a project's feasibility and evaluate whether or not a project plan could be successful
- Apply the principles of their own discipline to new or complex environments

B. Skill-based Outcomes

- Collaborate effectively in professional teams and in interdisciplinary contexts
- Increase confidence in their ability to problem-solve
- Apply oral, written and visual communication skills to present a coherent reply on a specific challenge set
- Demonstrate critical thinking based on their professional knowledge/skills while incorporating new subject knowledge

Lecturers

Em. Prof. Katerina ADAM (NTUA)

Mrs. Irene CHRISTODOULOU (NTUA)

Dr. Panagiotis ANGELOPOULOS (NTUA)

Dr. Efthymios BALOMENOS (NTUA)

Dr. Panagiotis XANTHOPOULOS (Sunlight Group Energy Storage Systems S.A.)

Mrs. Evangelia MYLONA (NTUA)

Dr. Emmy GAZEA (Hellas Gold S.A)

Assoc. Prof. Maria TAXIARCHOU (NTUA)

Em. Prof. Ioannis PASPALIARIS (NTUA)

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WORKSHOP PROGRAM

DAY 1 – INNOVATION IN THE PROCESSING OF SELECTED MINERAL RAW MATERIALS

- Critical and Strategic Raw Materials in the ESEE region, **Em. Professor Katerina Adam**
- Innovation in ore processing for the production of marketable concentrates, **Dr. Panagiotis Angelopoulos (ONLINE)**
- Metallurgical processing for basic metals and CRM recovery - The case of Bauxite, **Dr. Efthymios Balomenos (ONLINE)**
- Recovery of CRMs from end-of-life products - Upscaling a sustainable recycling process for the treatment of LFP, **Dr. Panagiotis Xanthopoulos**

Practical session: Teams formation - Presentation of challenges to be addressed and how to tackle the challenges, Irene Christodoulou

DAY 2 – ENVIRONMENTAL IMPACT AND CIRCULAR ECONOMY

- Environmental Permitting for raw materials projects, **Em. Professor Katerina Adam**
- Mine waste management: Characterisation, treatment and disposal systems, **Evangelia Mylona**
- Environmental and social management systems (ESMS) – The case of Cassandra Mines, **Dr. Emmy Gazea**
- Innovation and sustainability in the Industrial Minerals Sector, **Prof. Maria Taxiarchou**

Practical session: Teams cooperation – Mentoring by the Lecturers on how to pitch their ideas

DAY 3 – ECONOMIC ASSESSMENT OF INVESTMENTS

- Techno-economic analysis: a useful tool to evaluate the economic performance of potential investments in the Raw Materials Sector, **Em. Prof. Ioannis Paspaliaris (ONLINE)**

Practical session: Presentation of the trainees' projects on challenges

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Lecturer: *Em.* Prof. Katerina ADAM (NTUA)

Dr. Katerina Adam studied Mining and Metallurgical Engineering at NTUA and acquired her M.Sc. and Ph.D. as an NSF scholar from the School of Chemical Engineering and Materials Science, University of Minnesota, USA. She joined NTUA as Academic staff in 2007 and before she worked as a Senior Engineer and Manager in Research Institutes, Mining & Metallurgical Industry and Environmental Consultancy firms for the development and environmental management of Greek and International Mining and Industrial Projects. She acted as the coordinator or senior researcher in more than 58 National, EC and International funded research projects, and she conducted as an expert on behalf of UNDP a number of mine reclamation studies in the SW Balkans, 2011-2014. She authored or co-authored 102 articles in scientific journals and conference proceedings, and more than 150 Technical, Feasibility and Environmental Impact Studies. Since 2018 Professor K. Adam is actively involved in the activities of the EIT Raw Materials and mainly in RIS Projects of the Eastern CLC. She is a member of the Education Committee of the Eastern CLC and the Education Advisor of the EIT Raw Materials Hub – Regional Center Greece. Since November 2023, she acts as the Coordinator of the NTUA Team in the Alliance of European Universities, EULiST.

	<p>Name: Katerina ADAM</p> <p>Academic Title: <i>Em.</i> Professor NTUA</p> <p>Institution of employment: School of Mining and Metallurgical Engineering</p> <p>Contact number: 00 30 210 772 1293</p> <p>E-mail: katadam@metal.ntua.gr</p>
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Lecture: Critical and Strategic Raw Materials in the ESEE region

This lecture will provide an overview on the recent developments in EU regarding the secure and sustainable supply of Critical Raw Materials. Emphasis will be placed in the analysis of the recently published Critical Raw Materials Act, (CRMA), and its three main pillars including the Development of the CRM Value chain in the EU, Boosting the diversification of supply and partnering in a mutually beneficial manner in support of global production, and fostering sustainable sourcing and promoting circularity. Risk and challenges encountered for the implementation of the CRMA will be analyzed. Specific examples on the potential that ESEE region presents in Critical and Strategic Raw Materials will be presented.

Lecture: Environmental Permitting for Raw Materials Projects

Based on the prevailing EU legislation, a prerequisite for the implementation of a project that might pose significant environmental impacts, e.g. a mining project, is to assess its direct and indirect effects on the parameters of natural and manmade environment such as human beings, fauna and flora, soil, water, air, climate and the landscape, material assets and the cultural heritage. This lecture will provide an overview of the legal framework prevailing the Environmental Permitting of raw materials projects, relevant

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procedures, and requirements of the Environmental Impact Studies to be prepared by the Project Developers. Best Practices and Challenges encountered in significant mining projects under development in EU will be presented.

LECTURER: Irene CHRISTODOULOU, MEng., MBA

Irene CHRISTODOULOU studied Mining and Metallurgical Engineering at the National Technical University of Athens (NTUA) and holds a MEng. Degree in Industrial Metallurgy as well as a Master in Business Administration from the School of Electrical and Computer Engineering (NTUA) and the Department of Industrial Management and Technology of the University of Piraeus.

She is an experienced Metallurgical Engineer, an expert on industrial innovation for sustainability and a business development consultant of private companies. Since 1996, she has been working as a researcher in several national and EC research/innovation and education projects at the Laboratory of Metallurgy, School of Mining and Metallurgical Engineering, NTUA) and as a freelance Consultant on Environmental (EIA, SEIA) and Technoeconomic Assessment (TEA) Studies. Currently, she is a Teaching Associate at the same School. Her specialization covers the areas of Ferrous Metallurgy, Metallurgical Slags, Urban Mining and Secondary Metallurgy as well as Circular Economy, Industrial Value Chains and Clusters.



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Lecture: How to tackle the challenges on CBL – How to pitch your idea

DIM-ESEE 2: Innovations in ore processing workshop puts emphasis on Challenge-based learning (CBL). CBL is a learning experience where learning takes place through identification, analysis and design of a solution to an authentic problem. CBL has been promoted as a means for students/trainees to align the acquisition of disciplinary knowledge with the development of transversal competencies. In addition, coming up with scientific ideas and problem-solving may be relatively easy; presenting them attractively is hard.

The lecture will provide guidance to the trainees to prepare a well-organized presentation, with key points logically building on each other while using creative tools to capture attention. Keep in mind that your pitch should be concise and informative!

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Lecturer: Dr. Panagiotis ANGELOPOULOS (NTUA)

Dr. Panagiotis M. Angelopoulos has an MSc in Mining & Metallurgical Engineering (2007) and a PhD in Mineral Processing (2013) from the National Technical University of Athens (NTUA). His PhD was on the development and modeling of a new process for the production of expanded microspheres. In 2016-2017 he was IKY-Siemens scholar for PostDoc on “Process development for the transformation of low-value volcanic glass to high added value, closed-structure expanded microspheres”.

Since 2014 he has been working as a postdoc researcher at Laboratory of Metallurgy NTUA on projects related to metallurgical waste valorization, processes upscaling, sustainable minerals beneficiation, and processes optimization through simulation. He has more than 55 research publications in journals and conference proceedings. Since 2020, he has been a Research, Technical, and Marketing Consultant at the Perlite Institute. In 2016, he was awarded the Academy of Athens award for his work on the mathematical modeling of the perlite expansion process. In 2023 he was elected Laboratory and Teaching Staff at the School of Mining and Metallurgical Engineering of NTUA.

	<p>Name: Dr. Panagiotis ANGELOPOULOS Academic Title: Mining & Metallurgical Engineer, NTUA Institution of employment: NTUA Contact number: 00 30 210 772 2252 E-mail: pangelopoulos@metal.ntua.gr</p>
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Lecture: Innovation in ore processing for the production of marketable concentrates

Xanthates is a family of highly efficient collectors, widely used in the industry of sulphide minerals flotation. Xanthates are considered toxic and hazardous to the environment and can pose significant risks to aquatic life and human health. The need for its replacement by other more environmentally friendly reagents is of vital importance towards a more sustainable extractive industry.

The lecture will be focused on lignin; a green sustainable reagent that is alternative to xanthates. Lignin is a green substance extracted from paper or wood pulp which is practically abundant. Results from the use of lignin as a collector in the flotation of sphalerite, pyrite, and arsenopyrite from mixed sulfides will be presented. The quality of the obtained concentrates after the application of different xanthate replacement ratios will be presented and discussed, ending up with the optimum formulas. The challenge of reagent performance evaluation on industrial conditions and our strategy to achieve this will be discussed in detail.

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Lecturer: Dr. Efthymios BALOMENOS (NTUA)

Dr. Efthymios Balomenos studied Mining and Metallurgical Engineering at the National Technical University of Athens (NTUA) and received his PhD degree in Thermodynamics in the same school in 2006. Since 2008 he has been working in the Laboratory of Metallurgy as a postdoc researcher focusing on sustainable process development, CO₂ mitigation strategies, exergy analysis, and resource utilization efficiency. He is involved in the research management and coordination of several collaborative large-scale research projects (ENEXAL, EURARE, SCALE, ENSUREAL, RemovAl, BIORECOVER, AISiCaL, SISAL PILOT, HARARE, ReActiv) most of which focus on Bauxite Residue valorisation or alumina production.

He has more than 90 research publications in journals and conferences proceeding with more than 1,300 citations and an h-index of 19. Since 2015, he has cooperated with MYTILINEOS - Metals as a senior consultant in R&D projects. He was a recipient of the TMS Light Metals Subject Award – Alumina & Bauxite in 2017 and since 2022 he has been on the ICSOBA board of directors. In 2024, he was elected as Assistant Professor at the School of Mining and Metallurgical Engineering of NTUA.



Name: Dr. Efthymios BALOMENOS

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Lecture: Metallurgical processing for basic metals and CRM recovery – The Case of Bauxite

The lecture will present a comprehensive overview of the metallurgical processing involved in transforming bauxite ore into aluminium oxide, and ultimately, into primary aluminium metal. Special emphasis will be placed on the Bayer process, a pivotal ore processing method in the production cycle. Additionally, the lecture will explore the concurrent extraction of Critical Raw Materials (CRMs) from the by-products of the Bayer process. This segment will delve into the specifics of extracting gallium (Ga), vanadium (V), and scandium (Sc), particularly from the Greek bauxite ore processed at the MYTILINEOS alumina refinery.

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Lecturer: Dr. Panagiotis XANTHOPOULOS (Sunlight Group Energy Storage Systems SA)

Dr. Panagiotis Xanthopoulos has been working at the R&D Department of Sunlight Group Energy Storage Systems S.A. since 2023 and he is responsible for developing and demonstrating at pilot scale a sustainable technology for recycling LFP EoL and scrap. Prior to joining Sunlight Group, Panagiotis worked as a post-doctoral researcher in the SOLVEMET Group of the Department of Chemistry of KU Leuven (Belgium) and engaged in many bilateral and EU-funded projects related to metal extraction and recovery from various waste streams.

Prior to this, he carried out his doctoral research in the same group within the framework of the H2020 MSCA-ETN SULTAN project, for the remediation and reprocessing of sulfidic mining wastes. Before moving to Belgium, he worked as an Environmental Consultant at ECHMES Ltd. in Athens, where he was involved in ESG and LCA projects for Greek industries. Panagiotis earned an integrated MSc degree in Mining and Metallurgical Engineering from the National Technical University of Athens and a PhD in Chemistry from KU Leuven.

	<p>Name: Dr. Panagiotis XANTHOPOULOS</p> <p>Academic Title: Mining & Metallurgical Engineer, NTUA</p> <p>Institution of employment: Sunlight Group Energy Storage Systems S.A.</p> <p>Relevant website: www.the-sunlight-group.com</p> <p>Contact number: 00 30 693 684 3492</p> <p>E-mail: pan.xanthopoulos@sunlight.gr</p>
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Lecture: Investments in Circular Economy - The Case of EoL LFP Battery recycling

LFP batteries will dominate the stationary energy market (traction, ESS) with a demand exceeding 3,000 GWh per year by 2030 due to their low cost and intrinsic safety. Nonetheless, recycling of LFP batteries at industrial scale is limited or missing within EU region mainly due to economic concerns. Without proper management of the production scrap and LFP EoL, they can pose an environmental threat and a loss of the critical raw materials incorporated. This lecture will delve into the investment plans of Sunlight Group Energy Storage Systems S.A. to develop and upscaling an environmental and economic friendly technology for the recycling of LFP waste streams. The different unit operations will be presented in details with focus on the major challenges that one has to overcome for bridging the gap between the laboratory and pilot scale.

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LECTURER: Evangelia MYLONA

Evangelia Mylona studied Mining and Metallurgical Engineering at the National Technical University of Athens (NTUA). She worked in the mining industry for 2 years and since 1998, she has been working as a researcher at NTUA. She is currently a member of the specialized technical laboratory staff. She has more than 25 years of experience on the environmental management of industrial wastes, especially characterisation, risk assessment, treatment and development of rehabilitation technologies of extractive and metallurgical wastes. She has participated as a senior researcher in several national and EC research projects associated with the environmental management of mining activities and has co-authored more than 40 articles published in Scientific Journals and Conference Proceedings. She has been actively involved for more than 20 years in the services provided by the Laboratory of Metallurgy to mining and metallurgical industries regarding the environmental characterisation and remediation of waste.



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Lecture: Mine waste management: Characterisation, treatment and disposal systems

The lecture will provide a thorough overview of mine waste characterisation, treatment and disposal. Critical aspects including applicable European legislation, methodology for waste characterisation and classification, risk assessment and treatment methods to ensure physical and chemical stability of waste will be covered. Waste disposal options and best available techniques to prevent or minimise any adverse effects on the environment and health will be also presented. Specific examples of treatment and disposal methods for wastes exhibiting acid rock drainage potential and/or metal leachability will be described.

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Lecturer: Dr. Emmy GAZEA (Hellas Gold SA)

Dr. Emmy Gazea is a chartered Mining and Metallurgical Engineer, National Technical University of Athens (NTUA) with PhD in Environmental Engineering. Environmental Manager of HELLAS GOLD SA with thirty (30) years of industrial experience in the environmental management of the mining sector. Main activities involve design and coordination of integrated environmental monitoring and management plans, extractive waste and liquid effluents management, environmental protection and reclamation projects as well as elaboration of technical and environmental & social impact assessment studies. Participation in a number of R&D projects with more than 20 publications in international journals and conference proceedings.



Name: Dr. Emmy GAZEA

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Lecture: Environmental and social management systems (ESMS) – The Case of Cassandra Mines

Kassandra Mines encompasses Skouries Mine and Plant including an Integrated Extractive Waste Management Facility (IEWMF), Olympias Mine and Plant, Stratoni Mines-Plant and Port, Kokkinolakkas Tailings Management Facility (TMF) and Greek Nurseries, an operational nursery adjacent to Olympias, used to support closure and revegetation work.

The aim of this lecture is to present the design and implementation of the ESMS for Kassandra Mines. It will include an overview of the content and approval process of the regulatory EIA and ESIA studies, Environmental Auditing, and Environmental and Social Management Plans (ESMPs). Focus will be given to the Environmental Monitoring Program and the Management Plans on Air Emissions, Water Resources, Noise and Vibration, Extractive Waste, Non-Mineral Waste, Hazardous materials, Traffic and Transport, Biodiversity in relation to site clearance, Cultural Heritage in relation to pre-construction screening, Stakeholder engagement and Social Performance (community development, corporate social responsibility, and community investment) and Mine Closure.

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Lecturer: Prof. Maria TAXIARCHOU (NTUA)

Dr. Maria Taxiarchou is a Mining and Metallurgical Engineer, full-time professor in the School of Mining and Metallurgical Engineering and a member of NTUA Research Committee, which is responsible for the management of all the research funds of the University.

Her current activities involve research on technology development for the processing of ores and industrial minerals; development of energy efficient processes; design and techno-economic evaluation of new production processes; development of high-added value products from ores and industrial minerals for the construction and chemical industry; assessment of the environmental impact and LCA of products and processes. She has authored or co-authored 90 research papers and she has been granted one national and two international patents. She is a regular reviewer of several international journals in the field of metallurgical engineering, and she has participated in more than 65 European funded research projects. Currently, she is the executive director of the NTUA spin-off company Lightcoce.

	<p>Name: Maria TAXIARCHOU</p> <p>Academic Title: Associate Professor on Analysis and Design of Processes for Ores and Industrial Minerals</p> <p>Institution of employment: School of Mining and Metallurgical Engineering, NTUA</p> <p>Contact number: 00 30 6944 314432</p> <p>Relevant Website: http://research.labmet.ntua.gr/</p> <p>E-mail: taxiarh@metal.ntua.gr</p>
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Lecture: Innovation and sustainability in the Industrial Minerals Sector

Industrial minerals are naturally occurring, non-metallic materials that are essential for a variety of industries due to their specific physical and chemical properties. Their properties include hardness, thermal stability, chemical inertness, non-toxicity and good conductivity, depending on the specific mineral. The most common industrial minerals include perlite, kaolin, bentonite, silica, mica, zeolite, barite, diatomite, vermiculite, talc, feldspar, limestone and gypsum. Their unique properties combined with their versatility, abundance, and cost-effectiveness, making them key components in a wide range of applications like construction, manufacturing, agriculture, and chemical production. Additionally, many are environmentally friendly, supporting sustainable industrial processes.

The lecture will give a comprehensive overview of the research that is performed in the industrial minerals sector including new processes for the treatment of industrial minerals, development of new high-added value products for new applications based on industrial minerals. Moreover, emphasis will be given on how industrial minerals can contribute to the sustainability of various industrial sectors and the circular economy

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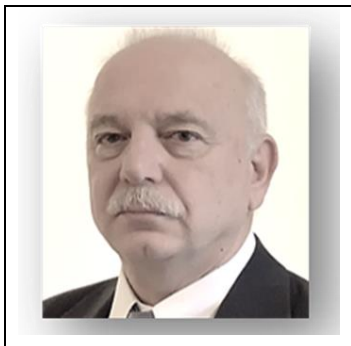
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concept. Specific examples of new processes and products based on perlite, bentonite, zeolite and kaolin will be presented in detail.

Lecturer: *Em.* Professor Ioannis PASPALIARIS (NTUA)

Prof. Ioannis Paspaliaris is a Mining and Metallurgical Engineer. He is currently an Emeritus Professor in the School of Mining and Metallurgical Engineering and has served as Dean of the same School and Rector of the National Technical University of Athens. His current activities involve research at the Laboratory of Metallurgy of National Technical University of Athens (NTUA). He has authored or co-authored 150 research papers and he is a regular reviewer to several international journals in the field of metallurgical engineering. He has been granted two national and two international patents. Throughout his research career he has participated in more than 50 European Union funded research projects. He has also participated as an expert in various European Union Committees and Platforms on Raw Materials exploitation and he is currently the director of the spin-off company LightCoce.



Name: Ioannis PASPALIARIS

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Lecture: Techno-economic analysis: a useful tool to evaluate the economic performance of potential investments in the Raw Materials Sector

Technoeconomic assessment (TEA) is a widely applied methodology in industry for evaluating the economic viability of a process technology, a product, or a project. TEA is an effective tool for taking high-level decisions concerning whether a project should proceed or terminated, which process alternative best meets a profitable business objective, and where attention should be given to reduce economic risk. The main steps for the development of a techno-economic model including Process Design, Process Modelling, Equipment Sizing, Capital Cost Estimation and Operation cost and key economic indicators of an investment like Net Present Value, Internal Rate of Return and Payback Period will be presented and discussed. An appropriate example from the Raw Materials Sectors will be also presented.