

EDUCATION IN MINERAL PROCESSING AND FILLING THE GAP OF TALENTED MINERAL PROCESSING ENGINEERS

Maria Sinche-Gonzalez[#], 0000-0002-7722-6839,
EMJM-PROMISE, University of Oulu, Oulu Mining School, Oulu, Finland

ABSTRACT – Mining countries such as Australia and the US have recognized the lack of mineral processing engineers as the demand for mineral resources increases for energy transition and climate change mitigation. However, this need is also due to the complexity of extraction, refining, quality control, environmental impact, supply chain and regulatory requirements associated with the increased demand of minerals and metals. Within the European Union (EU), there is an acknowledged requirement for clean energy technologies that rely on critical minerals such as copper, lithium, cobalt, nickel, and rare earth elements. Also, the EU wants to be less dependent on the supply of critical raw materials (CRM). Therefore, the demand for mineral processing engineers and metallurgists in Europe is expected to increase substantially over the next decade. However, there is not a delineated road map emphasizing the more technical and skilled professionals' education for resolving the workforce and a talent crunch in mineral processing and mining engineering-related areas. There are only a few attempts at filling the gap in education of talented mineral processing engineers. For example, the Erasmus+ program such as the Erasmus Mundus Joint Master in Sustainable Mineral and Metal Processing Engineering, EMJM PROMISE, is the first program focusing on mineral processing specialization. Addressing the shortage of mineral processing engineers requires educational reforms, efforts to attract young professionals, and investment in modernizing the industry's image to emphasize sustainability and technological innovation and cooperation.

Keywords: Education, Mineral processing, Shortage of skills, Cooperation.

INTRODUCTION

Given the increasing demand of minerals and metals for the green transition, there is a growing need for domestic extraction, processing, recycling, and substitution of critical raw materials. However, a fundamental challenge lies in the shortage of skilled professionals across the entire raw materials sector.

Europe is facing an acute gap in skilled professionals, particularly in industrial operation, mostly due to limited public awareness of the importance of raw material [1]. This is exacerbated by declining enrollments in mining, metallurgy, mineral processing, and related engineering fields (Figure 1) alongside insufficient investment in education and training.

Unlike the U.S. and Australia, which have developed comprehensive educational roadmaps [2], Europe still lacks a cohesive, large-scale initiative to tackle the talent and workforce shortage in these critical sectors.

[#] corresponding author: maria.sinchegonzalez@oulu.fi

Figure 1 shows the number of students graduating from related mining engineering programs has declined since 2016 across Canada, the U.S., and Australia. The downtrend transcends are not a national phenomenon in those countries but reflects the global nature of the mining sector.

It could be very convenient to attribute the observed trend to the cyclical nature of the mining industry. However, the number of students joining and graduating from mining-related programs dropped significantly despite commodity prices holding steady or increasing.

Unfortunately, we cannot find data from the European Union on education in mining-related professions. However, the publication of Euractiv [3] recognizes that the mineral processing graduates in Europe are almost negligible.

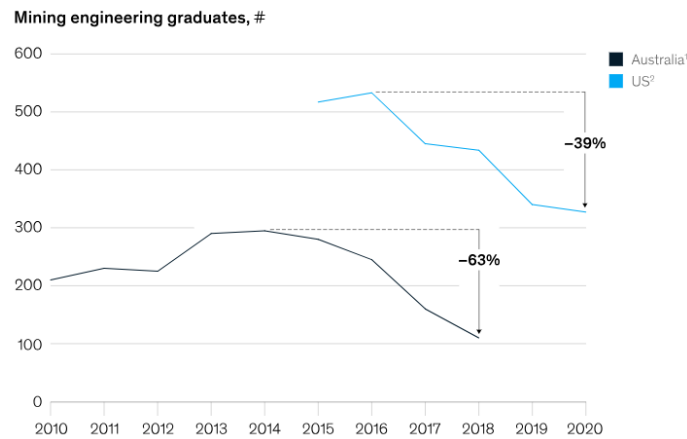


Figure 1 The number of students graduating from related Mining Engineering programs. Source [4].

METHODOLOGY

This paper considers an analysis of the need for mineral processing engineers making a review of the latest publications about education in the mineral processing in the EU.

The starting point was to reply to:

- What are the key areas that need mineral processing engineers?
- What are the reasons for the shortage of mineral processing engineers in Europe?
- How many mineral processing engineers will be needed?

An analysis of the competences of the new graduate's mineral processors and required by the industry, a survey of stakeholders collected the answers of 23 companies.

The existing mineral processing programs in the EU were identified and mapped.

Key areas of demand of mineral processing engineers

From electric vehicles to solar panels to future innovations, the global transition to clean energy is set to further heighten demand for critical minerals.

The global demand of minerals for energy transition will increase significantly in the coming decades. Figure 2 shows that between 2022 and 2050, demand for lithium will rise tenfold, nickel will double, and cobalt triple.

1. Lithium, vanadium, graphite, cobalt, and nickel processing: as the EU scales up battery production, engineers specialized in the processing and refining of these CRM will be critical.

2. Rare Earth Elements (REEs): the processing of rare earths, used in renewable energy technologies and electronics, will require specialists with niche skills in metallurgy and mineral processing.

3. Recycling and urban mining: metallurgists will also be needed in recycling facilities to recover metals from e-waste, batteries, and other discarded products.

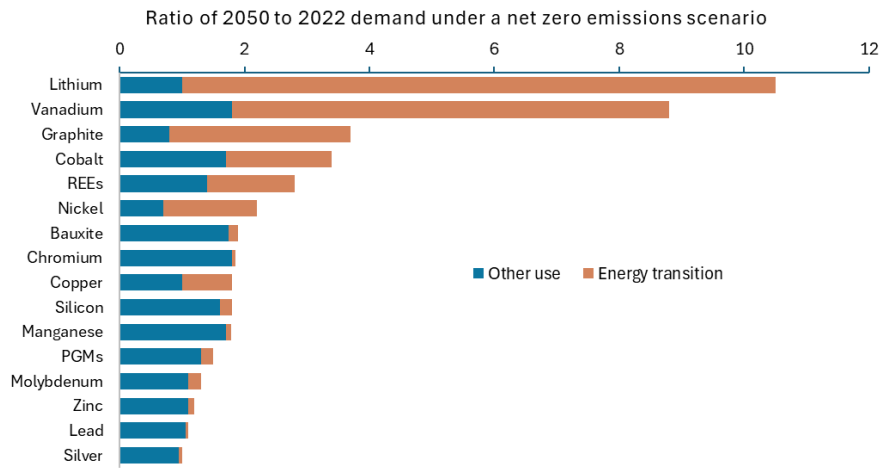


Figure 2 Increase in global demand for energy transition minerals.

*Source: International Energy Agency (IEA) in Surging Demand for Energy Transition Minerals, Projection under the IEA's net zero emissions transition scenario [5].

Reasons for the shortage of mineral processing engineers in Europe

There are various reasons for the shortage of engineers in the field of mineral processing, between them:

1. Limited investment in education and infrastructure
2. Aging workforce and retirements
3. Geopolitical and regulatory challenges
4. Declining enrolment in mining and processing programs
 - a. Perceived environmental and social impact
 - b. Competition with other sectors
 - c. Boom and bust cycles in the mining industry
 - d. Shift in industry focus
5. Digitalization and technological advancements
 - a. Increased demand for critical raw materials

- b. Europe is aiming for increased self-sufficiency
 - c. Reshoring of mineral processing activities
 - d. Recycling and circular economy
6. Stakeholders' different priorities, values, and expectations

How many mineral processing engineers will be needed?

Although exact figures are hard to determine, this industry necessitates expertise and know-how which is not available domestically and could require tens of thousands of professionals across mining, processing, and recycling sectors in coming years.

The demand for mineral processing engineers and metallurgists in Europe is poised to increase substantially over the next decade, driven by the magnitude of the shift towards green technologies, raw material independence, and recycling. It's estimated that thousands of new jobs will be created over the next decade. For instance:

- The EU's Raw Materials Action Plan could create upwards of 30000 direct jobs by 2030, many of which would be in fields like mineral processing and metallurgy.
- According to some projections, the battery materials supply chain alone could require more than 10000 metallurgists and mineral processing experts across Europe by 2030.

RESULTS AND DISCUSSION

Why is specialized expertise needed in mineral processing?

A key prerequisite to European competitiveness in Raw Materials is enhancing the competences of the mining and processing experts.

The survey carried out in 2021 collected the answers of 23 companies [6]. It shows the knowledge and skills expected from new graduates in mineral processing engineering in Figure 3.

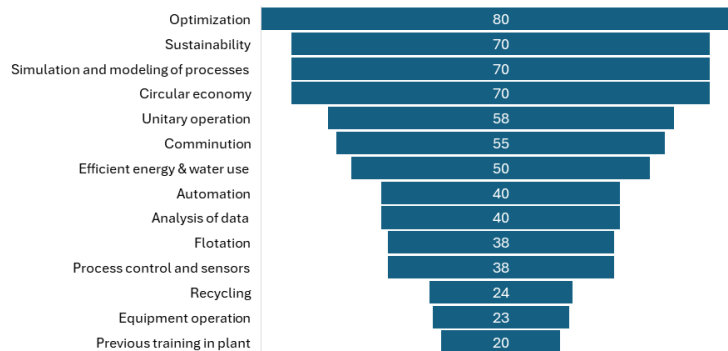


Figure 3 Stakeholder analysis of the needs of technical knowledge and skills [6].

An expert in mineral processing must have all the capabilities that support good decisions. These professionals must have knowledge and skills in chemistry, process mineralogy, breakage mechanism, theory and practice in sampling (TOS), comminution, flotation, separation processes, hydrometallurgy, pyrometallurgy, laboratory test, data

analysis, as well as develop new abilities of 360° communication, teamwork, shape creative approaches to solving production problems, use digital tools such as modelling and simulation (use of both software and mathematics is complementary) and take responsibility for the completeness of projects. These skills are required to continually design and redesign more complex mineral processing operations, which also need to be run in even more resource-effective ways.

Education programs in the EU

An analysis of the education programs in Europe and results show that few education programs cover the area of mineral processing.

At the bachelor level, there are no mineral processing degrees (BSc) in Europe (some related exceptions). Therefore, there is not a distinctive degree in mineral processing. Some related programs are:

- Bachelor's degree in Mineral Resource Engineering, LUT
- Bachelor's degree of Science in Mineral Resources Engineering, MUL
- Bachelor's degree of Science in Mineral Resources and Raw Materials Engineering, Technical University Bergakademie Freiberg
- Bachelor of Science in Raw Materials Engineering, RWTH Aachen University

At the master level (Table 1), there are few specific programs in mineral processing or extractive metallurgy, other related programs have less than 30% of mineral processing courses in their curricula.

Table 1 Master in EU related to mineral processing (MinPro)

Programs related to MinPro	With some relation to MinPro
1. AGH University of Science and Technology (Poland), MSc in Extractive Metallurgy and Mineral Processing	2. Luleå University of Technology (Sweden), Master Program in Georesources Engineering /MSc Geoscience
3. University of Oulu (Finland), MSc in Mining Engineering, Mineral Processing and Geophysics – Specialization in Mineral Processing	4. Aalto University (Finland), MSc in Chemical Engineering – Major in Sustainable Metals Processing
5. University of Lorraine (France), MSc in Geosciences – Mineral Resources and Extractive Metallurgy	6. University of Bologna (Italy) MSc in Chemical Engineering – Specialization in Sustainable Chemical and Process Engineering
7. Delft University of Technology (Netherlands), MSc in Sustainable Energy Technology – Specialization in Raw Materials Processing	8. Instituto Superior Técnico, University of Lisbon (Portugal): MSc in Mining and Geological Engineering
9. Montanuniversität Leoben (Austria), MSc in Mining and Metallurgical Engineering	10. Technische Universität Bergakademie Freiberg (Germany), MSc in Geosciences – Specialization in Mineral Resources and Sustainable Process Engineering
11. RWTH Aachen University (Germany), MSc in Raw Materials Engineering	12. University of Porto (Portugal): MSc in Mining and Geo-Environmental Engineering
13. University of Exeter (UK), MSc Minerals Processing at Camborne School of Mines (no EU)	14. Master European Mining Course (EMC) 2023 leading into triple degree, by Aalto University, RWTH Aachen University and MU Leoben

Other programs

Although the EU commission is aware of the skills shortage, education is not its direct competence. It established the following programs to support the development of new high skills in engineering, material science, geology or earth observation.

1. The European Institute for Innovation and Technology (EIT) has been created to enhance Europe's ability to innovate by integrating education and entrepreneurship with research and innovation at the EU level.
2. The Erasmus+ program includes the Erasmus Mundus Joint Master (EMJM) and Marie Skłodowska-Curie actions (MSCA) provides grants for a wide range of activities in education, training, youth, and sport.

EMJM PROMISE - Erasmus Mundus Joint Master in Sustainable Mineral and Metal Processing Engineering (EIT Labeled) provides a solid foundation in mineral processing and extractive metallurgy, preparing students for careers in both the technical and management aspects of the mining and minerals industry. Also, it emphasizes sustainability, green processing technologies, and environmental impact reduction, reflecting current trends in the field.

CONCLUSIONS

- The demand for mineral processing engineers and metallurgists in Europe is expected to increase substantially over the next decade, driven by the need for critical raw materials, the expansion of the green energy sector, and initiatives of the EU.
 - Although exact figures are hard to determine, the industry could require tens of thousands of professionals across mining, processing, and recycling sectors.
 - Addressing the shortage of mineral processing engineers requires educational reforms, efforts to attract young professionals, and investment in modernizing the industry's image to emphasize sustainability and technological innovation.
 - The skill shortage needs to be addressed through communication and partnerships between civic society, public authorities, universities, research organizations, and industry. The Commission supports the development of new high skills in engineering, material science, geology or earth observation.

ACKNOWLEDGEMENT

The support of the funds of EMJM-PROMISE program to sponsor the participation in IMPRC 2025 is acknowledged.

REFERENCES

1. European Commission. Skills and education. https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/skills-and-education_en.
2. Drinkwater, D. (2017) *A Roadmap for Mineral Processing Education. Mineral Engineering Knowledge and Skills for Today's Industry. IMPC Mineral Processing Commission.*

3. Stam, C. (2018) Europe's mining sector faces skilled workers shortage. <https://www.euractiv.com/section/circular-economy/news/raw-materials-industry-faces-skilled-workers-shortage-calls-for-linking-industry-with-education>.
4. McKinsey & Company. (2023) *Metals & Mining and People & Organizational Performance Practices*. <https://www.mckinsey.com/industries/metals-and-mining/our-insights/has-mining-lost-its-luster-why-talent-is-moving-elsewhere-and-how-to-bring-them-back>.
5. Surging Demand for Energy Transition Minerals. (2024) <https://www.voronoiaapp.com/natural%20resources/Surging-Demand-for-Energy-Transition-Minerals-1174>
6. Sinche-Gonzalez, M. (2024) Importance of the Erasmus Joint Mater in Sustainable Mineral and Metal Processing Engineering (EMJM-PROMISE) at the University of Oulu for the industry and the internationalization of education in the mining field in Finland. *Materia*.