# The Mining Sector's Strategic Need for UK Mining Engineering and Mineral Processing Graduates

UK Mining Education Forum

10 July 2022

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## Executive Summary

The products of the mining industry are fundamental to the existence and development of society. The UK underground mining industry produces important minerals – for example: gypsum, polyhalite fertiliser, rock salt, sand, barites (a weighting agent for drilling fluid), tungsten, gold, fluorite, tin, coal and electrode grade anthracite. Furthermore, the UK is home to mining companies worth over £500 billion with extensive international operations, with London a global centre for mining finance. There are several thousand companies supporting the mining supply chain, including equipment manufacturers, market researchers and technical consultancies.

Significant increases in mining will be required to transition from fossil fuels, for example the world will need to mine more copper in the next 25 years than in the previous 50 decades. Other critical minerals, such as lithium, will require even larger increases in mined volumes.

Mines in developed countries, including the UK, cannot be legally or effectively operated without appropriately educated and experienced mining engineers in charge of mining operations and the increasingly complex orebodies being mined will require skilled mineral processing engineers. In the UK, the education required by mining engineers includes a degree and competences defined by the Mineral Products Qualifications Council (MPQC) and vetted by the Health and Safety Executive (HSE).

The industry is committed to extending degree content and the competences to include Environmental and Social Governance topics. Camborne School of Mines (CSM) at the University of Exeter is the only remaining university with the capability to teach underground mining engineering and mineral processing. CSM is one of the most highly regarded mining schools in the world and delivers world class postgraduate courses, however undergraduate courses were “paused” in 2020.

The UK Mining Education Forum (UKMEF) has estimated that at least 48 mining engineering and 18 mineral processing graduates are required per year to sustain the UK mining industry. Analysis of mining and mineral processing engineers currently registered with the Engineering Council through the Institute of Materials, Minerals and Mining (IOM3) shows that there is a significant and growing shortage of these engineers, and that this will threaten the future of the UK mining industry and the domestic transition from fossil fuels. Of the 1,237 mining and mineral processing engineers registered with the Engineering Council, 80% are over the age of 50, with 39% over the age of 66. The lack of UK mining engineering graduates also threatens an important relationship with the major mining companies with presence in London.

The mining industry has recognised the critical shortage of qualified staff that is emerging, and the Mining Association of the UK (MAUK) is developing a Degree Apprenticeship in Mining Engineering Management with the Camborne School of Mines. This programme is on track to take its first apprentices in January 2023. However, while this programme will greatly assist the mine operators address their shortfall in mine managers, it will not address the requirements of the wider UK mining industry, for example equipment manufacturers, mineral processors and mining finance. With an

anticipated 15 apprentices there will be an estimated shortfall of 51 graduates per year. Re-instatement of the under graduate mining engineering and mineral processing undergraduate programmes at the Camborne School of Mines, or another UK University, are required as a matter of urgency.

The re-instated mining engineering and mineral processing courses must attract students to be successful, however, mining continues to attract severe negative publicity. Policy makers, politicians, learned bodies and the media must address this issue with leadership and support to demonstrate the vital need of raw materials to complete the energy transition with equal urgency.

## 1. Introduction

Mining was essential to the industrial revolution that created the modern UK economy. Locally educated and trained mining engineers went on to develop mines worldwide, serving international and domestic needs.

Globally, mining remains essential for the provision of the food, power, heat, transport, housing, goods and electronics required by individuals and industry. The transition from fossil fuels, global population growth, and geopolitical tensions are additionally creating unprecedented demands, especially for critical minerals. All these factors necessitate expanded mining activities, managed by mining engineers and mineral processors. The recruitment of UK students into undergraduate mining engineering degrees has however declined to a level that is inadequate for the development and maintenance of the UK mining operations.

Recruitment of graduates into international mining companies, many with a presence in London, is also at risk, threatening the UK supply chains with foreign origins, the return of company revenues to the UK, and the influence of a 'Global Britain'. A further consequence of low student recruitment is that the continuance of undergraduate mining engineering at the one remaining university mining school – Camborne School of Mines – is under review.

Lack of graduates has led to a minimum of a two-year gap in fresh UK graduate recruitment by home and international companies, the initiating aging employee communities, and a threat to the industry's ability to operate with a proper transfer of experience and responsibilities. This affects both the UK industry and the international industry that is based in, or operates through, London (worth £500 billion), a city which is known as 'the mining capital of the world'. The lack of UK mining graduates also affects the provision of industry support services and mining equipment sales internationally, involving about 5,000 supply chain companies recognised by the DIT.

The UK Mining Education Forum (UKMEF) is a group of senior professionals from industry, professional bodies, and academia, who wish to see these issues strongly addressed. The impact of the current circumstances will be both direct and indirect through an inability to produce staple minerals such as gypsum (British Gypsum) and

fertiliser (ICL Boulby and Anglo American), and critical metals such as lithium and tin (Cornish Lithium and Cornish Metals).

Inability to produce UK mining graduates negates the proven contribution that they make as professional ambassadors in their employment abroad — where they promote UK professional engineering standards, UK mining services, and UK-manufactured mining equipment. It will also remove the contribution that UK graduates make while working abroad for UK-registered companies (eg, Rio Tinto) through the corporation taxes paid by successful operators.

The mining industry faces growing challenges regarding the delivery of metals and minerals to alleviate climate change (the energy transition) and a focus on environmental, social and governance (ESG) issues. These challenges encourage educators to include essential new topics in the curriculum. Fortunately, UK academia, through its research and scholarly work, is well placed to scope and teach these new topics, and so deliver mining engineering degrees that are appropriate for the future based on, for example, the World Bank's Climate-Smart Mining Initiative[1]

Although UK universities can provide the teaching, the fundamental problem remaining is the lack of student recruitment from the UK. This could be tackled by informative programmes directed at school students and staff that develop understanding of the essential and positive contributions that mining and associated industries make to society, and the many rewarding careers that are available (see Table 2, page 18). A coordinated effort is required among all parties and this approach is emerging from within the UKMEF.

Mining career publicity must be underpinned, however, by the certain knowledge that UK universities will continue to offer undergraduate degrees in mining engineering for the foreseeable future. These courses must be fit for modern times, with UK students finding employment either at home or abroad, and foreign students able to return to their sponsor with a modern world-class degree.

The Mining Association of the United Kingdom (MAUK) and the British Overseas Mining Association have addressed UK student recruitment and teaching by initiating a Mining Management Degree Apprenticeship (MMDA) course. This proposed standard, aimed address the needs of the UK's underground mining industry, has been approved by the Institute for Apprenticeships and Technical Education. Camborne School of Mines will deliver this course, which will prioritise the mining engineering needs of MAUK members through in-industry training and experience.

The MMDA degree course could run in tandem with part time and conventional modern undergraduate mining engineering degrees, which would be open to non-MAUK sourced applicants. While primarily aimed at meeting the needs of MAUK member companies, the MMDA initiative helps to secure the continuity of degree provision at Camborne School of Mines.

[1] (https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action)

Additionally, UKMEF recommends that because the graduate recruitment problem is so critical, UK operators and foreign operators based in London should offer full scholarships (fees plus subsistence) to selected students, with corporate executives being involved in decisions related to the financing of mining career marketing and scholarships. This will certainly attract the attention of school leavers, and the target number of recruits will be determined by the industry's graduate requirements, fees charged, and income required by the UK universities.

The following paper presents the evidence that supports the UKMEF conclusions and recommendations relating to the continuance and development of mining engineering degrees in the UK. Mining engineering graduates must be seen as a necessary investment that is a national priority, requiring assistance until it becomes self-supporting through growth in student numbers. The present position is generating competency gaps in a critically important high-risk industry as experienced staff retire; UK mines cannot operate with gaps in certain key competences required by law. Maintenance and development of mining engineering courses fit for current and future challenges will maintain production of the minerals essential for the continuance and sustainable development of societies worldwide.

## 2. Mining Degrees – need, current provision and UKMEF objectives

The products of mining are fundamental to the UK economic and societal development. Worldwide, the consumption of mineral raw materials is rising rapidly owing to population growth, higher standards of living, urbanisation and new technologies[2].

Globally and nationally the mining industry must improve its ability to find and produce minerals responsibly. Crucially, the need to ensure a supply of essential minerals[3] to the UK has been greatly amplified by growing geopolitical instability. Supply-related pressures, coupled with heightened responsibility for environmental and social governance (ESG) issues, mean that the industry faces challenging times.

Well-qualified UK mining engineers and mineral processors play essential roles in meeting these challenges[4]. Given the present and future mineral supply pressures, it is concerning that currently (2022) no undergraduate mining engineering or mineral processing degrees are being offered in the UK, with only post-graduate courses available (at Camborne School of Mines).

Contrast this to the situation 30 years ago when the UK mining industry with its home and international revenue-generating operations was served by five university mining

[2] https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions; https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action

[3] For example, metallurgical coal for steel used in the construction of wind turbines and along with nickel and cobalt in syringe needles, fertiliser for agriculture, lithium for batteries and gypsum for the housing industry, fluorspar for the chemical industry, barites for well drilling and gold for electronics.

[4] (https://www.linkedin.com/posts/tim-biggs-0b507a75_mining-is-essential-activity-6922188716111241216-2STR?utm_source=linkedin_share&utm_medium=member_desktop_web)

departments hosting over 300 mining undergraduates. It is this legacy, and the large numbers of mining engineers trained by the UK coal industry, that has sustained the UK mining industry to date. However, these engineers are now at the end of their careers and, given the downturn in graduates, it is likely that parts of the mining industry will be at least five years behind in their normal staff replenishment schedules.

Mining engineering and mineral processing graduates are not simply required for the home UK industry, but also to serve the international operations of companies (Figure 1). These companies frequently have links to the UK because they either have a presence on the London Stock Exchange or have significant corporate offices in the UK (usually in London). The market capitalisation of these companies (at March 2022) is assessed at £500 billion[5], which is almost one-quarter of the global value of listed mining companies.

Mining in the UK supplies a number of strategic and critical minerals, and overseas operations are becoming even more important because of heightened security of supply issues. Of particular concern are metals such as copper and lithium, which are required to facilitate “the electrification of everything”. Despite this imperative, the UK mining industry is now reliant for mining engineering graduates on only one university department, the University of Exeter's Camborne School of Mines.

The graduates of Camborne School of Mines serve not only the needs of the indigenous UK mining industry, but also those of the cluster of international companies operating from London. Through this employment the graduates contribute to the UK's foreign earnings and act as ambassadors for UK engineering. Indeed, it is argued by Tim Biggs, former Deloitte Partner and EMEA and UK sector leader, Mining & Metals[6] that the production of graduates who go abroad to work is arguably more important to the UK than producing graduates for the home industry.

The decline in the number of mining-related degrees in the UK is substantially due to the demise of UK coal mining, and the residual poor public image of the industry. This translates into poor home student recruitment, and university mining departments becoming loss-making. Accordingly, mining-related degrees are not considered by most universities to be an essential part of the UK portfolio of engineering degrees.

This unfortunate disengagement from mining by students and universities has led to a developing crisis in the supply of graduates into the industry. Given the importance of mining engineering and mineral processing professionals, the lack of supply threatens the maintenance of a UK culture and national connectivity in this crucial industry similar to the disappearance of UK engineers from the nuclear industry.

The UK Mining Education Forum (UKMEF) has been formed by senior figures in the UK mining sector, drawn from industry, trade organisations, professional institutions, and academia. The Forum argues that to allow the disappearance of mining and mineral engineering graduates is unwise and is invoking all sectors related to the industry

[5] https://docs.londonstockexchange.com/sites/default/files/reports/Issuer%20list%20archive%202022_1.zip
[6] Personal communication

(including mining companies, financiers, lawyers, regulators, manufacturers, service providers, professional institutions and academe) to meet the challenge of recruiting sufficient students to enhance the provision of undergraduate degrees in Camborne School of Mines, and other UK university departments.

In promoting these courses at to potential students, UKMEF will incorporate technological, social and geopolitical components that demonstrate that the mining mineral engineering graduates play an essential role supporting of societal needs nationally and internationally and can be highly rewarded for so doing. Furthermore, a mining engineering degree is welcomed by other industries with a heavy engineering base as a desirable qualification, offering graduates career choice.

Another reason for having a vibrant UK-centred mining industry is the numerous jobs created in support of the profession. These roles include geologists, mineral surveyors, mining consultants and engineering consultants. There are also numerous mainstream organisations that have specialist mining and metals teams. These include research and information companies (eg, CRU), accountants and consultants (eg, Deloitte and PwC), most of the leading law firms, many of the investment banks and brokers (eg, JP Morgan and Bank of America Merrill Lynch), and executive search firms.

This paper states UKMEF's intent to strengthen the national role and international influence exerted by UK-trained mining and mineral engineers. The importance is heightened as the mining industry must continue to serve expanding societal needs while meeting the appropriately demanding Environmental and Social Governance (ESG) and Corporate Social Responsibility (CSR) standards required of a modern responsible industry.

There is a case (developed in Section 3) for the expanded provision of UK mining engineering degrees as part of a wider mining education landscape. UKMEF also records in this report examples of the challenges to be faced in a modern mining industry as it meets the demands of economic growth and technological developments, and hence the new content required in modern mining degrees to serve national and global needs. UK mining tertiary education must be a strategic UK imperative, and UKMEF suggests how that education could be delivered. This thinking will, for example, align with the recent development of an Expert Committee on Critical Minerals convened by the UK Government's Department for Business, Energy and Industry Strategy (BEIS).

## 3. The current mining education landscape

The functions served by mining and mineral processing engineers in the industry vary, ranging from mining technology development, mining process design and delivery, to deployment of safety equipment and process management. The mining sector must deliver the financial performance required to justify the extraction operation while adhering to safety standards and environmental impact controls. Engineers operate at all levels of management, typically making their way up the management ladder as they

gain experience, including to board level. These are the types of career for which their degrees must prepare them.

UK natural resource extraction (mining) industries have already formed several trade associations[7], and have organised training and education related specifically to their specialism.

The minerals industry, represented initially by the Minerals Education and Skills Board (MESB) empowered the Mineral Products Qualifications Council (MPQC) to deliver the training the industry required, and they do this through their MP Skills division, while their independent MP Awards division provides assessment according to national standards.

The Institute of Quarrying website directly features that sector's approach to education, including reference to the courses run by the University of Derby which include a Higher Apprenticeship in Mineral Products, University Certificates, a Diploma in Mineral Extractives Studies, a Foundation Degree in Mineral Extractives Technology, and an Honours Degree in Minerals Management.

These surface-based industries have lobbying organisations working with them that include the CBI Minerals Group, the Minerals Product Association, and the British Aggregates Association.

The Mining Association of the United Kingdom (MAUK), which represents mining companies with underground operations, provides a forum for discussion and debate for mine operators. MAUK brings together operators under a banner of mutual aid to support the industry's technical development, and the sector's national purpose and identity. MAUK develops guidance for operators – specifically associated with major hazard management and control. MAUK promotes cross-business interaction and experiential learning, fellowship and networking.

Concerned about the lack of UK mining engineering graduates, MAUK has submitted standards for a Level 6 Mining Management degree apprenticeship course (focussed on underground mining) to the Institute for Apprenticeships and Technical Education approval system which was approved in May 2022. The University of Exeter, Camborne School of Mines, has bid to provide the course content, and for teaching and assessing the student progress. The course could begin early 2023. This initiative by MAUK is a clear demonstration of the importance it attaches to solving the lack of UK mining university graduates.

The industry initiatives to solve their developing industry-threatening personnel shortage by committing to funding students and receiving them for on-the-job training as part of their studies are highly commendable. These depend, however, on university-based human resources and infrastructure being in place to receive and educate students, and hence direct or indirect government intervention or funding.

[7] https://www.netregs.org.uk/environmental-topics/trade-associations-bsos/mining-and-quarrying-trade-associations/

Focusing on mining and mineral engineering undergraduate degrees, it is apparent that the opportunity and responsibility for the delivery of these full programmes now falls, given the demise of other universities mining departments, on Camborne School of Mines at the University of Exeter, the only UK university to retain a full mining engineering teaching capability, witness its association with MAUK in the new apprentice degree.

Camborne School of Mines enjoys an internationally excellent reputation within the industry and academia (ranked 11th in the World and 1st in Europe for Mining and Minerals Engineering[8]). The School has a substantial portfolio of MSc degrees (Mining Engineering, Mining Geology, Geotechnical Engineering, Exploration Geology, Mineral Processing, Surveying and Land/Environmental Management and Mining Environmental Management) and a cohort of PhD students. After a fall consistent with the national decline, numbers on the undergraduate geology courses are now increasing. While the Camborne School of Mines post-graduate programmes are highly rated, they do not provide graduates with the same breadth of mining and mineral processing knowledge as those who have completed an undergraduate degree. For example, the breadth of knowledge obtained through a post graduate programme will be driven by the specific modules selected and the students' varied undergraduate backgrounds.

Based on previous conventional mining engineering and mineral processing degrees the School could – provided given appropriate support – deliver courses and continue research that keeps the UK in the forefront of the international mining industry as it faces the current challenges by accommodating climate change imperatives and heightened social responsibility in its teaching.

Unfortunately, the undergraduate mining engineering degrees has recently been 'paused' at Camborne School of Mines, with the Degree Apprenticeship being one of the ways in which provision of mining education at undergraduate level is continued. This effort is, UKMEF believes, worthy of support. This is not enough, in itself, however, and UKMEF would like to see conventional three-year undergraduate degrees in mining engineering and mineral processing offered at the School to provide the number of qualified graduates that are needed in the wider mining industry, and to ensure a dynamic curriculum that keeps pace with global developments in knowledge, understanding and best practice.

Camborne School of Mines (CSM) alumni have been working to bring industry support to both student recruitment and curriculum development and delivery. The Camborne School of Mines Association (CSMA) is the independent alumni organisation for CSM graduates, and has over 1,100 members globally. In response to the end of recruitment to the BEng mining engineering programme, CSMA organised a Mining Education Partnership initiative in 2021 which saw, at short notice, 18 companies across the resource sector sign up to a memorandum of understanding and framework to support

[8] QS Rankings, 2022

recruitment initiatives and to provide industry knowledge and resources to assist in the development of new programmes in mining engineering, mineral processing and mineral and resource surveying. These programmes are currently not represented at any UK education provider, although UCAS codes are still 'live'.

CSMA has recently signed a memorandum of understanding (MoU) with the new University of Environment and Natural Resources (UENR) in Ghana, following requests from Ghanaian alumni for exactly the kind of support offered through the 2021 Multicultural Engineering Programme (MEP). CSM alumni are already supporting UENR with curriculum development and programme accreditation in Mining Engineering, Construction Management and Resource Management. This demonstrates that the will and ability to help is there.

The only other degree level training related to mining is at the University of Derby, which offers an Honours Degree (BSc) in Minerals Management, developed with the UK quarrying industry. This is essentially for the surface mining of materials used mainly in the construction industry.

The wider area of geoscience (sometimes defined to include engineering) has also been under pressure, with a decline in entrants to university geology degree subjects since 2014. There are a number of initiatives underway to help address this problem[9], including a paper and strategy from the Geological Society of London and Universities UK.

Oil and gas extraction may be considered to be a specialised type of mining, and many mining graduates have spent their careers in the oil and gas industry. Global oil and gas production is forecast to remain around current levels at least out to 2050. The UK is a world leader in offshore oil and gas extraction, with the largest share of the global subsea market, and the UK is home to a significant number of oil and gas companies, meaning that there will continue to be demand for mining graduates. Given the intermittency of wind (and its unavoidable 30% to 40% duty cycle), gas will continue to play a crucial part in generating the UK's electricity supply until sufficient green storage is in place – many years from now.

There is a shortage in applicants for mineral resource related topics, whether it be in the geosciences related to their discovery and evaluation, or in their production by mining and mineral processing. While the purpose of UKMEF is to address the provision and stabilisation of mining engineering and mineral processing degrees, it is important for all the representatives of the strategically important mineral disciplines to collaborate in conveying the importance of these topics to government and prospective students.

[9] Enrolment in crisis: A UK-wide strategy for exciting, engaging and retaining students in the geosciences
A joint report from The Geological Society of London and University Geoscience UKhttps://98ca4554-1361-4fb1-a4d8-a1bb16d032e6.filesusr.com/ugd/f1fc07_bac8092441844af3ac950deda4d39ce3.pdf?index=true

## 4. The need for UK mining engineering and mineral processing degrees fit for the energy transition

### 4.1 Mining – the importance of engineers to an essential industry

Why are mining companies such an important part of the global economy? As one of the three primary industries, the products of mining are essential for both the functioning of current society and future development as the world seeks to meet the threat of climate change and the burgeoning ESG challenges. The importance of the mining industry is amplified given the prevailing geopolitical unrest and national supply re-alignments.

#### 4.1.1 Mining's contribution to modern society

The supply of metals

Mining provides the raw materials for important metals such as steel (iron, carbon and coking coal) and aluminum (bauxite) used in construction and manufacture; platinum and palladium for vehicle exhaust catalysts; battery metals such as copper, nickel and cobalt; and gold for electronics and investment.

Examples of UK mines producing minerals used in agriculture and manufacturing

In the UK, ICL Boulby (https://www.icl-uk.uk) had a long-standing history in the production of potash, which is a vital ingredient of fertiliser. The company supplied 60% of the UK's potash needs, and also exports to international markets, thereby contributing indirectly to UK food security. Having exhausted the potash reserves, ICL Boulby is now the world's first producer of polyhalite (an organic, low carbon footprint fertiliser supporting national and international crop nutritional needs). ICL Boulby's annual turnover is about £150 million.

Anglo American's new polyhalite mine in North Yorkshire (https://uk.angloamerican.com/the-woodsmith-project) is currently employing around 1,000 people and the company is set to invest £500 million over the next two years. This mine's output, coupled with that of ICL Boulby, will make the UK a net exporter of fertiliser.

Tungsten West's operation in Devon, which has graduates from CSM and London's Royal School of Mines (RSM) in senior positions, works one of the world's largest tungsten reserve. (https://www.tungstenwest.com/)

The importance of minerals used in construction

The Mineral Products Association (MPA) is the industry trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and silica sand industries. In a recent joint conference with CBI, 'Living with (Construction) Minerals', MPA affirmed that its minerals are essential to the UK economy, quality of life and decarbonisation.

Nigel Jackson, chair of the CBI Minerals Group and chief executive of MPA, introduced the conference with a reminder of the development of the UK's minerals strategy over the

past 20 years, stressing that it was "more important than ever and should continue to be used to steer policy and behaviour".

Jackson highlighted the essentiality of minerals, and how the strategy was aimed at helping decision makers 'make the link' between minerals, the economy and the UK's quality of life. Minerals, he said, were "often taken for granted and supply was assumed, but their supply needs to be planned, monitored and managed".

Tony Danker, Director General of the CBI, gave the keynote speech at the conference, acknowledging the importance of minerals to the economy, contributing £230 billion in gross value added. He said, however, that the sector is often overlooked by politicians and the media, reiterating that a supply of minerals was assumed. Explaining the CBI's new Seize the Moment strategy to transform the UK economy, he added that minerals had a vital role to play, as an innovative and inclusive sector, recognised as a net zero leader and regional champion.

'New' minerals with growing demand

Cornish Lithium is an innovative, eco-technology company focused on mineral exploration and development for the environmentally sustainable extraction of lithium used in batteries.

The company has secured agreements with the owners of mineral rights over a large area of the county and is using modern technology to re-evaluate the region for lithium and other technology metals which are essential components of modern life. A secure domestic supply of such metals is considered vital to the industrial strategy of the UK as it moves towards a net zero future. (https://cornishlithium.com/)

### 4.1.2 Accommodating increasing demand

Increasing global demand for minerals is driven by population growth and decarbonisation. Population growth will spur urbanisation with the associated large demand for minerals for construction (eg, structural steel and cement) and increased utilisation of the subsurface for accommodation (people and things) and transport (sewage and underground transport systems), increased demand for food and water driving demand for fertilisers and freshwater wells/pipelines, increased demand for energy to power modern lifestyles (heating, cooling, transport, computer systems, bitcoin, etc) with associated economic growth.

In its 2021 outlook, the Organization of Petroleum Exporting Countries (OPEC) forecast by 2045 an increase in the global population of 1.7 billion people (>20% increase on today's population), the global economy doubling and an associated 28% increase in energy demand – minerals will be required to manufacture all the things that this additional energy will be powering. The growth in the industry will require more graduates.

### 4.1.3 Meeting emerging challenges to the profession

The energy transition requires more materials and a wider variety of raw materials. The World Bank, for example[10], estimates that over 3 billion tonnes of minerals and metals will be needed to deploy wind, solar and geothermal power, as well as energy storage, required for achieving a below 2°C future temperature rise. More copper will be needed in the next 25 years than in the previous 5,000 years, and 5–10 times more lithium by 2050[11]. Specialist metals like neodymium, cobalt and lithium are classed as critical because of their economic importance but vulnerability to potential supply disruption. The UK Government has recognised the need to secure supplies of these elements in its NetZero strategy and has convened an Expert Committee to help it make a critical minerals strategy[12].

The mining of minerals can create environmental impact issues and produce greenhouse gases.[13] The UK mining industry (operating at home and abroad) has a key role in delivering these minerals (both critical and conventional) in a responsible manner, meeting modern ESG standards.

The British Geological Survey (BGS) and Camborne School of Mines formed a Critical Metals Alliance in 2011 to address the growing concerns over security of supply of critical minerals and continue to collaborate on this topic. Current research includes the UKRI Interdisciplinary Circular Economy Centre for Technology Metals and a NERC project on Lithium for Future Technologies.

Adding to the challenges related to growth, and new specialisations, increased attention must be given to ESG performance. This is one of the biggest challenges, and opportunities, for mining companies,[14] and work is being undertaken at Camborne School of Mines that will inform its students.

### 4.1.4 Why is there an insufficient supply of mining engineers and mineral processing degree applicants?

Applications from UK nationals for mining-related degree courses in mining and minerals engineering have declined over the past ten years, precipitating the withdrawal of courses and the closure of university mining departments.

Individuals choose not to take a mining or mineral processing degree for a variety of reasons. These will include legacy issues from previous mining activities, negative publicity, environmental activism, a lack of awareness of modern mining techniques and careers, insufficient promotion of the benefits of mining, an educational focus only on

[10] https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action
[11] https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions; https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action
[12] https://www.gov.uk/government/publications/net-zero-strategy
[13] As footnote 10
[14] https://www.ey.com/en_gl/mining-metals/top-10-business-risks-and-opportunities-for-mining-and-metals-in-2022

historical mining activities, and a perception that there is now little demand for UK mining and mineral processing engineers.

The current conflict in the Ukraine and the ensuing sanctions against Russia have increased global prices, thereby precipitating inflation and pressure on household budgets. Awareness of security of supply issues for key minerals, including oil, gas and fertilisers has increased. The public are becoming aware of the large volumes of minerals required to deliver the energy transition and support the growing global population. The scale of mining that will be required has not, however, been widely reported.

It is timely to pivot away from an educational focus on historical mining to an active promotion of the requirement for innovative mining techniques, modern careers in mining, and the benefits that mining can bring to the UK and local communities. The latter includes interesting and well-paid jobs, security of mineral supply, a reduction in the UK trade deficit, increased tax revenue, local community funding and securing a reliable supply chain (coupled with export potential). Raising awareness should improve the public perception of mining, in turn leading to greater acceptance and support for mining activities, and increased applications for mining and mineral processing courses.

To deny the societal importance of the mining industry and the place of the British graduate in that industry is to abandon a 200-year mining-engineering heritage that led to profound technological advancements, and contributions to world-leading university education. Failure to build on this intellectual heritage will ultimately lead to the transfer of the UK's role in setting the industry's performance standards to foreign companies and governments. Some of these participants will not naturally work to the high health, safety and corporate social responsibility (CSR) standards required today.

Failure to build on mining's intellectual heritage in the UK will also be an abrogation of the country's responsibility to help solve the global resourcing challenges in a responsible manner by following responsible sourcing initiatives, including the Extractive Industry Transparency Initiative[15]. An appreciation of the past, present and future importance of a national and international mining industry served by UK graduates must be used to counter the current negative attitude of potential degree applicants.

### 4.2 Degree content influenced by modern challenges

Graduate mining and mineral engineers play a key role in the operation and management of mining operations. In well-regulated jurisdictions, a mine must be managed by mine managers with a recognised mining engineering degree qualification and certified competences. These managers will be responsible for mine production and legally responsible for the health and safety of the mine workers. In a high-hazard industry, with large workforces, the latter is an especially important role. Traditionally, UK mining engineering graduates have filled these, and supporting, management positions,

[15] https://eiti.org

their entry point being facilitated by the respect held around the world for the UK mining degrees.

Traditionally, an English three-year mining engineering first degree would require mathematics and science for entry, and then focus on geology, mechanical engineering, electrical engineering, surveying, mining methods and design, mine ventilation, laws and regulations, and financing of natural resource extraction projects. In a four-year Scottish degree, the first year would concentrate on mathematics, physics and chemistry, with the remaining years being the same as in England.

The scale of the technological and societal challenges that new mining recruits will face is beyond the scope of the traditional undergraduate mining and mineral engineering degrees. For example, Anglo American's future plans (https://www.angloamerican.com/futuresmart/futuresmart-mining) require that the graduate engineers should be educated in digital methods, and in the engagement with management of multi-disciplinary teams, including process safety management. ESG and climate change impact management are also significant topics.

According to PwC in their paper Mine 2022 A Critical Transition [16] addressed to the top 40 mining companies according to their criteria (including the top two who are Australian/UK) identify key areas of focus including:

- Evaluating their exposure to critical minerals and working out where they need to be
- Building trust with stakeholders and strengthening mining's social licence to operate by increasing their focus on ESG

Given the breadth of existing and emerging challenges placed on the mining industry, the British mining engineering and mineral processing degrees should be structured and resourced to enable the necessary range of topics for a modern global and societally engaged mining industry to be taught. This will probably require collaboration between universities, with the teaching made possible using blended learning, and stretching beyond the three-year English degree to provide the professional qualifications required by engineers practicing in the mining industry.

Creating these world-leading degrees would keep the UK at the forefront of this essential and powerful industry, helping it to meet its societal obligations. Hence the strategic imperative of the continuance (and indeed further development) of UK mining engineering and mineral processing degrees – likely required to be a combination of an undergraduate and specialising postgraduate qualifications.

[16] https://www.pwc.com/ca/en/mining/publications/1368240-mine-2022-a-critical-transition-june-2022.pdf

## 5. UK's access to global mining offers international opportunities

Many of the employment opportunities in mining, and much of the international significance of UK engineering, is because of London's role as the mining finance capital of the world.

Deloitte's paper, London: Mining's Finance Capital notes "London's position as a genuinely international hub, through which globally significant and therefore influential transactions flow, remains its trump card. This, combined with the volume and quality of resources-specific capital houses it hosts, makes it a clear leader for mining finance." [17]

The top five mining companies operating from London in March 2022 had a market capitalisation of £300-400 billion. A few London-based mining companies also have domestic operations. Anglo American is the biggest UK mining company, with operations mainly abroad but also in the UK – notably the new polyhalite mine it is developing in North Yorkshire.

Companies present in London include those listed in Table 1.

[17] (https://www2.deloitte.com/uk/en/pages/energy-and-resources/articles/london-global-hub-for-mining-finance.html)

**Table 1: Mining companies with a presence in London (using a cut-off of £500 million market capitalisation)**

| Company | UK HQ | LSE | Comment |
|---|---|---|---|
| Anglo American | Yes | Yes | London head office |
| Antofagasta | No | Yes | Chile HO but London-listed and significant UK influence. |
| ArcelorMittal | No | No | Mining Division HQ based in London |
| Atalaya Mining | No | Yes | Spain HO but CFO based in London |
| Barrick Gold | No | No | Canadian, but significant management in London (ex-Randgold, incl. CEO and CFO) |
| BHP | No | Yes | Melbourne based but significant London office |
| Centamin | Yes | Yes | Jersey head office |
| Central Asia Metals | Yes | Yes | London head office |
| Endeavour Mining | Yes | Yes | London head office |
| Ferrexpo | No | Yes | Swiss HO but London-listed and UK directors |
| Fresnillo | No | Yes | Mexico City HO but London-listed and UK directors (including SID) |
| Glencore | No | Yes | Swiss head office but big London presence |
| Hochschild Mining | No | Yes | Peru HO but London-listed and UK directors |
| Hydro (Norsk Hydro) | No | No | Norwegian but London presence |
| KAZ Minerals | Yes | No | Now private but formerly London-listed, CEO and CFO still London-based |
| Kenmare Resources | No | Yes | Irish HO but London-listed and UK directors |
| Rio Tinto | Yes | Yes | London head office |
| Vedanta Resources | No | No | Private, Indian company but big London presence including senior executives |
| Yellowcake | Yes | Yes | London head office |

According to M Garside at Statista (https://www.statista.com/contact/) "At £102.9 billion, Glencore was by far the largest mining company based in the UK in terms of revenue in 2021 (although this is inflated by Glencore's trading activities. This was approximately three times more than BHP, the company with the second largest revenue among UK mining companies. The British-Swiss multinational company Glencore operates in more than 50 countries worldwide and generated nearly one-third of its revenue in Europe in 2020."

According to Tim Biggs, a mining expert, formerly with Deloitte: "Of the top seven global mining companies, three of them have their primary listing in London, and then one each in Australia, China, Brazil and the United States. Looking at corporate headquarters, that

becomes two in London, and one each in Australia, China, Brazil, Switzerland and the United States. Of those seven, four have significant management capability based out of London. It is reasonable to assert that the UK is a dominant hub for the top end of the mining industry."

Mining engineers feature at all levels of management of such global mining companies, including their boards. UK mining engineering graduates recruited for work abroad become effective full-time foreign ambassadors for the adoption of UK engineering methods, technology and societal standards that are increasingly becoming high-profile concerns. In contributing to the success of the UK companies such as Anglo American and Rio Tinto, UK mining engineering graduates also contribute to UK corporate tax revenues.

Biggs concluded that "As home to the world's largest diversified mining houses, London has been the default location for industry-shaping discussion in historic periods of transformation. It is positioned for leadership".

London is also home to national and international industry associations, some of which are listed below.

Women in Mining (UK) is based in London, drawing many members from mine finance and law but also with strong technical representation. Through its partnerships with leading mining companies and other industry participants, WIM UK provides thought leadership, analysis and research on the business case for diversity, inclusion and the economic advancement of women in the sector. (https://www.womeninmining.org.uk/)

The International Council on Mining and Metals (ICMM) is headquartered in London. This is a CEO-led organisation of large mining companies promoting good industry practice. Its membership comprises about one third of global miners.

ICMM describes itself as "a unique industry body. We are not a lobby group or trade association, but a global leadership organisation for sustainable development. We judge our success by our contribution to creating a safe, just and sustainable world through responsibly produced metals and minerals." (https://www.icmm.com)

The Institute of Materials, Minerals and Mining (IOM3) provides professional support to a wide range of professions related to materials, minerals and mining. IOM3 describes itself as "Supporting you to be a hero of a resource efficient society – IOM3 member benefits include access to knowledge and information, career support, professional qualifications, training events, grants, achievement awards, access to networking groups and a free member magazine". (https://www.iom3.org/)

## 6. UK mining engineering/mineral processing graduate employment

While employment in various capacities in operating mines is the mainstream employment for graduate mining and mineral processing engineers, these engineers are also employed in supporting sectors, as shown in Table 2 along with an assessment of the placement statistics or graduate engineers made by the UKMEF.

In a report produced by Piran Mining Research for the Camborne School of Mines Trust (CSM Trust) in 2015, Paul Burton calculated that there was an annual demand from market-economy countries for 1,300 mining engineers and 500 mineral processing engineers. Burton noted that while global universities could likely meet the demand for mining engineers, the universities could not meet the demand for mineral processing engineers. As the mining industry is forced to exploit different and potentially more complex orebodies, it is anticipated that mineral processing will become ever more important (the current lithium prospects being looked at in Cornwall provide a good example of this).

**Table 2: The employment of mining engineers and mineral processors with UK degrees**

| The Sectors | Status | Assessed UK mining engineering (ME) and mineral processing (MP) graduate placement statistics. Average per year for 15 years commencing 2026 (teaching commencing 2023) |
|---|---|---|
| **The international mining industry**<br>**(Many companies with a UK base.)** | Examples include<br>• Taking Glencore as one example of a UK-based mining company, according to Statista [18]<br>"The £103 billion British-Swiss multinational company Glencore operates in more than 50 countries worldwide and generated nearly one-third of its revenue in Europe in 2020."<br>• Anglo American is a multinational mining company headquarters in London and is the world's largest platinum producer. It also mines copper, nickel, iron ore and diamonds.<br>• Rio Tinto is a London-based mining company that operates primarily in North America and Australia. It | |

[18] https://www.statista.com/statistics/447478/top-mining-companies-in-the-uk-by-turnover/

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|---|---|---|
| | primarily produces copper, iron ore, bauxite, diamonds and uranium.<br>• BHP Group, based in London, is the largest mining company in the UK (in terms of market capitalisation) and the third most valuable company in terms of revenue.<br>• For other examples, see Table 1<br>• In Northern Ireland, Dalradian Gold's high-grade Curraghinalt project contains one of the world's largest unmined gold deposits. It also contains copper and silver. Currently in the planning phase, the operation has the potential to create a new mining industry for Northern Ireland. | 20ME 10MP |
| **The UK home mining industry**<br>The British mining industry is growing in size and diversity | Examples include<br>• Anglo American's major Woodsmith polyhalite mining project in Yorkshire, – with US$1.1 billion already invested. Currently employs 16 qualified mining engineers in its operations. Typically recruits two engineers per year. (https://www.angloamerican.com/products/polyhalite)<br>• Scotgold's gold mine at Cononish in Scotland (with RSM graduate on the Board). (https://www.scotgoldresources.com/)<br>• Tungsten West's operation in Devon (which has graduates from CSM and RSM in senior positions) is the world's second largest tungsten reserve. (https://www.tungstenwest.com/)<br>• ICL Boulby, a polyhalite and rock salt mine, produces about 1 Mt/y of polyhalite for fertiliser, supplying the UK and over 50 countries around the world. Employs about 500 people, with operations approved by authorities until 2048. (https://www.icl-uk.uk/)<br>• The Duntanlich barite mine will be capable of supplying all the UK demand for barite (barium sulphate) and employs about 30 people. Currently under development but will come into production within the next few years. (https://duntanlich.com/) | |

| | | |
|---|---|---|
| | • British Gypsum operates five underground mines providing over 1.5 Mt/y of gypsum for the manufacture of plaster and plasterboard products and as an essential ingredient in the manufacture of cement. (https://www.british-gypsum.com)<br>• Cornish Lithium is an innovative, eco-technology company focused on mineral exploration and development for the environmentally sustainable extraction of lithium. The company has secured agreements with the owners of mineral rights over a large area of the county and is using modern technology to re-evaluate the region for lithium and other technology metals which are essential components of modern life. (https://cornishlithium.com/)<br>• Cornish Metals is reopening the South Crofty mine at Poole, near Redruth. South Crofty has one of the highest-grade tin mineral resources in the world that are not currently in production. The mine has the potential to be amongst the lowest cost producers globally. Having previously operated until 1998, there is significant mining infrastructure still in place, most notably several mine shafts that can be used for future production and ventilation purposes, and the operation is located within an industrial area with access to the national electricity grid as well as existing transport infrastructure. Cornish Metals is raising £40.5 million with a strategic investment of £25 million by Vision Blue Resources (led by Sir Mick Davies) and £15.5 million private placements. Tin is a key strategic metal for the energy transition and demand is exceeding supply. (https://www.cornishmetals.com/)<br>• Cornish Tin plans to mine the The Great Wheal Vor group of 26 former producing tin and copper mines in the mining district of Breage, Cornwall, for lithium, tungsten and geothermal energy in addition to the tin and copper. (https://www.cornishtin.uk/)<br>• EnergyBuild (the Aberpergwm mine) is a producer of specialist carbon products. The mine produces high-grade anthracite, which has wide domestic and industrial use throughout the world due to its unique | |

| | | |
|---|---|---|
| | characteristics – high carbon content and calorific value for specialist uses. Aberpergwm is the only producer of high-grade anthracite in Western Europe. (https://www.energybuild.co.uk/cases/carbon–'electrodes/)<br>• Fluorsid British Fluorspar Ltd established its presence in Derbyshire in 2012 at Cavendish Mill within the Peak District National Park, with the objective of becoming a leading industrial mineral miner that supplies good quality acid grade fluorspar to the fluorochemical industry. (https://fluorsid.com/who-we-are/where/derbyshire-uk/) | 10ME 5MP |
| **Related natural resource and high-risk engineering industries**<br>The content of a mining engineering degree also prepares graduates for employment in a number of other industries | • The Oil and Gas Industry (petroleum, production and drilling engineers)<br>• Civil Engineering (tunnel and cutting creation and management))<br>• Rail infrastructure (tunnels and cutting management, engineering project management)<br>• Geothermal (shallow, including water in legacy mines, and deep boreholes)<br>• Carbon capture and storage (geo-engineering project management)<br>• Underground energy storage (tunnelling and boreholes) | 5ME |

| | | |
|---|---|---|
| **UK HSE and Mines Inspectorate**<br><br>"The UK currently has approximately 118 working sites including 21 licenced underground coal mines employing around 3,950 personnel.<br><br>"Mines can be hazardous environments and the possibility of fire, flood, explosion and collapse has the potential to simultaneously affect a large number of people. Continued work between HSE and stakeholders is aimed at controlling these risks" | UK Mines Inspectorate<br><br>• Mines Inspectors (Mine Managers, Electrical Engineers and Mechanical Engineers)<br>• Support staff with mining degree and experience | *2ME |
| **The UK's mining equipment, technology and services (METS) Sector** (with services ranging from contracting of operations to design, technical consultancy and project management) | According to Deloitte,[19] "The Department for International Trade (DIT) has been mandated to redouble its efforts to promote UK firms abroad. There is increased awareness of the METS industry, with some 90 mining-specific support firms in Cornwall alone (www.cornwallminingalliance.org) and more than 5,000 companies tracked by the DIT through the UK's mining supply chain. The DIT will look to support the establishment of new businesses." | 3ME 1MP |
| **Provision of technical/operations expertise to other sectors** | Finance Sector<br>Legal Sector<br>Insurance Sector | 5ME |

[19] (https://www2.deloitte.com/uk/en/pages/energy-and-resources/articles/london-global-hub-for-mining-finance.html)

| | | |
|---|---|---|
| **Education** | Teaching British and foreign students:<br>• The University of Exeter (Camborne School of Mines); Mining Engineering, Mineral Processing, Mining Geoscience<br>• Robert Gordon University; Drilling Engineering<br>• The University of Manchester; Geoscience<br>• Other courses that include aspects of mining include those at Newcastle, London Imperial and Cardiff | 1ME 1MP |
| **Research** | Pursuing topics of significance to the existing and developing industry:<br>• University of Exeter (Camborne School of Mines)<br>• University of Manchester<br>• Robert Gordon University<br>• University of St Andrews<br>• University of Durham | 2ME 1MP |

**Total Cross-Sector Graduate Recruitment**

a. 48 mining engineering graduates are required per year of which 28 are UK based (15 of whom will be recruited by MAUK) the remainder being employed in the UK or abroad based abroad.
b. 18 mineral processing graduates per year of which 8 are UK based and 10 based abroad.

* UK HSE and Mines Inspectorate will recruit experienced Mining Engineers as Inspectors, ultimately creating a gap in established mining operations to be filled with graduates.

## 7. Proposed actions

### 7.1 UKMEF outcomes – immediate and future

UKMEF is seeking representation (directly or by association) of all mining tertiary education stakeholders. The Forum will be managed by a Board comprising mining company CEOs and a member of the senior management of each participating university or college. This Board will provide direct connection between the industry and the

educational institutions, aided by a Council that will manage the recommended actions. The process is divided into four key steps. Steps 1 and 2 are implemented by the current group", with Steps 3 and 4 being implemented by the properly constituted Board and Council (supported by a secretariat).

Step 1 is to construct a Board and Council for the Forum who are ideally placed to operate the 'UKMEF system', or an alternative effective approach, drawing in the first instance on the already identified stakeholders, shown in the Table in Annex 1.

Step 2 recognises and acknowledges broadly the challenges associated with the provision of modern mining engineering and mineral processing tertiary education, and envisages a route to their solution. The route to solution will involve making the 'UKMEF system', or an alternative, comprising the industry, government, regulatory authorities, institutions and academia work by managing the perceptions and commitments of all, including seemingly peripheral but still influential bodies. Figure 3 is a draft organogram for this system.

The timelines for the system actions and deliverables will be largely governed by course starting dates and related student recruitment processes, and these are controlled by the course providers.

Step 3, under the direction of the Board and Council, is to complete the UKMEF system by converting the neutral or negative stakeholders to be positive and committed so that the system can potentially deliver its required outcomes, with the top priority at this time being student recruitment to mining degrees suitable for the current issues facing society.

The support sought from stakeholders for all schemes could include:

i. Assistance with the design and delivery of the course content for the current industry requirements and beyond.

ii. The University of Exeter's full engagement as currently the lead university for mining and mineral processing degrees.

iii. A similar allocation of academic responsibility will be made for other university input.

iv. A 'stamp of approval', and agreed support, from IOM3 and RAEng.

v. Scholarship support from the Mining Institute of Scotland and the Camborne School of Mines Trust funds – other funds to be contacted.

vi. Assistance with student recruitment from the various sectors of the industry, based on the provision of scholarships and the promotion of the degrees as entry to a strategically important, exciting and well-paid industry.

vii. The UK companies and international majors based in the UK will offer scholarships, student placements and jobs.

viii. All relevant accrediting authorities will recognise the academic awards.

ix. Whilst the MPQC, the Institute of Quarrying and the CBI Minerals Group have a bias towards quarrying they do form a part of the 'Minerals' Sector' and should be consulted regarding the education on offer. The Forum should certainly learn from their lobbying capability.

Step 4 is the biggest of all, namely student recruitment. Given success with all of the previous steps, the UKMEF system must be made to work so that the objectives (i.e., modern Vision and Mission Statements) are achieved, underpinned by confidence that the UKMEF process captures the need for the developing content of mining engineering and mineral processing degrees fit for current issues, considers and guarantees the provision of that content, and addresses student recruitment – UK and foreign.

The recruitment process can be stimulated as follows:

Sharing of existing mining educational material; followed by review and refinement to produce relevant quality material that is then posted across websites to improve access and visibility, along with the generation of leaflets and booklets that can be distributed at events and sites such as mining museums.

Encouraging mining education officers to deliver more material on modern mining benefits and opportunities through providing material and support, including personnel to participate in events (eg, school careers fairs and presentations) and site visits.

Provision of material for the media, politicians and interested groups, including the mining museums.

In order to deliver these steps (1-4), the UKMEF will have prepared and have accepted by all stakeholders a definitive modern Mission and Vision for the UK's mining related education provision (including underground and surface working) for the home and international mining sectors, and a related Mission and Vision for its own activities.

By engaging with education providers, tertiary study schemes will be recognised or proposed that will prepare graduates for employment in the mining/mineral extraction and other industries that are concerned with the subsurface and are firmly grounded in recognised engineering and other necessary fundamentals.

The study schemes will also address the emerging challenges that will be felt by the industry due to advances in digital technology, modern ESG responsibilities and climate change challenges.

Given the multi-disciplinary nature of the mining industry and the multiple entry and exit points required, it is possible that several linked schemes ranging from apprenticeships through undergraduate to postgraduate courses will evolve. The current competence roadmap for career-related competences for progression from

graduate to mine manager is shown in Figure 2 and this is the backbone of MAUK/CSM apprentice degree which is a very significant start to the re-generation of mining tertiary education in the UK.

It should also be noted that in order for mining-related education to contribute to the statutory standing of the graduate and courses must be accredited by the Mining Qualifications Council.

### 7.2 Progress with study schemes so far

University of Exeter's Camborne School of Mines (https://emps.exeter.ac.uk/csm/) is developing a blended learning course at degree level in mining engineering, to replace their “paused” full time degree. It is a four-year course to qualify students for progression to managerial positions, and the idea has been welcomed by industry.

For English students this will take the form of a degree apprenticeship, utilising the English levy scheme to provide a Level 6 education in mine management, with 80% of time spent in industry and 20% in the classroom. Qualification would entail a portfolio of work being assessed and delivered with industry participation. The Institute for Apprenticeships and Technical Education has accepted this concept. Students in the home nations will do the same course but it won’t be an apprenticeship funded through the apprenticeship levy due to ESFA rules.

The consultation group is led by Andrew Fulton (ICL) with Neil Battison (HSE), Stuart Hoult (MRS Training) & Pat Foster (CSM). The specification for this, which includes the duties, knowledge, skills and behaviours along with the end-point assessment, has been approved in principle by the Institute for Apprenticeships and Technical Education and is awaiting Ministerial sign off. The proposed course start date will be 2023. MAUK and CSM are to be congratulated on this initiative, which is a worked example of what can be done when senior industry personnel (in this case Andrew Fulton, CEO of ICL Boulby and President of MAUK) recognises the need for, and support, a new venture, and it is essential that this type of partnership is repeated.

While the mining engineering (and mineral processing) degree qualifications offered will be 'owned' by Camborne School of Mines, delivery of specialisations that are not part of the University of Exeter's portfolio of expertise could be delivered by partnering with other UK universities. For example, Robert Gordon University (https://www.rgu.ac.uk) would consider providing a drilling engineering module related to geothermal, heat retrieval from abandoned mines, CCS and the storage of gas and hydrogen.

The University of Manchester could provide input through its Centre for Masters Training in Energy Transition. The Mining Institute of Scotland has supported geoscience teaching and research at the University of St Andrews and it could be approached if necessary. Furthermore, the experience gained by the University of Derby in working with the Institute of Quarrying will be valuable.

The study schemes should have meaningful specialisation options and study methods that suit the known challenges and emerging challenges related to ESG and climate change. The development of the content for these new topics will be driven in part by industry emerging practice (eg, Anglo American's FutureSmart™ Mining and the World Bank's Climate-Smart Mining Initiative) (https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action). Figure 2 shows the competence roadmap underpinning a mining engineer's career progression, and the new course's content, while retaining this approach, must somehow be adjusted to include the most modern ESG skills.

CSM is proposing at degree level a minimum of mining engineering and mineral processing degree study schemes managed by CSM at the University of Exeter which could have much of the content required for the current and future issues facing the sector. The learning/degree package would demonstrate to the international mining industry that the importance of the modern industry is recognised and well served by graduate engineers educated in the UK. Other mining-related degrees and qualifications could follow.

### 7.3 Conclusions

Mining engineering qualifications were originally created some 100 years ago to address and manage safety and productivity, and since then British mining engineers and mineral processors have made significant contributions to economic and societal developments in the UK and worldwide. Original professional challenges met by engineers in the industry have been added to by concerns about climate change, the exploitation of the planet, the ethics of high ESG standards and, most recently, the impact of geopolitical instability.

UKMEF's proposed education schemes would equip UK mining engineers and mineral processors with the required skills, so that wherever they work in the mining industry, in the UK or abroad, they are equipped to evolve into leaders in their profession.

As well as being required directly by the UK industry, graduates employed abroad will become embedded advocates for UK professional engineering standards and methods in their host countries, continuing what has long been a UK tradition. Furthermore, through the success of their employer's mining ventures, they will contribute directly to the global component of the UK's economy.

Quoting Deloitte, "As home to the world's largest diversified mining houses, London has been the default location for industry-shaping discussion in historic periods of transformation. London is positioned for leadership." [20]

The UK Mining Education Forum (UKMEF) has estimated that at least 48 mining engineering and 18 mineral processing graduates are required per year to sustain the UK mining industry. Analysis of mining and mineral processing engineers currently registered with the Engineering Council through the Institute of Materials, Minerals and Mining (IOM3) shows that there is a significant and growing shortage of these engineers, and that this will threaten the future of the UK mining industry with its crucial domestic presence and international reach. and the transition from fossil fuels. Of the 1,237 mining and mineral processing engineers registered with the Engineering Council, 80% are over the age of 50, with 39% over the age of 66. This is an untenable position if a truly UK centric mining industry with global presence is to continue to contribute to the UK's wellbeing and economy.

The need for provision, development and diversification of UK mining expertise creates a demand for continuing UK mining related tertiary education. This is a demand with a legacy that all existing and potential stakeholders can surely relate to and appreciate. The current and future strategic need for mining engineering and mineral processing education from apprenticeship up to postgraduate degree level must be recognised by all stakeholders and serviced.

The key role of the UK Mining Education Forum is to bring together all stakeholders to co-ordinate the activities that will achieve greater impact with regard to the education offered and student recruitment than that possible by working independently.

[20] (https://www2.deloitte.com/uk/en/pages/energy-and-resources/articles/london-global-hub-for-mining-finance.html)

## Table 3: Acronyms and Abbreviations

| | |
|---|---|
| ABMEC | Association of British Mining Equipment Companies |
| BAML | Bank of America Merrill Lynch |
| BEIS | Department for Business, Energy and Industrial Strategy |
| BGS | British Geological Survey |
| BHP | Broken Hill Proprietary |
| bn | Billion |
| BSc | Bachelor of Science |
| CBI | Confederation of British Industry |
| CBIMG | Confederation of British Industry Minerals Group |
| CCS | Carbon Capture and Storage |
| CEng | Chartered Engineer |
| CEO | Chief Executive Officer |
| CFO | Chief Financial Officer |
| CMA | Competition and Markets Authority |
| CMTET | Centre for Masters Training in Energy Transition |
| CRU | CRU International Ltd |
| CSM | Camborne School of Mines |
| CSMA | Camborne School of Mines Association |
| CSMT | Camborne School of Mines Trust |
| CSR | Corporate Social Responsibility |
| DEES | Dept of Earth and Environmental Sciences |
| DfE | Department for Education |
| DIT | Department for International Trade |
| EITI | Extractive Industry Transparency Initiative |
| EMEA | Europe, the Middle East and Africa |
| ERACS | Electrical Research Association Computer Software |
| ESFA | Education and Skills Funding Agency |
| ESG | Environmental and Social Governance |
| EU | Exeter University |
| GBP | British pound sterling |
| Geol Soc | Geological Society of London |
| GVA | Gross Value Added |
| HO | Head Office |
| HQ | Headquarters |
| HSE | Health and Safety Executive |
| ICL | Israel Chemicals Ltd |
| ICMM | International Council on Mining and Metals |
| IEng | Incorporated Engineer |
| ILM | Institute of Leadership and Management |

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|---|---|
| IMechE | Institution of Mechanical Engineers |
| IOM3 | Institute of Materials, Minerals and Mining |
| IQ | Institute of Quarrying |
| KSB | Knowledge Skills Behaviour |
| LSE | London Stock Exchange |
| MAUK | Mining Association of the United Kingdom |
| MEP | Multicultural Engineering Programme |
| MESB | Minerals Education and Skills Board |
| METS | Mining Equipment, Technology and Services |
| MIMinE | Midland Institute of Mining Engineers |
| MIST | Mining Institute of Scotland Trust |
| MPA | Mineral Products Association |
| MPQC | Mineral Products Qualifications Council |
| MQB | Mines Qualification Board |
| MSc | Master of Science |
| MU | University of Manchester |
| OPEC | Organisation of the Petroleum Exporting Countries |
| PhD | Doctor of Philosophy |
| PM | Project Management |
| PwC | PricewaterhouseCoopers |
| QCF | Qualifications and Credit Framework |
| QS | Quacquarelli Symonds |
| RAEng | Royal Academy of Engineering |
| RGUDS | Robert Gordon University Drilling School |
| RSM | Royal School of Mines |
| SID | Senior Independent Director |
| UENR | University of Environment and Natural Resources (in Ghana) |
| UK | United Kingdom |
| UKMEF | United Kingdom Mining Education Forum |
| WCM | World Class Manufacturing |

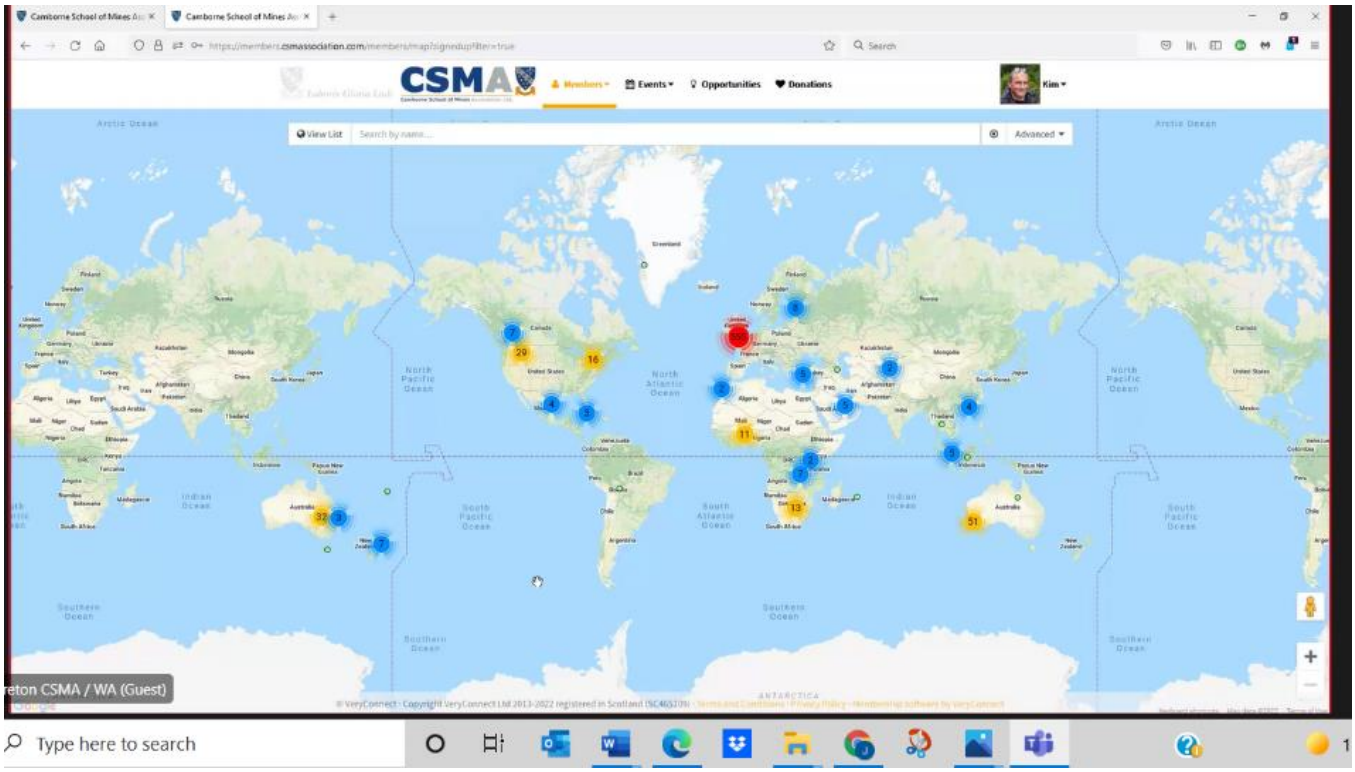


Figure 1: The global distribution of active Camborne School of Mines alumni

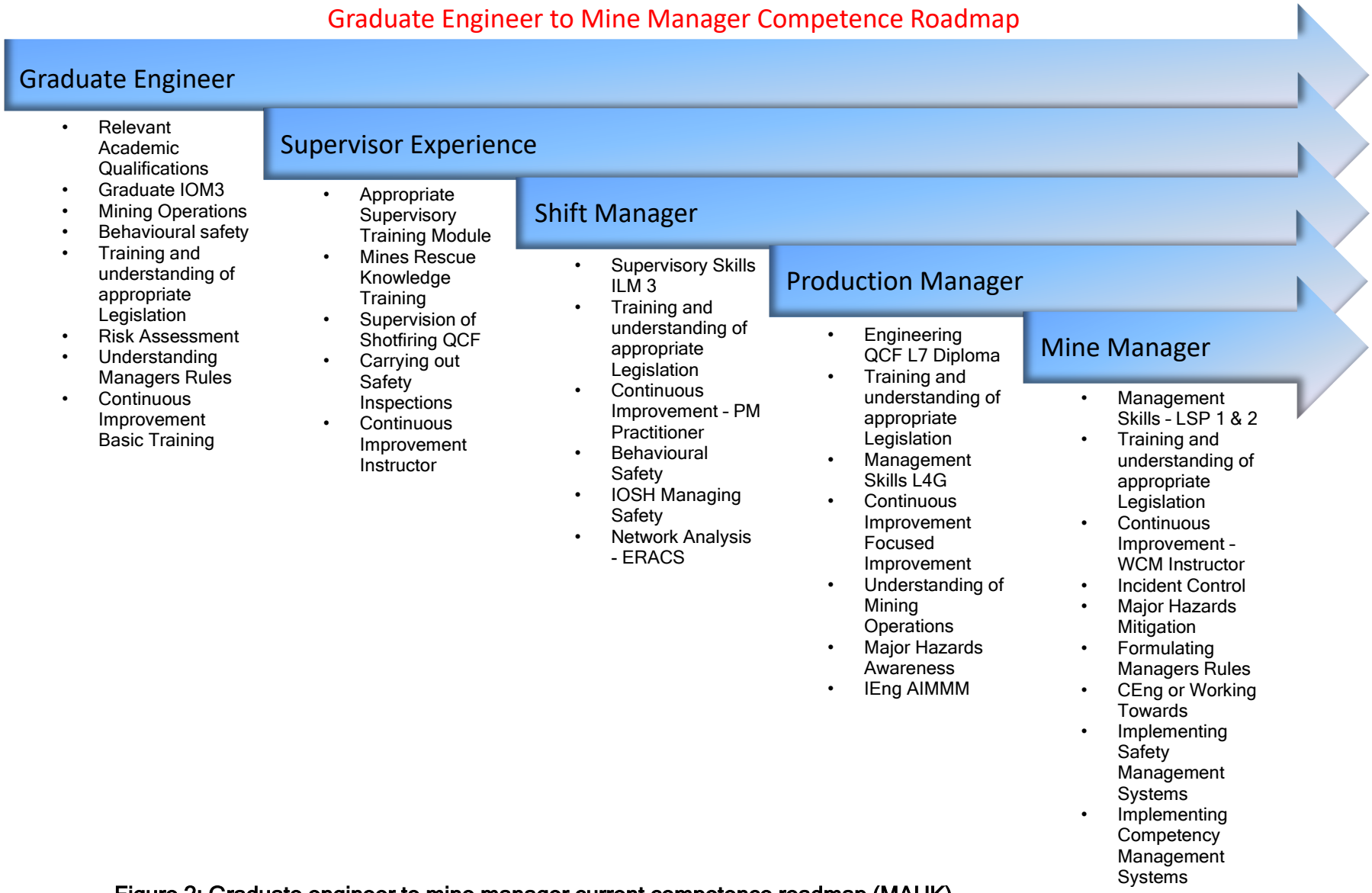


**Figure 2: Graduate engineer to mine manager current competence roadmap (MAUK)**

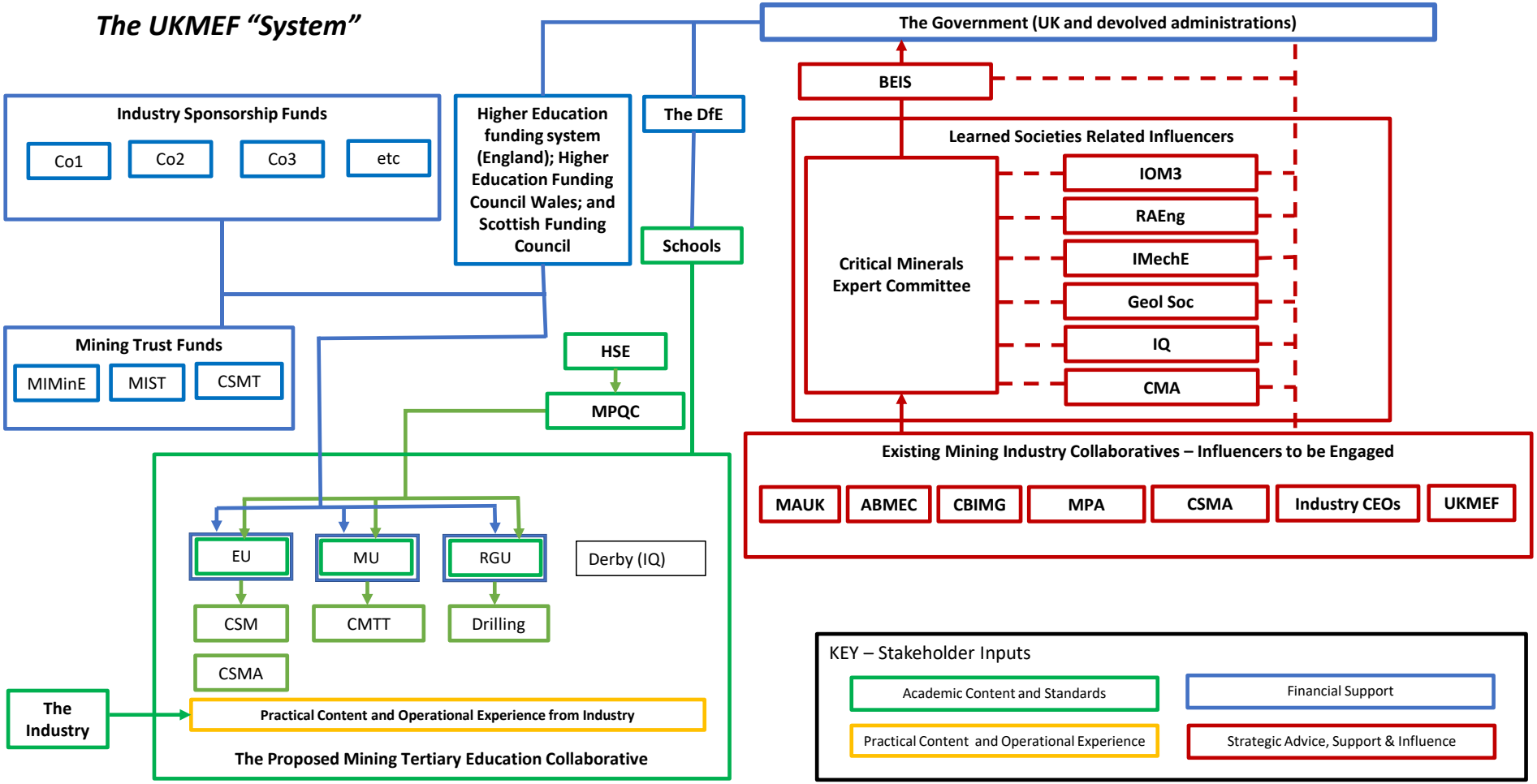


Figure 3: The UKMEF system for engaging all mining engineering and mineral processing education stakeholders

# UKMEF

ANNEX 1. Current and possible UK Mining Education targeted stakeholders

| Sector | Affiliation |
|---|---|
| The International Mining Industry | All mining companies, represented by CEOs from 3 to 5 of the majors on a UKMEF Board |
| The UK Home Mining Industry | *CEOs from UK Mine Operators<br>*Mining Association of the UK (MAUK) President<br>Chair of the Mineral Products Qualifications Council |
| UK HSE and Mines Inspectorate | HM's Chief Inspector of Mines<br>MRS Training & Rescue (formerly Mines Rescue Service) |
| In the UK's mining equipment, technology and services (METS) sector | *ABMEC (formerly The Association of British Mining Equipment Companies) |
| As a technical/operations expert in the UK mining industry | Wardell Armstrong International<br>*IOM3's Mining Technology Group |
| Universities – undergraduate (and postgraduate) degrees | *The University of Exeter – Mining Engineering, Mineral Processing,<br>*The University of Manchester –' Geosciences<br>*Robert Gordon University – Drilling engineering<br>(The University of Derby – Quarrying)<br>Note 1: University Senior Management must be engaged<br>Note 2: The universities of Durham and St Andrews also teach relevant subjects |
| Degree industry and Regulator accreditation | The Mineral Products Qualifications Council<br>The Mines Qualification Board |
| Researchers | *The University of Exeter<br>*The University of Manchester<br>*Robert Gordon University |
| Industry Institutions and Associations | *The Mining Association of the UK |

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|---|---|
| **Learned Societies** | *The Institute of Materials, Minerals and Mining<br>*The Royal Academy of Engineering<br>*The Institute of Quarrying<br>The Institution of Mechanical Engineers |
| **Trust Funds** | *Camborne School of Mines Trust and Alumni Association<br>*Mining Institute of Scotland Trust<br>*The Midland Institute of Mining Engineers |
| **The Government** | The Department for Business, Energy and Industrial Strategy<br>The Department of International Trade<br>University Funding governing bodies |
| **UK Related Industry** | The Minerals Products Association<br>The CBI Minerals Group |
| **Lobbyists** | To be confirmed |

**(* Members of these organisations are members of the UKMEF)**

## ANNEX 2 Members of UKMEF

| NAME | ORGANISATION | POSITION |
|---|---|---|
| Jane Isaacs | ABMEC | Trade Association (TA) representing British mining supply chain – supporting & facilitating this forum |
| Carol Marson | ABMEC | As above |
| Paul Freeman | ABMEC | President of ABMEC, mining engineer |
| Pete Bexton | British Gypsum | Compliance & Competence Manager for mines. |
| Jim Davies | British Gypsum | Chief mining engineer British Gypsum and member of Mining Association UK (MAUK) |
| Kevin Sabin | Brownlee Cale | Mining Engineer & President of ABMEC |
| Nick Clarke | Central Asia Metals Ltd | CEO mining company |
| Jonathan Redfern | Centre for Masters Training (CMT) | Professor of geology & science, University of Manchester, co-leading energy transition, mainly geothermal, also mining |
| Bernard Vining | Centre for Masters Training (CMT) | Professor at Royal Holloway |
| Chris Harker | Cornish Lithium | Head of exploration. |
| Lucy Crane | Cornish Lithium | Also involved with the Critical Minerals Association and Women in Mining |
| Jeremy Wrathall | Cornish Lithium Ltd | CEO |
| Owen Mihalop | Cornish Metals | Chief Operating Officer |
| Richard Williams | Cornish Metals | CEO |
| Reza Sanaee | COWI UK Ltd | Principal Engineer |
| Frances Wall | CSM | Professor of applied minerology, UK government advisor, CSM Trust, science advisory committee, rare metals & a governor at Truro College |
| Pat Foster | CSM | Director of Education. |
| Steven Hesslebo | CSM | Professor of geology, Head of CSM since August 2021, employed at CSM for 10 years |
| Tim Biggs | CSM | Advisor to mining companies and part time professor at CSM |
| Declan Vogt | CSM | Lecturer |
| Tony Batchelor | CSM Trust | Chair of CSM Trust, Mining Engineer, head of a Geomechanics Consultancy |
| Carol Richards | CSMA | Secretary of Trust |
| Kim Moreton | CSMA | Mineral surveyor, Wardell Armstrong, Bristol. Part time lecturer at CSM. Chair of CSMA (independent alumina with 1,100 members), RSCIS standards board, providing accreditation. lack of skills in UK – planning regime. |
| Roman Webber | Deloitte | UK Mining & Metals Sector Leader |
| Murilo Silva | Deloitte | Associated Director – Energy, Resources & Industrials |
| David Holtam | Deloitte | Partner |
| John Coggan | Exeter University | Professor |
| Tim Henderson | Glencore | Technical Direcgtor |
| Vince Fowler | HSE | Principal HSE Regulation Directorate - Energy Division ED2. HM Inspector of Electrical Engineering in Mines |

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|---|---|---|
| Neil Battison | HSE | HSE Regulation Directorate - Energy Division. HM Principal Inspector of Electrical Engineering in Mines |
| Julie Hogan | ICL Boulby | |
| Andrew Fulton | ICL Boulby | General Manager, President of MAUK (Mining Association UK) board of MPQC. |
| Ian Bowbrick | IOM3 | Director of professional standards at IOM3 |
| Diane Aston | IOM3 | Head of educational development. |
| David Joseph | Korn Ferry | Mining and metals executive search sector lead. |
| Darron Dixon-Hardy | Leeds University | Senior Lecturer |
| Angela Platt-Higgins | Liverpool University | Lecturer |
| Steve Bedford | Mining Institute of Scotland (MIS) Trust | MIS Trust board member, IOM3 Energy Transition Group board member & Well Engineering Authority with the British Standards Institute. |
| Brian Smart | MIS Trust | Consultant mining engineer, MIS Trust Board member |
| David Seath | MIS Trust Chairman | MIS secretary, IOM3 executive board member, MTD & chair of MIS Trust |
| Andrew Dobrzanski | NEIMME | Geologist, business & research engagement in material science with Cambridge University, secretary of NEIMME |
| David Manning | Newcastle University | Professor & geologist. Former President of Geological Society in London, CSMA trustee |
| Chris Hinde | Pick & Pen Ltd | Mining engineer & retired journalist, representing the media |
| Iain Steel | Robert Gordon University (RGU) | Head of Engineering |
| Sarah Hillyear | Robert Gordon University (RGU) | Business development |
| Christine Blackmore | Wardell Armstrong | IOM3 VP & MTD Chairman |
| Darryn Quayle | Worley | Leads Worley's mining sector in Europe & Central Asia, formerly a UK Government mining engineer |