

Raw Materials Research and Innovation to achieve the European Green Deal

A Position Paper of the ETP SMR

Foreword

With its inclusion into the Horizon 2020 research programme, raw materials supply – for the very first time – became a societal challenge in EU policy making, 2 years after the EU raw materials initiative submission and development of the Strategic Implementation Plan for its fulfilment. This political agenda paradigm shift was primarily caused by the need to overcome Europe’s raw materials supply distortions, already apparent in 2006 when the German Magazine DER SPIEGEL reported in a special issue: The New Cold War – The Battle about the Raw Materials¹. In line with Horizon 2020 many member states’ R&I programmes adopted this agenda. In the same spirit, further funding of raw materials R&I originated from concerted actions by a number of member states ([ERA-MIN](#)). In addition, other EU grants, such as CLIENT and [INTERREG](#), focused on improving framework conditions to mature the ground for better R&I results exploitation, target oriented policy making and raising the public awareness of raw materials in order to foster the valorisation of European domestic mineral wealth.

During this period, the principle aims were to stop deindustrialisation, raise resource efficiency and regain lost expertise, especially in the processing and downstream sector, as a prerequisite for new mining in Europe and to acquire more raw materials expertise ‘Made in Europe’ needed to regain lost ground. Today, the EU27 face far more fundamental challenges at a global level impacting the European raw materials supply than 12 years ago: the COVID19 pandemic, strategic competition, inner European conflicts and EU sanctions, rising emerging economies and the ascent of new strategic collaboration patterns, such as BRIC/S or the Shanghai Cooperation Organisation. The European Union committed to a fundamental change towards a new growth strategy, the [GREEN DEAL](#), that considers climate change and environmental degradation as an existential threat to Europe and the world. In the same way Raw Materials disappeared in the successor to the Horizon 2020 programme, Horizon Europe, and is now hidden behind ‘Industry and Digitization’. With these new challenges in mind, there is need to successively build up the Horizon Europe work programme. The need for a European Critical Raw Materials Act proposed by the EC might help address this issue.

Need for Research & Innovation (R&I)

It is common knowledge that the energy and mobility transition as well as digitization – as the main resource related drivers today – require substantial amounts of raw materials (RM). Furthermore, emerging technologies, in which Europe wishes to be a technology leader, will target new raw materials in the future; to achieve this, mining development based on new research findings will have to start immediately. Considering the above aspects of the foreword it is also known that R&I will be always needed, it is fundamental in a technical society, sustaining and promoting participation in the global competition for technological leadership. One of the core tasks of the ETP SMR is to pinpoint the research priorities for the raw materials sector, and as such it has maintained and updated a Strategic Research & Innovation Agenda (SRIA) since 2006 that has proved valuable in providing input towards EU research programming – now it is time for the latest update. Thus, we consider, among others, the following topics

of the raw materials sector for assigning distinct R&I actions that will be elaborated in the next update of the ETP SMR SRIA:

- Decarbonisation of industry, transport and traffic, housing, including CCS
- Implementation of energy transition in production, storage + distribution of renewable energies
- Introduction of new energy systems as a heat source in energy intensive systems (processing, refining, smelting) and utilizing waste heat
- Raising resource and energy efficiency, specifically in those operations that process critical raw materials (CRM) with high energy consumption
- New materials for emerging technologies and their procurement, production and recycling
- Updating the knowledge base to attract the major exploration and mining companies to Europe
- Total RM needs and comparing them to the evolution of mines and eco-settings at production sites
- Identify CRM which constitute the limiting factors for the production of the quantities of products as required by foreseeable demands (e.g. new generations of energy storage systems) and forecasting under various scenario assumptions
- Substitutability in terms of technology development trends that determine for a longer period of time the supply of specific CRM

Additionally, accompanying coordination and support actions (CSA) are needed to improve the framework conditions, in order to:

- Strengthen the mineral resource R&I sector from its existing small, fragmented base.
- Maintaining and strengthening current initiatives such as ERA-MIN, connecting them with similar research funding initiatives from partner regions such as Australia, Canada, and the US, giving access to a stronger, broader, more mature R&I community, while expanding the possibilities for strengthening strategic CRM connections with such partners.
- Inclusion of R&I calls in Horizon Europe addressing entities from countries with which the EU has strategic partnerships on raw materials, in conjunction with coordination and support actions in order to optimize the framework conditions for a raw materials partnership of mutual benefit.
- Encouraging Member States to boost national funding for complementary research to the sector and to connect to the ERA-MIN network.
- Building on current and future R&I funding initiatives, adding value for industry and research partners to raise the technical readiness level and to enhance market uptake of research results and gained intellectual property.
- Consider provision of financial instruments to aid uptake/implementation of R&I results to industry to further strengthen Europe's industrial competitiveness.
- Encourage territorial mapping through a European Geological Service and National Geological Surveys to strengthen EU-level partnership on building a pan-European geoscience knowledge and expert base that can update foundational data to support European mineral resource R&I and to better attract suitable mining investors.
- Stimulating vertical integration of EU manufacturing companies (OEM) into upstream supply chains (backward integration).
- In addition, R&I funding should also be applied to analysis of the impact of other EU and Member State policies and legislation on supporting, or inhibiting, development of the European exploration and mining sector. In parallel, and on the basis of this research and analysis, the EU should encourage Member States, who have not already done so, to develop their own Minerals

Strategies, in line with EU policy, and including R&I funding initiatives to contribute to building a strong EU-wide mineral raw materials research base.

- Ensuring by steady R&I that the EU and member states funding programmes complement each other (as exemplarily carried out for the [SRIA in Circular Economy by the EU CICERONE project](#)).

In order to raise the effectiveness and efficiency of these actions it is necessary to:

- Reduce financial risks in exploration and mine development, aiming at stimulating economic unlocking of domestic mineral resources, especially with a focus on the upstream
- Improve the EU's current poor standing relative to strong mining jurisdictions in regard to investment in R&I and pre-competitive data, and other forms of risk reduction
- Encourage member states to set up minerals cadastres as part of their investor approach and to safeguard valuable exploitable historic data on past and present exploration and mining
- Enable researchers, policy makers and any other interested stakeholders to gain overviews of the state of the art of research and of the state of the art of knowledge with the possibilities to search along certain criteria, such as materials, product groups, CRM markets and their characteristics (e.g. Herfindahl index, price volatility, key players etc.). In this respect, the installation of a [Critical Minerals Intelligence Centre](#) by the British Geological Survey, and similar initiatives in France and Germany, can be seen as an exemplary model for a similar initiative at European Union level, which is being investigated by the Horizon Europe funded project "A Geological Service for Europe" (GSEU - Grant Agreement nr 101075609). The GSEU project aims to set up an EU International Centre of Excellence on Sustainable Resource Management in support of UNRMS and promoting UNFC classification, which can become a tool for harmonizing information on RM projects and for resource management.
- The facilitation of relevant business opportunities and the attraction of private investment, the development of the necessary skills for high-quality jobs, especially in the emerging sectors of new clean technologies.

Why do we need more raw materials?

Minerals and metals are fundamental to almost every aspect of modern society. The most important driver increasing raw materials consumption is increasing global prosperity. Our previous consumption of raw materials was generated primarily by the needs of the western world and those of the industrially aspiring emerging technical societies in the Far East. These include far less than half of the inhabitants of the earth. However, the right to prosperity cannot be denied to other peoples, many of whom do not yet have the basis for a social turnaround in terms of consumption and resource consumption. Their focus is entirely on initial requirements and the satisfaction of elementary needs, which are resource-intensive. Who will deny them that?

For Europe – more pressing – raw materials are key components to achieve the targets of the [GREEN DEAL](#) and to hold and reach technological leadership in key industry sectors, even more raw materials will be needed if the fight against climate change is conducted in the same way by all countries. According to the [International Energy Agency](#) the world will need six times more minerals and metals in 2040 compared with today only to achieve the ambition of net-zero emissions. Recycling, reuse and circular methods are essential, but will still be insufficient to meet market demand². The ambitions of [RepowerEU](#), to make Europe independent from Russian fossil fuels well before 2030, has once more highlighted the urgency of security of access to raw materials. In this regard, Europe is highly import-dependent and there is a need to increase supply security and decrease dependence on unreliable suppliers and geopolitical risks. This applies not only to CRM, but also for many other metals and mineral resources including aggregates required for the green transition. For instance, by 2050, European demand for aluminium and copper will reach 130-135% of today's consumption levels for manufacturing of electric vehicles, electricity networks, batteries, wind turbines, and solar panels³. Energy-saving uses in buildings will also drive demand. Mineral inputs will at the same time account for an increasingly important part of the value of key components, making their overall costs more vulnerable to potential mineral price swings.

Europe holds great potential for boosting domestic supply

The European bedrock holds significant quantities of the minerals and metals needed for the most challenging transitions in EU history: the energy and mobility transition as well as digitization at present put most pressure onto the supply scheme. The minerals and metals industry therefore plays a crucial role in Europe's ability to decrease its vulnerability to supply risks and achieve the twin transition, both, by increasing mine production and reducing carbon footprint. To do this, new technical methods for how new deposits are identified, investigated, and extracted need to be developed and faster permitting and easier access to finance need to be secured. Technically, we need a better understanding of the formation of different deposit types, to stimulate, guide and cheapen exploration, and to advance production technologies for minor metals produced as by-products from refining (metallurgy) in an economically and environmentally sustainable way. By striving for greater resource efficiency and circularity, the EU can reduce its dependence on imports of critical and strategic minerals and metals. Resource-efficient mining requires using as much as possible of the minerals and metals extracted from the ground. It also means maximizing recycling from material previously regarded as waste. In terms of ESG, European mines should also be regarded as front runners not only in regard to EU taxation but also as attractive workplaces, with the highest environmental performance, based on fossil free energies, fully utilising the potential of digitalization and automation to create safe and secure workplaces. In conclusion, these actions will ultimately raise Europe's industrial competitiveness. The minerals- and metals industry is ready to take on the mission to deliver sustainable supply of raw materials. However, to undertake such a challenge several factors need to be in place – not least access to research funding in association with the right socio-economic framework conditions as listed above.

How can R&I investment help solve Europe's key mineral raw materials challenges?

Foster basic research The degradation of the European RM research and knowledge base – especially in terms of basic research - has led to a decline in geoscience student numbers (which in turn has resulted in reducing budgets for essential field and lab skills and a significant number of geoscience department closures), fewer research and academic positions at universities, less diverse and up-to-date university level education, and a brain-drain to more dynamic, well-funded research environments abroad. The resultant low level of response to recent Horizon Europe calls related to mineral resources is one result of this degradation. In this regard, the [EIT Raw Materials](#) provides a collaborative environment by connecting business with academia, research, and investments but their funding focus is on near innovation projects. If the European mineral research ecosystem is not building on a firm foundation of basic research and with equal focus along the entire value chain, the innovation system will be hampered and more focused around the parts of the value chain where the European industry is already fairly strong and competitive. No part can be left behind if we are to build a robust raw materials ecosystem. The ERA-MIN research programme, which aligns the national EU research programmes and includes strategic international partners, helps cover some of the basic research needs through smaller and more specialised projects, while also providing a good platform for skills development and student participation across the sector. ERA-MIN has proven its success by securing co-funding from its member countries and the EU across two framework programmes (FP7 and Horizon 2020) but it now faces an uncertain future as its third phase is coming to an end, with the phasing out of ERA-Net programmes under Horizon Europe. A solution needs to be found to ensure that such an important programme continues. It must be ensured that the ERA-MIN calls are strictly complementary to those of Horizon Europe in order to achieve maximum synergy effects.

Stimulate collaborative research Europe is still at the forefront with regard to mining technology. Not least in the endeavour to achieve zero-emission mine and processing operations. Close collaboration between European mines with global leading technology providers has led to world leading technology

for mining operations. However, greater, more systemic innovations require collaboration across different types of organizations (e.g., machinery producers, suppliers, sensor technologies, biotechnological process developers, software companies, research institutes and universities). Such alliances / partnerships will be encouraged by funding from the public sectors. Additionally, co-funding by industry partners might provide opportunities to (a) deliver additional European R&I funding into mineral resources and (b) strengthen public private partnerships, as has been highly successful in, e.g., Australia. Provision of financial instruments to aid uptake/implementation of R&I results to industry can further strengthen Europe's industrial competitiveness.

Encouraging junior mining companies for R&I Compared to other mining jurisdictions, European exploration investment is low and Europe fails to attract the mining companies to invest in exploration and related research in Europe. European junior exploration companies are S(M)Es and do not have the possibility to obtain research funding as their activities are financed by risk capital and most operate with limited cash flow. Almost no juniors have income from active mines. More than this – due to their negative balance sheet – many junior companies do not fulfil the financial reliability criteria to be funded. In terms of future R&I investment this would require a change of the mission rules of the future European R&I programmes. Furthermore, most exploration activities focused on CRMs are conducted by junior companies. Funding possibilities that enable research actions related to ore geology, exploration and extraction of CRMs and their relation to carrier metals are vital for Europe to build up a pipeline of exploration targets. Innovative technologies to explore and reopen old mines in a sustainable and acceptable way can further increase Europe's ability to secure important mineral resources, cf ROBOMINERS (Horizon 2020, grant agreement n°820971). Conversely, contributions by junior mining companies should also be made possible. As happened, for example, in the Horizon 2020 project "FAME - Flexible And Mobile Economic processing technologies", grant agreement number 641650.

Raise EU downstream industry's competitiveness The EU has dramatically lost refining and smelting capacities and associated expertise. Furthermore, the digital and green transition requires a diversity of metals that Europe has not previously extracted, processed, or refined. Europe's knowledge base of domestic mineral resources to methods of extracting them must be increased. And with regard to the particularly energy-intensive processing steps economically viable processes need to be researched and quickly implemented. Investment in R&I further along the value chain is a must. Lithium provides a good example: China holds only a 15% share in extraction but more than 85% of processing and refining. Many of these operations are energy intensive and Chinese production is still based on fossil energies. As such, more R&I in economically viable decarbonized processing and refining can support Europe not only to regain expertise but also to raise EU downstream industry's competitiveness in the long term towards a neo-ecological approach that more closely coincides with potential customer demands

Elaborating and setting of standards A modern, environmentally friendly and economically viable RM industry is based on the highest standards. It will contribute to neo-ecology, a megatrend that will shape the twenty-first century like no other: environmental awareness has been transformed from an individual lifestyle to a social movement. Sustainability from the consumption trend to the economic factor. R&I investment will help the EU to set more global standards and improve the implementation of environmental, social and governance (ESG) standards. Involving the research community is vital to ensure that current EU-legislation is based on verified research findings, not the subject of an ideologically driven discourse.

Achieve synergies by international research collaboration We also need to strengthen research partnerships with other resource rich countries. While the EU has, wisely, invested in and should continue

to invest in such forward-thinking initiatives as the EIP on Raw Materials, Europe is far behind those countries, such as Canada and Australia, with similar fundamental values but much stronger exploration and mining sectors in terms of investment in mineral raw materials R&I and the long-term strength and maturity of their mineral raw materials research sectors. Europe must look to other countries with existing strong exploration and mining jurisdictions to learn how to build and sustain this crucial base of data and expert knowledge. While difficult to assess the exact monetary contribution of public funding in Australia and Canada, as examples, to their minerals raw materials R&I, this certainly exceeds 200 million AUD and CAD respectively per annum and, based on the new initiatives related to Critical Minerals ([Australia's Critical Minerals Strategy](#), [Critical Minerals Office](#), Critical Minerals Facility, and Critical Minerals Accelerator Initiative, and Canada's Critical Minerals Strategy, including Critical Minerals Research, Development and Demonstration Program, and Net Zero Accelerator) has further extended this funding into the billions of dollars. Even ignoring recent initiatives, mineral raw materials investment in Australia, for example, has funded highly successful Cooperative Research Centres for decades to target key needs in developing the mineral raw materials sector and build a mature national research base. The "International geoscience collaboration to support critical mineral discovery" publication is another relevant example of international collaboration endorsed by the Federal governments of Australia, Canada, and the United States (<https://pubs.usgs.gov/fs/2020/3035/fs20203035.pdf>).

Mineral raw materials R&I investment in other relevant jurisdictions outside Europe

Several countries outside Europe have recently enacted critical minerals strategies combined with financial tools that also consider investments in R&I.

Canada has just closed the consultation phase of their critical raw materials strategy⁴. Their raw materials strategy is backed by nearly \$4 billion in 2022 and covers the entire value chain from exploration, mining, processing, manufacturing, to recycling. The federal government has communicated that they will build upon private sector investment to advance technological innovation and environmental performance in Canada's critical minerals sector and associated industries. Budget commitments from 2021 and 2022 cover different aspects of the value chain including \$79.2 million for public geoscience and exploration to better assess and identify mineral deposits, \$47.4 million for targeted critical mineral R&D through Canada's research labs and \$144.4 million for critical mineral research and development, and the deployment of technologies and materials to support critical mineral value chain. Canada aims also to promote climate actions and environmental performance by, for example, focus on reduction of greenhouse gas emissions through the deployment of clean technologies in the mining process. They will also enhance international collaboration with allies. In 2020 Canada and U.S. finalized a Joint Action Plan on Critical Minerals Collaboration including research and development cooperation, supply chain modelling and increased support for industry.

On June 14, 2021, Canada and the European Union announced a new strategic partnership around critical mineral supply chains. The EU member states would benefit if research collaboration and joint research actions could be part of this partnership. Existing instruments such as ERA-MIN could be used. Cooperation could also be facilitated through Horizon Europe, with Canada and the EU entering the final stage of negotiations over Horizon Europe association.

Australia's situation is somewhat similar to Canada's, seeking to maintain investment in exploration and mining, while promoting sustainable development practices. Both are vast countries, in which the federal states (or provinces/territories) play a strong role in funding, co-funding, and providing free data. Decades of public-research funding supported industry-academia partnerships via Cooperative Research Centres,

research partnerships, and dedicated industry research centres (e.g. [CSIRO](#)) have led to a mature mineral industry focussed R&I environment with a strong focus on new technologies to support under cover and deep exploration, and optimised mining. With the 2019 launching of a [Critical Minerals Strategy, Australia](#) has invested heavily in public research funding to support research, exploration, training, pilot plants, and financial support for key early to mid stage commercial projects. Australia is an example of a jurisdiction where strong, ongoing public funding for industry-academic collaboration at individual to institutional level over decades has generated a strong research environment with diverse opportunities for cross-collaboration and sharing of expertise.

The United States is a country with significant minerals endowments and a strong processing industry, however, the relative share of the mining industry is smaller than in Canada and Australia. The US has also a [critical minerals strategy](#) which identifies actions to reduce the US reliance on imports, preserve its leadership in technological innovation, support job creation, and improve national security and the balance of trade. As a result of a renewed strategy in 2019, the Department of Commerce published a report that addresses critical mineral and material supply chain challenges through calls to action and specific recommendations focused on research and development, industrial supply chain development, mapping improvements, permitting, and workforce development. The [U.S. Department of Energy](#) (DOE) plays a leadership role in the Federal Government's efforts in the area of critical minerals and materials, such as the [National Science and Technology Council](#) (NSTC), which convenes Federal science and technology leaders in committees, subcommittees, and working groups to establish national goals for policy and investment. The DOE's strategy supports domestic mineral and material supply chains, fosters scientific innovation and develops technologies that will ensure resilient and secure critical mineral and material supply chains. The DOE's goal is to build a long-term minerals and materials innovation ecosystem—fostering new capabilities to mitigate future critical mineral and material supply chain challenges and to increase the American critical minerals workforce. They will bolster education, promote interdisciplinary collaboration among materials and chemical science, computer science, and related disciplines to modernize the minerals supply sector industry. DOE presents a clear vision in their strategy - *The Department of Energy will be an essential source of science, technology, and engineering solutions for re-establishing U.S. competitiveness in critical mineral and material supply chains*. In August 2022 DOE sought public input (Request for Information) on a \$675 million Critical Materials Research Program⁴ to strengthen clean energy technology manufacturing in America. Funded by President Biden's Bipartisan Infrastructure Law, the program will address vulnerabilities in the domestic critical materials supply chain. In September 2022 the DOE announced up to \$156 million in funding from President Biden's Bipartisan Infrastructure Law for a first-of-a-kind facility to extract and separate rare earth minerals and critical minerals from unconventional sources, such as mine waste, into vital materials for clean energy technology. This funding opportunity aims to support American manufacturing jobs and help build a strong domestic supply chain for the next generation of clean energy technologies vital to reaching President Biden's goal of a net-zero emissions future⁶.

The [Critical Materials Institute](#), or CMI, one of the DOE's energy innovation hubs designed to accelerate the pace of energy technology development, was established in 2013 as a partnership between universities, national laboratories, and private industry to advance research priorities set by the first Critical Materials Strategy. CMI has achieved remarkable success in its short life. While it normally takes 20 years to develop a new material, it took CMI researchers only one year to create a replacement for europium used in high-efficiency lighting. CMI has also published hundreds of papers, issued several invention disclosures, and even begun licensing its technologies for commercial use⁷.

The Inflation Reduction Act (IRA) of 2022 contains several provisions that will boost U.S. domestic supply chains for CRMs. In the event that the IRA is implemented in its current form, a number of challenges would arise for the EU, to which the EC would have to find an answer. Under the *Advanced Manufacturing Production Credit*, mining companies producing CRMs will be eligible for a tax credit, an equivalent of ten percent of the production costs for each eligible component. IRA also makes updates to *the electric vehicle tax credit*. To be eligible for the full new vehicle \$7,500 tax credit, EV manufacturers, beginning in 2023, must either source a minimum of 40% of the battery materials from the US or free trade agreement partners, or recycle it in North America. This sourcing requirement is incrementally increased each year, reaching 80% by 2027. The IRA also allocates \$500 million for “enhanced use” of the Defense Production Act (DPA). The sponsors of the bill have indicated that this appropriation is intended in part to support President Biden's DPA action concerning critical minerals announced in the first quarter of 2022⁸, i.e., a way to help companies receive governmental funding aimed at increasing domestic mining and processing for CRMs needed for supplying the production of large-capacity batteries. IRA also commits an additional \$40 billion to the DOE’s Innovative Technology Loan Guarantee (Title XVII) program. This program seems to be an additional way to support projects that increase domestic supply of CRMs.

References:

- ¹ [The New Cold War: The Global Battle for Natural Resources - DER SPIEGEL](#)
- ² [The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA](#)
- ³ KU Leuven, 2022. Metals for Clean Energy: Pathways to solving Europe's raw materials challenge. <https://www.eurometaux.eu/media/jmxf2qm0/metals-for-clean-energy.pdf>
- ⁴ Canada’s critical minerals strategy: Discussion paper, opportunities from exploration to recycling: Powering the green and digital economy for Canada and the world 2022. <https://www.canada.ca/en/campaign/critical-minerals-in-canada/canada-critical-minerals-strategy-discussion-paper.html>
- ⁵ U.S. Department of Energy 2022. Biden-Harris Administration Launches \$675 Million Bipartisan Infrastructure Law Program to Expand Domestic Critical Materials Supply Chain. <https://www.energy.gov/articles/biden-harris-administration-launches-675-million-bipartisan-infrastructure-law-program>
- ⁶ U.S. Department of Energy 2022. [Biden-Harris Administration Announces \\$156 Million for America’s First-of-a-Kind Critical Minerals Refinery](#) <https://www.energy.gov/articles/biden-harris-administration-announces-156-million-americas-first-kind-critical-minerals>
- ⁷ International Raw Materials Observatory, 2016. Fostering International raw materials cooperation. Analyses of Research and Innovation, Operational report. [INTRAW WP1 Transactionalreport R-I final.pdf](#)
- ⁸ U.S. Department of Defence 2022. Defence Production Act Title III Presidential Determination for Critical Materials in Large-Capacity Batteries. <https://www.defense.gov/News/Releases/Release/Article/2989973/defense-production-act-title-iii-presidential-determination-for-critical-materials-in-large-capacity-batteries#:~:text=Immediate%20Release-Defense%20Production%20Act%20Title%20III%20Presidential%20Determination,Materials%20in%20Large%2DCapacity%20Batteries&text=On%20March%2031%2C%202022%2C%20the,base%20for%20large%2Dcapacity%20batteries.>