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CORDIS Results Pack on

mineral extraction

A thematic collection of innovative EU-funded research results

October 2020

Securing access to raw materials at minimum environmental and social costs

Research and Innovation

Contents

Editorial

State-of-the-art minerals extraction technologies developed by EU Horizon 2020-funded research and innovation projects will reinforce the competitiveness of the EU industry and reduce negative environmental and health and safety impacts and risks. Contributing towards meeting ambitious energy and climate targets, the projects featured in this CORDIS Results Pack will help to gain the trust of EU citizens in the mining sector.

Securing sustainable access to raw materials, such as metals and industrial minerals, is crucial to achieving the objectives of The European Green Deal. This is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use.

Sustainable use of raw materials, and especially critical raw materials (CRMs) of high importance to the EU economy, is one of the main requirements for this change to take place. The challenge for the extractive industry is to scale up promising innovative production technologies and to demonstrate that raw materials can be extracted sustainably at minimum environmental and social costs.

Reduced negative impacts

Crucial for Europe's current industries and innovative clean technologies, CRMs are indispensable for the development of low-carbon technologies such as batteries, wind turbines and solar energy.

The accomplishments of six Horizon 2020-funded projects, focusing on innovative mineral extraction technologies with improved economic, environmental and health and safety performance, underline the significance of raw materials and the performance of some of the strongest innovators in the extractive industry.

Spotlight on EU research

In this CORDIS Results Pack we focus on the innovative results developed by Horizon 2020-funded projects working on minerals extraction technologies for a sustainable supply of raw materials.

For example, bringing together the world's leading mining companies, universities and technology suppliers, SIMS delivered demonstrators for the electrification and automation of mining equipment, and communication and positioning in mining operations.

The project X- MINE facilitated the implementation of large-scale innovative pilot actions of sensing technologies, improving the efficiency and sustainability of mining operations.

ITERAMS developed solutions for complete isolation of mining process waters from adjacent water systems, and the Blue Nodules project developed new highly automated technologies for the sustainable harvesting and in situ processing of deep-sea polymetallic nodules.

SLIM developed cost-efficient low-impact mining solutions for exploitation based on advanced rock blasting and environmental technologies for minimum rock damage and far-field vibrations. Finally, IMPaCT developed an integrated modular plant and containerised tools for selective, low-impact mining of small high-grade deposits.

Robotics, automation and 5G go underground

EU-funded research has jump-started an Industrial Revolution in the mining industry with automation, all-electric vehicles and 5G connectivity. Outcomes will enhance miner safety, mining sustainability and efficiency, and public support for the sector that supplies the raw materials instrumental to our economy.

Our rocky planet is a treasure trove of valuable commodities, including minerals and metals used by sectors as varied as automotive, aerospace, chemicals, construction, electronics and renewable energy. The mining sector is the bridge between these raw materials and industry and is thus critical to the world's economy.

The EU is taking decisive action to reduce its dependence on imports of these materials and enhance supply chain security. Within this context, improved mine worker safety and reduced environmental impact of mining are key pillars. The EU-funded SIMS project brought together the world's leading mining companies, universities and technology suppliers to deliver intelligent mining systems that meet these important challenges.

Blazing a trail

A few years ago, the mining industry began formulating a technological roadmap of where the industry should be within 10 years. In response to the challenges, SIMS delivered a wealth of new technologies related to digitalisation, robotics and automation to promote safer mines, fewer atmospheric emissions, less land and water pollution, and higher efficiency. According to project coordinator Jan Gustafsson, of Epiroc: "SIMS is a pioneering project in the mining sector. Within 3 years, our team created multiple demonstrators of these envisioned technologies, proved them in real mining environments, and advanced them as industry standard technologies."

Towards an 'Industrial Revolution' in the mining industry

The third Industrial Revolution, also known as Industry 3.0 as more commonly applied to factories, witnessed the integration of electronics, telecommunications, computers and robotics into operations and processes. SIMS has created just such a movement in the mining sector with sustainable intelligent mining, focused on the automation of key operations such as driving, inspection, blasting and material handling. Numerous battery-powered machines were developed and verified in a real mining environment.

SIMS has demonstrated that the further digitalisation, automation and use of robots in the mining industry will contribute to enhanced safety, higher efficiency and less harm to the environment.

A new generation of battery-operated all-electric vehicles and the infrastructure for battery charging and handling were created to replace conventional diesel fleets. The vehicles are bustling about and the working environment for miners is substantially improved thanks to less diesel particulate matter, noise and vibration. A literally groundbreaking controlled seismic de-stress blasting method together with improved installation of rock bolt and mesh (rock reinforcement) increased installation efficiency by 64 % and significantly enhanced miner safety. Autonomous aerial inspection of mines and a vehicle-mounted real-time imaging system for crack detection were also successfully demonstrated.

Automation and robotic control in the underground isolation of a mine is no easy task. The team developed and tested a 5G-enabled industrial communication network to connect people, data, sensors and machines, including remote-controlled mining machines. Even ventilation can be controlled via the 5G network, based on sensors in the mine. Finally, the team created two virtual reality environments: one for personnel training, and another for raising public awareness and enhancing social acceptance.

Enhancing efficiency and creating safer, more sustainable mines

Gustafsson concludes: "SIMS has demonstrated that the further digitalisation, automation and use of robots in the mining industry will contribute to enhanced safety, higher efficiency and less harm to the environment." Moving the industry towards sustainable mining while unlocking the potential of mineral reserves and simultaneously creating ergonomic and safe workplaces should improve public acceptance and trust.

PROJECT
SIMS - Sustainable Intelligent Mining Systems

COORDINATED BY
Epiroc Rock Drills AB, Sweden

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/730302

PROJECT WEBSITE
simsmining.eu/

3D and X-ray vision for sustainable mining

A major fraction of minerals used in Europe come from outside the EU as imports. A multidisciplinary European consortium has advanced X-ray and 3D technologies to help European industry to better access mineral resources in Europe and decrease import dependency.

The European Union is facing the challenge of a high dependence on imports of raw materials which support sectors that have a combined value in excess of EUR 1 000 billion and provide employment for some 30 million people.

© Orexplore AB

There is a need for better exploration methods to discover mineral resources within the EU and to make ore extraction in existing mining operations more efficient. This would make the mining of smaller and complex deposits economically feasible while increasing access to European mineral resources in an environmentally friendly way.

The EU-funded X-MINE project set out to demonstrate cutting-edge sensing technologies using X-ray fluorescence (XRF), X-ray transmission (XRT) and 3D vision technologies. The team has developed the X-Analyser, a drill core scanner, and the X-AnalySorter, a mobile sorter, for demonstration at mines in Sweden, Greece, Bulgaria and Cyprus.

The main deliverable of the project is the X-MINE online analysis platform, which includes the drill core analyser, the mineral sorting system and the 3D ore deposit modelling, all combined with the data fusion platform.

Developing new technologies

Project partners developed several prototypes of 3D cameras, X-ray cameras and XRF spectrometers and tested them in pilot settings. They integrated their 3D vision and X-ray sensor technologies into a conventional mineral sorting technology and an X-ray drill core scanner. “The main deliverable of the project is the X-MINE online analysis platform, which includes the drill core analyser, the mineral sorting system and the 3D ore deposit modelling, all combined with the data fusion platform,” says project coordinator Janne Paaso.

X-MINE researchers developed fast single-photon counting, multi-energy XRT camera prototypes, a new XRF spectrometer and a new 3D camera platform for mineral exploration and extraction applications. The team has also improved the existing 3D tomographic drill core scanning technology Orexplore in many ways, including novel sensing technology, element and mineral analysis, and enhanced analysis software. They demonstrated the drill core scanner technology in mines in Greece and Sweden.

"The integration of the drill core scanning data in 3D geomodels is ongoing, and the first results are really interesting and promising," Paaso remarks.

Demonstrating X-AnalySorters

X-MINE developed two container-based mineral sorting systems they call X-AnalySorters. These were created based on conventional X-ray sensors with improved sorting algorithms. The team installed the first AnalySorter system at the Lovisagruvan mine in Sweden, testing it on many different use case scenarios.

"When applying this sorting model to sortable fractions, about 25-27 % of the mass will be removed as waste rock and about 95 - 98 % of ore minerals (zinc and lead) will be retained for further processing, making possible significant reduction in energy use and carbon dioxide emissions," Paaso notes.

What's next?

Project members developed their online analysis platform to be commercialised as products of companies such as Orexplore, Comex, Advacam. "The academic institution partners of the project will use the innovative results of the project in research and development cooperation with mining companies and other end users in the future," Paaso concludes.

PROJECT
X-MINE - Real-Time Mineral X-Ray Analysis for Efficient and Sustainable Mining

COORDINATED BY
VTT Technical Research Centre of Finland, Finland

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/730270

PROJECT WEBSITE
xmine.eu/

Reinventing the role of water and waste in mining

Mining operations use large amounts of water and land and produce tailings waste, taking a major toll on the environment. Researchers have developed technologies to help mining companies reduce their water consumption and extract value from their tailings waste.

Processed ore requires large amounts of water and is responsible for over 90 % of the mass of the waste stream produced. The unsustainable use of water must be reduced, in particular by circulating the water for reuse, along with decreasing the volume of mining tailings by extracting more value from the waste.

The EU-funded ITERAMS consortium set out to develop a proof of concept for more environmentally friendly and economic mining operations in Europe and the rest of the world. The project focused on making water recycling much more efficient and on making it possible to extract more value from tailings by turning these leftover materials into geopolymer cement for important uses such as backfilling and coating.

"This will bring cost savings and added income streams, especially for small mines," says project coordinator Päivi Kinnunen. "When the water is recycled and the mining waste is used as valuable products in geopolymers, the overall environmental footprint will be minimised and the mining industry's performance and image will be improved."

Analysing tailings in three countries

The ITERAMS researchers collected and analysed water and tailings samples from three mines in Finland, Portugal and South Africa. They chose these mines as they have varied seasonal and hydrogeological conditions, such as temperature and the availability or scarcity of fresh and treated water.

Team members conducted a data analysis on the water, modelled water systems, developed real-time and online measurements for mining water and improved water treatment methods. They used online analytics to detect low-grade feed material that can then be removed to improve the flotation performance of the material. ITERAMS developed different approaches for the production of geopolymers from the tailings samples.

Saving water and finding value in mining waste

Project partners developed different water treatment technologies, including ion exchange resins, polishing filtration, electrocoagulation and dissolved air flotation. They used mathematical modelling to find the best experimental approaches to create closed water loops.

When the water is recycled and the mining waste is used as valuable products in geopolymers, the overall environmental footprint will be minimised and the mining industry's performance and image will be improved.

The team developed online and continuous electrochemical sensors that can differentiate ions such as calcium, sulphate and thiosulphate ions to produce water-quality measurements. The researchers used microbiological analysis to show the importance of managing microorganisms in flotation plants.

"Sustainability and hot-spot assessments have confirmed that water use and closing water cycles are the main pressing issues in mining, which in turn reinforce the relevance of the ITERAMS project," Kinnunen explains. "One of the main aims of the project is to collect all information and develop a water-recycling protocol for the mine sites, and this protocol is currently under development."

The knowledge created from the project will be instrumental in helping mining companies become more economically sustainable and environmentally friendly in their operations.

PROJECT
ITERAMS – Integrated mineral technologies for more sustainable supply of raw materials

COORDINATED BY
VTT Technical Research Centre of Finland, Finland

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/730480

PROJECT WEBSITE
iterams.eu/

Deep-sea mining system for polymetallic nodules in the oceanic abyss

The deep seabed is a vast resource of raw materials, including critical raw materials (CRMs). Crucial for Europe's current industries and innovative technologies, CRMs are indispensable for the development of key technologies for the energy transition such as batteries, wind turbines and solar energy.

Polymetallic nodules found on the abyssal seabed of most ocean basins contain millions of tonnes of metals such as nickel, copper, cobalt and manganese as well as gallium and rare earth elements. Efficient deep-sea mining of these nodules requires a complete high-tech mining value chain but, to date, no integrated system of harvesting, vertical transport and surface processing has ever reached industrial viability. Simultaneously, it is vital to understand the biodiversity and the ecosystems of the deep-sea so that effective environmental impact assessment standards and regulation are put in place to respond adequately to future deep-sea mining and associated environmental challenges.

This ambitious initiative is a major step in the development and testing of environmentally friendly seafloor harvesting and processing technologies for polymetallic nodules.

Seafloor to shore

With EU funding, the Blue Nodules project has "designed the layout of the entire logistics chain while tackling the complex problem of environmental protection up to technology readiness level 6 (TRL 6)," outlines Laurens de Jonge, project coordinator. "This ambitious initiative is a major step in the development and testing of environmentally friendly seafloor harvesting and processing technologies for polymetallic nodules," he says.

At the centre of operations is the subsea harvesting vehicle Apollo II used for collection of the nodules in water depths up to 6 km. The seabed crawler is connected to the offshore production vessel with a jumper hose to the vertical transport system and an umbilical cable, containing the data connections and electrical power supply.

With in situ processing at the seabed, the nodules are separated from the sediments. On board the vessel, the nodules are dewatered and the deep sea water is returned to its origin. Another ship then takes the ore for processing on land, to extract the metals.

Minimal environmental impact

Using detailed computer simulations, the Blue Nodules team developed a nodule collection process in which disturbance of the seabed, which is essentially soft, sticky sediment, is reduced to a minimum. The model simulations for plume, noise and seafloor substrate alteration have been validated by lab experiments and field tests in 2018 and 2019.

Priority was given to minimising the mobilisation of seabed sediment and the dispersion of suspended sediment in plumes, caused by the vehicle movement, nodule extraction and return water from the surface operations.

For the future, the project researchers are working on reducing the kinetic energy of the plume released by the vehicle, which will in turn mean a smaller plume. They are also trying to remove hydraulic components to reduce the risk of contamination of the seafloor.

"Environmental standards in legislation only make sense if they can be incorporated in the design process, in the operation and can be consistently monitored," de Jonge emphasises. "By cooperation between science, industry and legislators during engineering and testing, Blue Nodules not only designed sustainable equipment but also developed a monitoring and sensor setup. This will measure, detect and objectively quantify the environmental impacts, like plume, noise and substrate alteration."

Deep-sea mining to become a reality

The successor of Blue Nodules is the Blue Harvesting project. With many of the original partners, Blue Harvesting will focus on developing and improving the collector to reduce environmental impact while maintaining production rate and efficiency. Integrated field tests and pilot mining tests in a relevant offshore environment will attain TRL 7.

Comprising 167 Member States and the European Union, the International Seabed Authority – ISA is mandated under the UN Convention on the Law of the Sea to organise, regulate and control all mineral-related activities in the international seabed area for the benefit of humankind as a whole. The ISA has issued regulations on exploration in international waters and is currently working on regulations for exploitation.

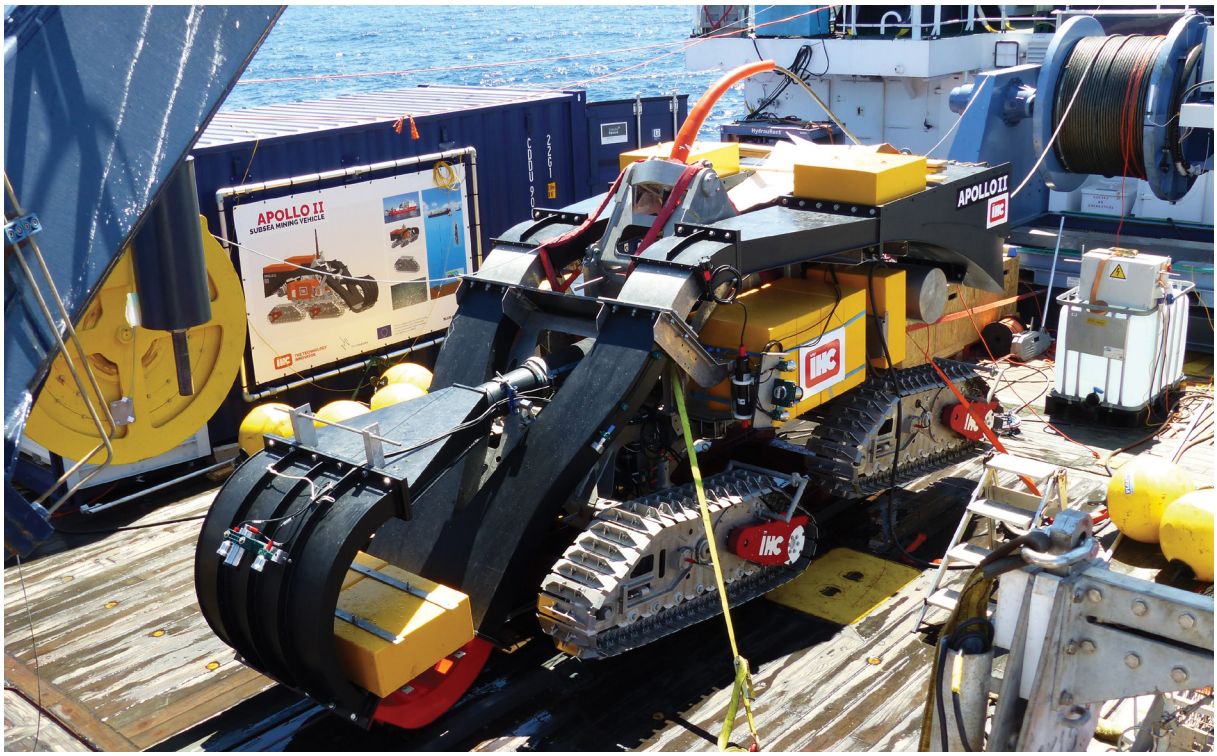
PROJECT
Blue Nodules - Breakthrough Solutions for the Sustainable Harvesting and Processing of Deep Sea Polymetallic Nodules

COORDINATED BY
IHC MINING BV, Netherlands

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/688975

PROJECT WEBSITE
blue-nodules.eu/



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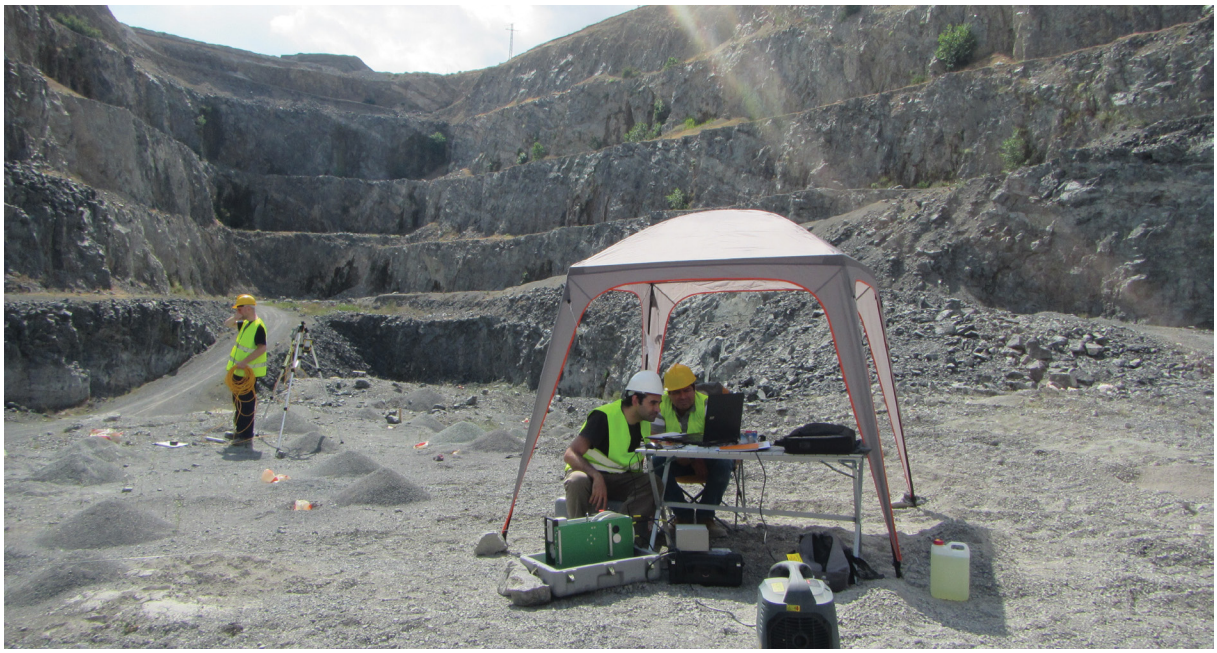
Explosive new development in small-scale mining

Researchers have developed software and technology to help small-scale mining operations conduct targeted rock blasting with minimal effort and impact on the environment.



© José A. Sanchidrian, UPM

There is currently no reliable solution to reduce the environmental impact of small-scale mines, especially considering that current mining technology relies on rock blasting and mobile mining equipment for loading and transportation.

Some of this equipment uses the expensive and difficult to install Measurement While Drilling (MWD) system, which is inefficient for small-scale mining operations.

The EU-funded SLIM project set out to develop cost-effective and more sustainable ways to blast and fragment rock using explosives in small-scale mining operations. Using advanced automatic blast design software, the SLIM project consortium focused on mitigating typical mining issues such as airborne particulate matter, vibrations and nitrate leaching.

"The SLIM approach consists of injecting state-of-the-art techniques into the mining operation by developing tools to control the excavation face, fine-tune the processing plant and reduce environmental effects, in order to improve feasibility and profitability of mines, and gain public acceptance and trust." says project coordinator José Sanchidrián.

A new generation of explosives

The SLIM team started by developing technologies capable of characterising explosives, identifying blasted rock fragments using artificial intelligence, and using systems that can predict the effect of certain explosives on specific rock types.

SLIM developed a new generation of explosives and smart-blast design software that can characterise rocks better than current systems and reduce the impact of rock blasting on the environment. This development is not only important for the European mining industry but for mining operations all over the world, to help them reduce economic cost and the environmental impact, such as groundwater contamination.

The team experimented with and developed models to simulate how explosives would perform in mining operations, to understand rock fragmentation, the velocities, and the damage caused. Such information has already given mining operations the data they need to better understand and improve their overall performance by being as efficient as possible with minimal environmental impacts.

MWD using LiDAR

SLIM developed and retrofitted a more cost-efficient Measuring While Drilling (MWD) system that uses the detailed analysis of photographs to predict the impact of explosives on target rock. In an effort to make mine planning smoother, the SLIM team created a system that uses light detection and ranging (LiDAR) to analyse rock damage and environmental impact after a blast, as opposed to the non-direct methods used currently.

The SLIM team also developed a software that mitigates negative impacts such as fly rock or vibrations, and characterises the result of a blast, or the 'muck hole'. "This software is important to improve the surface blasting work, as only reliable and correct assessments of blasting results improve mining operations," Sanchidrián says.

Real world data for further development

Minera de Órgiva, a SLIM partner from Spain, used improved rock excavation technologies and processing plant monitoring and control to nearly double its production at Sierra de Lújar mine. This enabled the profitable mining and processing of lower-yielding ore – from a cutoff grade of nearly 40 % fluorite to an expected cutoff of 20 % by the end of the project. The result is increasing reserves more than threefold and extending the working life of the mine by at least 50 years.

"The SLIM project partners have accumulated an exceptional amount of data from laboratory and field trials and this dataset has a fundamental value in facilitating future research and development in the fields of explosives technology, rock blasting, performance assessment, and mining automation," Sanchidrián concludes.

The SLIM approach consists of injecting state-of-the-art techniques into the mining operation by developing tools to control the excavation face, fine-tune the processing plant and reduce environmental effects, in order to improve feasibility and profitability of mines, and gain public acceptance and trust.

PROJECT
SLIM - Sustainable Low Impact Mining solution for exploitation of small mineral deposits based on advanced rock blasting and environmental technologies

COORDINATED BY
Polytechnic University of Madrid, Spain

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/730294

PROJECT WEBSITE
slim-project.eu/

Novel modular mining equipment supports sustainable and cost-effective mining in Europe

Earth is not running out of metallic and semi-metallic resources, but the largest, highest-grade, and shallowest deposits have been depleted. Enhancing the economic feasibility and adoption of lower-impact small-scale mining operations will address market needs and environmental protection while boosting competitiveness.

IMPaCT demonstrated that it is logistically possible to rapidly design, construct, deploy, refit, and redeploy modularised mining and processing equipment, powered by renewable or hybrid energy on existing mine sites. Importantly, the technology now exists to extensively apply best practices and responsibly access resources from more diverse types of ore deposits.

Global material extraction has risen more than 200 % since 1980 with important impact on the environment. The EU-funded IMPaCT project focused on a switch on-switch off (SOSO) mining paradigm similar to plug-and-play for electronics. It cost-effectively accesses ore deposits while facilitating an ethical relationship with the community and the environment.

Small-scale mining versus small deposits

Small-scale mining has the potential to operate on both small, high-grade deposits and on large deposits to minimise economic risk. Project coordinator Kathryn Moore of the University of Exeter, Camborne School of Mines explains: "We differentiate between mining of small deposits and small-scale mining. The term small-scale relates to the size and complexity of mining operations and their impacts. The concept of small-scale mining has multiple possible modern contexts: mining of small deposits, low-footprint and low-risk mining of large deposits, and artisanal mining."

Flexible tools for the mining industry

A small underground mining tool works with more surgical-like precision, extracting the desired rock while damaging less of what is left behind. Its cutting head controls particle size at the rock face, reducing the subsequent crushing required. Sorting technology separates the ore from the waste prior to crushing. A portable processing plant can accommodate various types of ore deposits. Finally, the infrastructure can be mobilised in standard 20-foot containers, decreasing the associated environmental impact of transport and deployment.

The SOSO business model decreases capital investment costs by renting adaptable total mining and processing solutions, savings that can be used for operating expenses. Tests at two sites in the Western Balkans showed that the time to install the equipment varied from a few days to only a few hours.

Reducing energy consumption is critical. Modelling showed that the IMPaCT system dramatically reduced energy consumption and that biomass or combined biomass-diesel energy provision

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in the Western Balkans is as reliable and more cost-effective than fossil fuels alone. A policy brief was prepared to address required policy and societal framings to promote modern best practice for mining expansion in Europe.

No time like the present

The mining industry is facing unprecedented challenges due to the Covid-19 pandemic. The dramatic decrease in metal prices from March to April 2020 has been compared to that of the financial crash of 2008-2009. Small deposit mining by small-scale operations could not have come at a better time. "IMPaCT demonstrated that it is logistically possible to rapidly design, construct, deploy, refit, and redeploy modularised mining and processing equipment, powered by renewable or hybrid energy on existing mine sites. Importantly, the technology now exists to extensively apply best practices and responsibly access resources from more diverse types of ore deposits," Moore concludes.

To help end users identify and locate small, high-grade complex deposits, the team has extended the European Minerals Knowledge Data Platform with a data/visualisation layer dedicated to small complex deposits. IMPaCT outcomes will help Europe rapidly initiate small-scale mining in response to high commodity prices or rapidly increased demand, and transfer operations to other locations with minimal environmental impact when economic viability for large-scale mining decreases.

PROJECT
IMPaCT - Integrated Modular Plant and Containerised Tools for Selective, Low-impact Mining of Small High-grade Deposits

COORDINATED BY
University of Exeter, United Kingdom

FUNDED UNDER
H2020

CORDIS FACTSHEET
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RESULTS PACK ON MINERAL EXPLORATION

This Results Pack focuses on the innovative results developed by six Horizon 2020-funded projects working on exploration technologies for a sustainable supply of raw materials.

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