



Open to the world

The European Union's Horizon programme for research and innovation

An exploration and mining technology workshop at the
PDAC convention in Toronto



EUROPEAN COMMISSION

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Executive summary

The European Union held a workshop on exploration and mining technology at the PDAC convention in Toronto. European Commission and government representatives highlighted the importance of international cooperation on raw materials, as key enablers for the green transition, of evidence-based decision-making, and of doing the right investments in the next few years. Horizon 2020 projects presented their key results, the benefits they can bring, and their experiences working with civil society to build trust in the extractive industry. They gave examples of new geophysical exploration techniques and field-augmented reality for geological models, improved approaches to managing water and safe tailings, innovations in zero waste mining and processing and piloting electrification and automation of mines. A panel on mineral exploration discussed how technology projects can engage civil society in the application of the technologies. Another panel on mining and mineral processing discussed approaches for using research and innovation in mining to build trust in the extractive industry.

One of the main issues highlighted in the panel discussions was the hurdle of a bad reputation gained by mining companies, resulting from their past performances. Technologies reducing the footprint of mining activities have great potential in improving this reputation, but technology optimism without considering the human element can backfire and again undermine trust in the sector. It is therefore important to recognise what can realistically be achieved by a given innovation, and carefully consider what a technology application means for the different people concerned. It is also important to consider how these innovations are communicated to the wider public. The academic and research world is well positioned to engage with youth, local communities and civil society, and is perceived as understanding and contributing to social responsibility. Mining and exploration companies, in contrast, risk being seen as self-serving, and therefore need to have greater focus on demonstrating the good practices that emerge from research and innovation in this sector.

Conveying the message that the mineral industry is an enabler for the green transition can attract young professionals, being increasingly value-driven. The cross-disciplinary character of projects in the Horizon programme can also attract people who have not previously been in contact with the industry.

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1. Introduction

With Europe striving to be the first climate-neutral continent by 2050, the transition towards a carbon neutral economy implies a rapid implementation of clean energy, efficient energy storage and clean mobility. This requires significant amounts of certain metals and minerals, which increased recycling alone cannot cover. How can innovation in metals and minerals exploration, mining and processing help the industry to meet the needs of this transition at minimum environmental and social costs, and how can research and innovation projects engage with civil society to co-design solutions for a responsible and trusted extractive industry that brings benefit to society and local communities?

In this technology workshop at the PDAC¹ convention in Toronto, some of the Horizon 2020 projects working on these issues presented their key results and experiences, including solutions relating to exploration, water and tailings management, automation, digitalisation and electrification of mines, and the importance of engaging the public in the process.

Representatives of the European Commission and the European Institute of Innovation and Technology's Knowledge and Innovation Community on Raw Materials presented the opportunities that the Horizon programme offers in terms of collaboration with leading research organisations across the world, including funding for organisations from developing countries, together contributing to building a knowledge base on raw material related issues.

Panel discussions centred on the role of research and innovation projects in engaging civil society in the application of new technologies, and in contributing to a responsible and trusted extractive industry.

The workshop was supported by the Partnership Instrument of the European Commission through the EU goes to PDAC project, seeing a collaboration between the Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW), the Executive Agency for Small and Medium-sized Enterprises (EASME), and the EIT RawMaterials.

2. Opening

Arnoldas Milukas, Head of the Unit Horizon 2020 environment and resources at EASME, opened the workshop welcoming the participants. He spoke about taking a pilot approach; for the first time, in Horizon 2020, the European Union dedicates a specific part of its research and innovation programme to raw materials. Between the Societal Challenges and EIT RawMaterials, the Horizon 2020 programme spends about one billion Euros on raw material research and innovation.

He further spoke about the importance given to international cooperation in Horizon 2020, in particular in the field of raw materials, with significant contributions from across the world, for example from South Africa, Chile, Australia and Japan, as well as other advanced mining nations. He hoped that



¹ Prospectors and Developers Association of Canada

participation from Canada, and from other advanced mining countries, would increase in Horizon Europe as discussions advance on extending the programme association to countries that are geographically distant from Europe.

A good example of international cooperation is the HiTech AlkCarb project, where industry and academia experts from around the world met to funnel-in leading practices and knowledge on geomodels and interpretation methodologies. Expertise gained in African exploration improves the chances of finding new “hi-tech” element deposits in Europe. The project also contributes to the Horizon 2020 outreach through a free online course on sustainable mining called “Technology Metals for a Green Future”.

Arnoldas concluded by highlighting the future importance of raw material research and innovation for the carbon-neutral economy, and its significant place in the upcoming Horizon Europe programme, before introducing Peter Handley, Acting Director of the Directorate for sustainable industry and mobility at DG Grow.

2.1. Raw materials for the climate-neutral economy

Peter Handley opened by introducing the legal act² to be published the following day, setting out 2050 as the target date for a carbon-neutral European Union, which means virtually eliminating greenhouse gas emissions, requiring a shift in the economy. At the start of the value chains that support our economy, are raw materials. Peter talked about the European Commission’s work to support this, in particular with its Joint



Research Centre, JRC. He highlighted the new list of Critical Raw Materials (CRM), soon to be published, as well as a report looking ahead to the 2030 and 2050 horizons. The European Commission sees the challenge of resource security as a combination of securing access to raw materials and ensuring that those raw materials are clean, sustainable and responsibly sourced, in order to be confident that customers will not shy away from products.

He also mentioned the work on sustainable, responsible and transparent battery supply chains, and the work with member state authorities and industry on a sustainable mining code for Europe. Further he spoke about the new industrial strategy to decarbonise, going digital, and keep jobs in Europe. He underlined the importance of research and innovation reaching the market, and gave examples on block chain technology to trace material, and making mining operations more sustainable through electrification and automation.

Peter closed by saying that “It is a time of change and with the long and capital-intensive investment cycles in the sector we need to make sure that we make the right investments in the next few years”.

² Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Climate Law)

2.2. Societal challenges: innovation, evidence-based decision making and public trust

Arnoldas Milukas introduced Dr Eibhlin Doyle, Chief Geologist heading the Exploration & Mining Technical Division of the Government of Ireland, for her talk on Societal Challenges: innovation, evidence-based decision-making and public trust.

Eibhlin started with an introduction to the Raw Materials Initiative (RMI), the raw material policy package forming part of the supporting competencies between the European Union and its member states, as decided in the EU Treaty of Lisbon. Research funding is an important tool to implement the RMI, with action areas identified in the Strategic Implementation Plan (SIP) set up by the European Innovation Partnership on Raw Materials, bringing together stakeholders in the sector. One of the main components of the Horizon 2020 has been to develop the knowledge base on raw materials, in order to facilitate evidence-based decision-making. The SIP also identifies social acceptance as a key area, and the European Commission has incorporated this in the Horizon 2020 work programmes. Eibhlin gave the example of the PACIFIC project, with Nicholas Arndt taking part in the first panel on mineral exploration and intelligence (section 2.1.1). Eibhlin recommended viewing the Raw Material Information System set up by the Joint Research Centre, as the main platform for the European knowledge base on raw materials.



Eibhlin concluded by encouraging participants to get involved in the Horizon 2020 programme, to join the research community, and contribute to evidence-based decision-making and social acceptance.

2.3. Introduction to EIT Raw Materials

Arnoldas Milukas introduced the next speaker, Jens Gutzmer, one of the directors of the Helmholtz Institute Freiberg for Resource Technology, and a board member of the EIT RawMaterials.

Jens started by saying that the European Union certainly has done something right in establishing the EIT RawMaterials, the world's largest partnership in raw materials research. Joining the partnership of some 370 partners in 23 different EU member states, organised in 12 hubs, is a good way of getting involved with some of the leaders in the field. The partnership has funded some 250 projects, working for example on sourcing of lithium, nickel and cobalt, clean steel, sustainable production of goods, or developing talent in the sector. He highlighted examples on projects working with recycling of batteries, removing asbestos fibres from steel that so far can only be dumped, improved design of products for repair, and certification schemes for responsible sourcing of critical raw materials.

Seven Master degrees are EIT-labelled in an initiative that includes students from different parts of the world, and which are expected to work internationally.

He emphasised that raw materials are key enablers for the green transition and will substitute fossil fuels in the long run, evidencing this with figures related to electric cars, photovoltaic and battery storage to show the immense potential increase in demand. This demand can be satisfied with recycling to a limited extent, making it necessary to secure new sustainable sources and supply chains for raw materials.

Jens rounded off with an invitation to the Raw Material Summit in Berlin, where the raw material community comes together to discuss issues related to raw materials.



2.4. Introduction of the moderators

Arnoldas Milukas introduced the moderators of the two panels on mineral exploration and intelligence and on mining and mineral processing. Anthony Hodge is professor at the Queen's University, Canada, and at the Sustainable Minerals Institute of the University of Queensland, Australia. He is the former CEO of the International Council on Mining & Metals, his career spanning the private sector, government, civil society organizations, communities, and Indigenous peoples, and has had several advisory roles, including for a Horizon 2020 project on international dialogues, STRADE.

Masuma Farooki is the Consulting Director at MineHuthe, and has been involved in Horizon 2020 projects. As development economist, she has over 10 years of experience working on commodity related issues for developing and advanced resource-rich countries, her focus is on measuring the socio-economic impact of the resource sector and developing frameworks for the implementation of responsible mining practices. Her work involves analysis of global value chains, industrial, trade and mineral policies, and the social licence to operate.

3. Mineral exploration and intelligence

3.1. Presentations

Anthony Hodge introduced the panellists:

- Nicholas Arndt, emeritus professor of petrology/geochemistry at the University Grenoble Alpes, president of Sisprobe, a small company that uses ambient-noise seismology in mineral exploration. He has held academic positions in the United States, Canada, Australia and Germany, has worked in the minerals industry, and has published several books on ore deposits and mineral resources.

- Fabian Stamm, from the institute for Computational Geoscience and Reservoir Engineering (CGRE) at the RWTH Aachen University, with a geological and technical background and also having studied the environmental, societal and economic aspects around mineral and energy resources exploration and production. He is co-founder of Terranigma Solutions, a spin-off from the University.
- Alireza Malehmir, Professor of Applied Geophysics at Uppsala University and vice chair of the Near Surface Geoscience Division of European Association of Geoscientists and Engineers (EAGE), also serving on the editorial boards of Geophysical Prospecting and Nature Scientific Reports.
- Frances Wall, Professor of Applied Mineralogy at Camborne School of Mines (CSM), University of Exeter, who specialises in technology raw materials, especially rare earth elements, with interests in geology, processing, responsible sourcing and circular economy. A former Head of CSM, Frances has been involved in many international research projects, including on social licence to operate, and is a Steering Group member of the Cornwall Mining Alliance. Frances was named one of the 100 Global Inspirational Women in Mining 2016 and awarded the William Smith medal of the Geological Society of London for applied and economic aspects of geology in 2019.

Anthony invited Nicholas Arndt, Fabian Stamm and Alireza Malehmir to introduce the findings of their Horizon 2020 projects to the audience. Frances Wall joined the panel discussion afterwards.



3.1.1. Passive seismics to reduce environmental impact and costs of mineral exploration – PACIFIC

Nicholas Arndt spoke about the PACIFIC project - passive seismic techniques for environmentally friendly and cost efficient mineral exploration. The project's emphasis is on passive seismic methods, but it also works on the social acceptance. He started with an example from the Rouez district in France, where in 2013 an exploration company obtained the first exploration permit in France in 20 years. Although the company had communicated with local communities, well-organised movements from the public stopped all exploration activities in the area.

Nicholas spoke about the need for metals in a low-carbon economy, and the need to explore deeper and cheaper. One approach is to use passive seismic techniques, as active seismic techniques are expensive. The project uses portable seismometers in dense surface arrays and ambient seismic noise, i.e. anything that sets the earth vibrating, to produce tomographic images of the subsurface. Nicholas showed some preliminary results from demonstration sites at the Marathon deposit in Ontario and the Kallak iron ore project in Sweden. The team works on improving the methods by extracting body waves, rather than surface waves, from the ambient noise signal, as this allows for greater resolution and enables the detection of reflections. It also combines surface arrays with downhole arrays in a multi-array method.

The social acceptance work, led by Aoife Braiden of the Geological Survey of Ireland, shows that many misunderstandings come from the way information is communicated.

Preliminary results from areas in Ireland with no mining activity show relatively positive views on mining; in these areas, the perceived positive impacts outweigh the negative. The group will now ask similar questions where mining is currently underway, and more results will be available by the end of the project in roughly one year.



3.1.2. Upscaling mineral exploration through field augmented reality – FARMIN

Fabian Stamm took the floor to speak about field augmented reality in the FARMIN project, an EIT upscaling project resulting from the recently ended Visual3d network created in 2017, with partners across Europe from mining industry, university, and research institutions. FARMIN involves four of those partners, RWTH Aachen University, Luleå Technical University (LTU), Boliden and DMT, and a number of external partners.

There is great potential for digitalisation along the raw material value chain. First in the chain comes geology, where we need a good understanding of the subsurface for mining to succeed. Common techniques for visualisation are neither efficient nor intuitive. The temporal and spatial difference between field and office activities gives rise to miscommunication and operational delays, ultimately leading to errors in



decision-making. FARMIN develops a software solution with which the geological expert will be able to visualise and interact in real-time in an immersive augmented reality environment with geological models, on any device. The vision is that in the future a geologist going in the field would be able to see a holographic projection of the geological model on site. The geologist would be able to update the model with new observations in real-time. There are potentially

great benefits in terms of improved decision-making, reduced environmental impact, and appealing ways of communicating, both between teams and in outreach to the wider public.

3.1.3. Deep mineral deposit targeting through new geophysical technologies - Smart Exploration

Alireza Malehmir spoke about the Smart Exploration project, deep mineral deposit targeting through new geophysical technologies, with 27 partners, of which 11 SMEs. Alireza said it is a good moment for their project as a lot of effort goes into decarbonisation, being dependent on minerals and metals, and Europe has good mineral potential. "Incentives for exploration could be better, but on the positive side, environmental legislation and standards are strong in the EU, and exploration expenditure is likely to increase".

The first year focused on legacy data, and the team demonstrated how legacy data holds great potential to discover new ore bodies. Alireza showed the examples of the Lombador ore deposit in the Neves-Corvo mine in Portugal, and from the Ludvika mines.



Smart Exploration also generated new data from six test sites in Kosovo, Fisoka and Gerolekas in Greece, Siilinjärvi in Finland, Neves-Corvo in Portugal and Ludvika mines in Sweden, using 2D and 3D active-source and passive seismics, with sensors in tunnels and on surface, SkyTEM surveying, ground-penetrating radar, magnetic, gravity, resistivity, induced polarisation and geochemical surveying. Field camps, schools and visitors attended most of these, peaking at 150 people from different schools at one time in Ludvika.

The second year focused on producing five prototype geophysical systems, including a GPS-time transmitter that allows to synchronise receivers, a broadband E-Vib seismic source, a deep penetrating Helicopterborne time-domain (HTEM) system, a Slimhole modular-based digital seismic-magnetic-temperature system, and a UAV electro-magnetic system, quite likely pioneering in the world.

Smart Exploration has already generated two patents, and produced more than 40 publications in open access, most of them peer-reviewed. 20 young professionals are involved in the work.

3.2. Panel discussion on what technology projects can do to engage civil society in the application of technologies

Anthony Hodge said he felt privileged to see the depth of thinking in these projects. At the same time, the world out there has a different sense of mining, and sometimes very negative. For this reason, he posed three questions to the panellists:

- Given these technological innovations – what goal do you see for engagement with the world out there, with communities, with non-scientific people, with the people that will not come to PDAC?
- What impediments restrict engagement with the public right now on these themes? So that people can understand what we are dealing with, and what is possible?
- What steps do we need to take to strengthen the relationship between technology developers and civil society?

Each panellist spoke for a few minutes, and then Anthony opened the floor for questions from the audience.

Frances Wall started by saying that we often talk of exploration in relation to mining, but there are other fields, like geothermal, that also require exploration to take place in order to know the subsurface. Frances and her collaborators have started to use the word geo-resources when speaking to people about the underground, because the different resources are very much related.

She mentioned two examples from her own experience. One is a story of failure in a natural laboratory in southern Germany used in the HiTech AlkCarb project. The project had no interest in mining, only in research, wanting to drill one hole of 3-400 metres. Expertise from Namibia, having high standards in public consultation, supported the interaction with the public. The team was well received by the local community, but local politicians would not give the necessary permits, as they were worried about negative impacts after problems with the drill holes of a nearby geothermal project, having caused the hydration of anhydrite to gypsum, with extensive damage to the centre of a historic town in the area. The example shows that once it goes wrong you cannot easily come back.

A success story on the other hand is from mineral and geothermal exploration in Cornwall, UK, where companies have taken care in speaking to the local communities right from the beginning. Good educational activities have helped the outreach to the wider public, young and children.



Alireza Malehmir started by saying that as a University they have a technical responsibility, but also a social responsibility. "Even though we are technology developers, we are part of society as well". Communication is often key and a bad reputation can be a big hurdle. "We have to drill for exploration, but we can overcome the hurdle of a bad reputation by explaining that we can now do things much better than in the past. We can say that we will be able to tell the public what is in the ground – and not knowing that is a bad thing". The Smart exploration project invites people from local communities to the test sites. "Coming from a university you are in general more trusted, so involving academia is useful".

Fabian Stamm mentioned that augmented reality could provide a good opportunity for new communication channels. It can provide opportunities for the wider public to interact and understand the work of exploration and mining, and give members of a community a positive experience related to the work. "Many approach technological progress with scepticism. It is up to us, as technology developers, to bring down barriers and build bridges".

Nicholas Arndt came back to his example from the Rouez district in France. In that case there were several reasons for the opposition to exploration. One was that mining companies had not performed well in the past. Another related to the public and local communities getting most of their information from online resources and social media, where negative opinions on mining are dominant. "If people are asked if they are positive about local sourcing of products, they would usually say yes, but if you ask the same question specifically for local mining of minerals and metals the answer will often be different".

Anthony Hodge noted that there is so much in the question asked. He took the example of mining and music – no orchestra would exist without metals. Frances agreed that making the connection to culture often works.

Alireza Malehmir added that mining is important to achieve the UN's Sustainable Development Goals. "If we can mine in Europe, it is our responsibility to do it, and not outsource the negative impacts of mining".

Anthony responded that the question of responsibility is central. On the other hand, if you see the examples of what damage has been caused by mining, it is very difficult to take a positive view of it, and that is where the disconnect can be.

Alireza said that technology could help. Mining today is not what it was 30-40 years ago – the footprint will not be the same. Nicholas Arndt mentioned that companies have made similar statements just before major disasters, and Anthony agreed that is exactly the issue that may create problems with trust.

Fabian Stamm agreed to Alireza's point that innovation has a huge potential to improve performance. He took the example of developments that allows dissolving gold without cyanide, which would be very good for public perception. He added that we also have to start earlier with education, giving examples of interactive outreach in the FARMIN project.

Anthony rounded off the discussion by saying that in the presentations we had talked about the potential that change can bring. He asked the question of how much of the innovation is social, and if we put enough emphasis on that. This would be the topic of the second panel discussion on building trust in the mining sector.

3.3. The European Commission's Raw Material Information System (RMIS) – a knowledge management and monitoring tool

The mineral exploration and intelligence panel ended with a presentation by Constantin Ciupagea, Head of the unit Land Resources at the European Commission's Joint Research Centre, on the Raw Material Information System (RMIS) – a knowledge management and monitoring tool.

Constantin started by setting the scene of an even higher increase in demand for critical raw materials (CRM) and base



metals coming with the EU Green Deal, bringing Europe into the digital age and low carbon society. He stressed the importance of foresight activities. The European Commission and the JRC established the RMIS in 2015 exactly because they noticed that there is an exchange needed between people that speak different languages, and there are large gaps in data and knowledge. RMIS acts as the reference access point to the EU knowledge base on raw materials and facilitates the availability, coherence, and quality of knowledge needed to inform policy.

The RMIS includes tools that show strategic industrial supply chains, trends and profiles for different countries and raw materials. It also addresses important knowledge gaps on secondary raw materials, important to monitor indicators related to the policy on a Circular Economy. It provides a space for projects funded under Horizon 2020, acting as a gateway to those projects.

The JRC supports DG Grow in the criticality assessment of raw materials, and the RMIS has a number of publications related to that and other raw material issues.

4. Mining and mineral processing

4.1. Presentations

Masuma Farooki, the moderator, introduced the idea of the second panel, to look at how we can use technology developments, and the benefits they bring, to build trust among communities and citizens. Do we need to change the message from “we need mining” to “mining is a perfectly safe and green industry”? She introduced the panellists:

- Anthony Hodge, adding to his previous introduction his impressive knowledge of the stakeholders in the sector, having worked both with the industry and local communities.
- Niclas Dahlström, a senior project manager at LTU Business and in the programme office for Swedish national strategic innovation program for the mining and metal producing industry (SIP STRIM).
- Juraj Janocko, professor at the Technical University of Kosice.
- Päivi Kinnunen, heading the metals and materials recovery group at VTT in the fields of material recycling, hydrometallurgical process development and geomicrobiology.



4.1.1. Innovation and public engagement in the mining industry: setting honest boundaries

Anthony Hodge started the panel with a presentation called “Innovation and public engagement in the mining industry: setting honest boundaries” prepared together with Laeeque Daneshmend from the Department of Mining at Queen’s University. He explained that the idea of the presentation came from their observation that trust often is undermined by unkept promises from mining companies. “Today there are good players in the mining industry, who are asking themselves why they cannot gain public trust. Another thing that has emerged in the past three years is a tremendous dependence on innovation, where mining companies highlight innovation as a reason

to invest in them. But, let us be honest about the limits on what we can do and not do with innovation, because, if we overhype the impacts, it will again undermine trust in the industry in the long term."



Anthony talked about the lifecycle of a mining project and of a product, where innovation could be applied at every step, and about direct and indirect outputs of the metal and minerals industry. He talked about different types of innovation; technical and social innovation, with solutions that often require the active collaboration of constituents across government, business, and the non-profit world. The social side is also in need of innovation, including the capacity for people to take

on change successfully and not reject it. If that is not in place, all the innovation in the world is not going to work. People need to have the sense of pride and that the future is positive – and the mining companies are often in a very strong position to deliver that.

He spoke about incremental and transformative innovation, giving different examples. It is clear that innovation in the industry is not happening overnight – robotics have taken 30 years to arrive to the point of implementation.

The reasons for innovating is to enhance efficiency, i.e. to maximize benefits to society and community, and minimise costs, risks, and negative implications. The context of efficiency has gone from classical concepts of maximising outputs for a given input, through eco-efficiency in the early nineties, to sustainable concepts of maximising wellbeing and minimising stress on people and ecosystems. This means carefully considering what a technology application means for the different people concerned, i.e. what are the positives, who will gain, and what are the negatives?

Technology optimism, without the sensitivity of the human element, causes problems. Setting honest boundaries, recognising what can and cannot be achieved by a given innovation, moves us from short-term to long-term thinking, imbues integrity and honesty, and engenders the trust we are seeking. Anthony suggested that we should test innovation against a set of criteria, such as the scope and time horizon, whether it is incremental or transformative, enhanced positives, reduced negatives, who gains, who pays the true cost and what degree of change will result. For example, what does a design time of 50 or 100 years mean for a facility that may have to operate safely for a thousand years, which some mine tailings must do?

4.1.2. Sustainable intelligent systems for a global mining industry - SIMS

Next Niclas Dahlström spoke about the SIMS project, Sustainable Intelligent Mining Systems, finishing in April. The project receives 12,7 million Euros from the Horizon 2020 programme, and some industrial partners are adding significant extra funds to the project. The partnership includes five mining companies, six suppliers and two universities. The starting point of the project was four years ago when the mining companies expressed their needs for the future. The project does about 30 pilots in eight different mines at Agnico Eagle in Finland, LKAB and Boliden in Sweden, K+S in Germany, KGHM in Poland, and in a virtual mine at the Luleå Technical University.

Niclas highlighted some successful demonstrations in communication and positioning, battery electrical vehicles and robotics in real underground mine environments. SIMS implemented a 5G-enabled industrial communication network at the Boliden Kankberg mine in Sweden. Positioning allows drivers of underground vehicles and machines to navigate in the mine, see where other vehicles are, and to get to the closest rescue chamber in case of evacuation. The project demonstrated a robotised autonomous charging machine for blasting at the Boliden Garpenberg mine, as well as autonomous drone prototypes for inspection activities. Three different machines with Northvolt battery systems and infrastructure were demonstrated at 1000 metres underground in an Agnico Eagle mine in Finland.



Niclas also presented the extensive outreach work in the project, and emphasized the importance of communicating what we are doing. He closed by saying that the EU has good geological conditions, and we could mine much more – Europe's consumption of minerals is disproportionate to its production, which is not responsible.

4.1.3. Zero waste concept for underground mining and processing - MineTALC

Juraj Janocko presented the zero-waste mine concept of the MineTALC project, an EIT RawMaterials project that just started. The mining and backfilling system developed in the project integrates technologies ready for market launch. Backfilling technologies using tailings will enable economical extraction of low and medium strength deposits and avoid tailing dams. Closed water circuit for flotation, and use of mine water for



flotation and an onsite concrete plant, aims to achieve operations with zero waste. A prediction model will show the best mineralisation sites and allow determining the best extraction technology. The project pilots these technologies in the Gemerska Poloma talc mine in Slovakia.

A spin-off competence and training centre will provide consultation services, courses, academia support, and the infrastructure of the Gemerska Poloma talc mine in Slovakia, to support knowledge sharing and competence building.

4.1.4. Making a business case of water and safe tailings - ITERAMS

Päivi Kinnunen presented the ITERAMS project, making a business case for water and safe tailings. The project consortium of 16 partners wants to change the mining concept, going from water cost minimisation to taking care of water properties. Similarly, it wants to go from tailings disposal to use in backfilling and surface covers. The aim is to rethink water and waste in mining and take care of the value in them. This will enable a future sustainable mineral supply.

The questions behind the project is whether we really know how closing the water loops will influence the contaminants and flotation performance, or whether we have understanding about how storing water in a closed reservoir will impact water quality and recovery, and how contaminants can be measured real-time, on-line, and at a reasonable cost.

Through field testing, the partnership developed an understanding of the most critical mechanisms for closed water loops, and how to monitor and treat water, and reduce contaminants, just enough for the flotation process to work properly. Especially fine particles are important, including oxidised sulphur species and microbiology.

ITERAMS used three case sites in Finland, Portugal and South Africa, representing very different seasonal, hydrogeological and microbiological contexts, to test the developed geopolymers for surface covers, and the water monitoring sensors and water treatment, in the field. The project has also focused on ore sorting, because it is possible to reduce water consumption and improve the amount and quality of tailings by removing the non-economical part of the ore. Päivi highlighted the ore sorting potential by showing results from one of the case sites evidencing that 10% of the ore is non-economical. She further showed results evidencing the good properties of alkali-activated tailings for backfilling and covering layers for high sulphur containing waste rock, minimising water penetration in order to mitigate acidic rock drainage.



The project analysed the sustainability of the technologies and concepts with life cycle assessment and modelling of environmental impact.

4.2. Panel discussion on how research and innovation can contribute in building trust in the extractive industry

Masuma Farooki started by asking Anthony Hodge whether he thought there is a generational gap in understanding the mining sector and building trust.

Anthony started by noting that during the presentation of the FARMIN project by Fabian Stamm in the previous panel, he could not help thinking what an opportunity their augmented reality is to interact with young people.



He continued by answering, “yes, there is a generational divide, especially in developed countries. If you go to other countries, like Chile or Peru, it is full of young people in the mining sector. That means that it is likely that these countries will take over the lead. The opportunity to build trust with the younger generation might be slipping away too. Social media dominates the communication, where info on mining is not very flattering. The mining industry cannot defend itself, because it is self-serving. The mining industry has to gain confidence that their actions will speak louder than words, that is, they have to demonstrate good practices. The credibility gap increased tremendously with the many recent mining tragedies, and those happened in advanced countries”.

Masuma noted that many of the presented developments, in for example the SIMS project, seem to be focused on employees and operations. She asked the question to Niclas Dahlström if people care, outside the mine site.

Niclas said that young people more and more are looking to make a difference, not only to earn well. “If they understand that the mineral business is an enabler for the

green transition, they might be more interested in the industry". His team will pilot a free of charge Virtual Reality environment, developed in SIMS, to put in museums and schools.

Masuma asked Päivi Kinnunen about the case studies used in ITERAMS, in so different environments – had she seen a difference in how the three regions reacted to the idea of closed water circuits?

Päivi answered that one of the things they had seen is that, no matter if water is scarce or not, water is seen as a priority in all three regions and companies.

Masuma Farooki opened to questions from the public. A participant asked a question in relation to the younger people that seem to have deserted the industry in developed countries. He asked whether the panellists thought it was time to totally change the type of education for mining professionals. Masuma thanked for the good question, and linked it to her last question how we can attract young professionals, and if it is the responsibility of the industry to do that.

Päivi responded that "the challenges are so great that one organisation cannot solve them alone. A great thing with the Horizon 2020 projects is that they bring together people from very different disciplines, for example microbiologists and social scientists in the case of ITERAMS, and maybe that is also a possibility to attract new people to work in the industry".

Päivi said that often we start too late with attracting people. "University level is too late, as people have already made their choices". In ITERAMS they invited school children to see their labs and work places. The pupils that visited had very clever questions, and they have a positive view of the raw materials sector.

Juraj Janocko said that "people from many different disciplines take part in mining activities. Gradually young people could end up in mining through other disciplines. We also need some more generally educated people in the business".

Niclas said that it is important that the industry can convey the message that it is important for the global health. For example, in the SIMS project, partners that had not worked with mining before, such as the telecommunication companies, started to become interested in mining through the project.



Anthony replied, "yes, we need a change in education, but the industry also needs to change. The mining industry is shooting itself in the foot". He gave the example where, when the market crashed, top companies let down graduate students by revoking already signed contracts. "These people have now left the mining profession. When the industry aims for survival in an economic downturn, trying to cut costs, the first thing that goes are young people. Young people want to make the world a better place. For example they are attuned to the idea of addressing

climate change, and the mining industry has not demonstrated a capacity to absorb these kind of persons and thinking". He finished by saying that he hoped that the upcoming Horizon Europe will have a part of its programme looking at changing management, on how to bring people into change in a way that is respected and motivates integrity.

4.3. ERA-MIN - Public-public partnership coordinating research and innovation programmes on raw materials

After the panel discussion, Ana Luisa Lavado, programme manager at the Portuguese Foundation for Science and Technology (FCT), presented the ERA-MIN network, an ERA-NET public-public partnership coordinating national research and innovation programmes on raw materials. It is a network of 21 public research funding organisations from 18 countries and regions in Europe and beyond, including Argentina, Brazil, Chile and South Africa, and Quebec associating to two calls.



It has implemented a call for project proposals on raw materials research and innovation in 2017, where the EU provided a third of the funding through Horizon 2020, and two additional calls, in 2018 and in 2019, with only national funds. In total 28 projects have been provided 21 million Euros for research on exploration and mining, product design, processing, production and remanufacturing, recycling of end-of-life products, and on crosscutting topics. ERA-MIN will grant 10 million Euros in 2020, and continue for another 5 years under a new Horizon 2020 action starting in 2021.

4.4. Participating in the Horizon programme and where to find out more

Next, Jonas Hedberg reconnected to Eibhlín Doyle's encouragement to get involved in the Horizon 2020 programme, and gave some advice on where to find partners and support. He emphasised that the programme is fully open to participation from



organisations across the world. Some 130 developing countries are automatically eligible for funding, and participants from others countries can receive funding if their role is essential for a project. He presented a number of platforms with results from the Horizon programme, the Environment and resources data hub, the Horizon results platform, the Horizon dashboard and CORDIS, with a particular mention to a

recently released CORDIS results pack on mineral exploration. He went into more detail on the Innovation Radar, a tool developed to identify high potential innovations and innovators in the Horizon 2020 projects. The results are public on the platform www.innoradar.eu.

5. Closing

Arnoldas Milukas closed the workshop complementing the speakers on their very interesting interventions, and thanking for the insights on how we can innovate both technologically and socially to address the challenges ahead and build trust in the mining industry.

He highlighted the great needs for minerals and metals as enablers of the climate-neutral economy that had run like a thread through the different talks.

He also concluded that it is clear that there are solutions to progress against more sustainable and responsible mining practices and that the industry is moving in that direction. The Horizon programme's openness to global participation, and funding to organisations from developing countries, is an important enabler for the international cooperation that is so crucial to ensure that this is happening globally.



He thanked the European Union's Service for Foreign Policy Instruments, DG Grow, and EIT RawMaterials. He thanked the moderators Anthony Hodge and Masuma Farooki, and all the speakers and participants in the workshop.

He concluded the workshop saying that he hoped to see the workshop participants again as participants in the Horizon programme.

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