SWEDISH
MINING
INNOVATION

Projects 2020

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Swedish Mining Innovation

Swedish Mining Innovation is the strategic innovation program for the Swedish mining and metal producing industry. The program has been under the name SIP STRIM until May 2020. The program is funded by its stakeholders and partners, and by Vinnova, the Swedish Energy Agency and Formas. Swedish Mining Innovation has its basis in the Strategic Research and Innovation Roadmap for the Swedish Mining, Mineral and Metal producing industry, and all projects within the program aim to realise the Roadmap's goals and vision. Beyond the innovation projects, the program organises idea competitions aiming at identifying new project ideas, workshops, education activities and other activities aiming at outreach and internationalisation. Our innovation projects range from short pre-studies, to fullscale innovation projects, pilot tests and demonstration projects. All projects are initiated by our various stakeholders and each fullscale and pilot project involves at least two partners from the industry and one academic partner. In addition to these projects, a number of strategic projects are initiated by the programme management each year. In this folder, all our current projects are presented. For more information about the projects, please contact the project leaders or Swedish Mining Innovation program office.

Contents

Photo: Lars deWall.

FULL-SCALE PROJECT

Face-to-Mill

Project leader: Luleå University of Technology, Daniel Johansson
Project duration: July 2017–August 2020
Partners: Atlas Copco, Boliden, Forcit Sweden

The main objective of the project is to increase the overall production capacity in large open-pit mining. This is done by adapting the findings from the previous project Face-to-Surface I, and extending the project scope of the production optimisation to also include mill performance. To improve the knowledge of how varying rock mass characteristics can be controlled with adaptive blasting technique and procedures, to optimal fragmentation through the mining chain.
The suggested methodology involves extensive machine and operation monitoring, where a big-data approach is suggested. The project aims to suggest an overall optimal fragmentation through the mining chain, to develop a technique for adaptive charging of explosives based on rock characteristics and to reduce the total energy consumption of the mining operation.

FULL-SCALE PROJECT

Assessment of rock fall and optimisation of rock support for deep underground mines

Project leader: Luleå University of Technology, Erling Nordlund
Project duration: August 2017–July 2020
Partners: Lundin Mining, Boliden, LKAB

The aim of the project is to improve safety and productivity, and reduce the ore losses, dilution and the amount of waste rock by improving the ground control strategy. Objectives in detail are to: improve the understanding of the failure mechanism of rockfalls, develop statistical analysis methods for assessing rockfall hazards, develop design guidelines for support of large potentially unstable volumes, and develop design guidelines for bolt-shotcrete arches and mesh and mesh overlaps. The successful completion of this project will result in:
1. An innovative methodology for assessing the rockfall hazards based on deterministic (forensic investigation) and statistical (DFN modelling) analyses.
2. Improved performance of the rock support system to prevent large rockfalls controlled by geological structures through new design guidelines.
3. Improved performance of bolt-shotcrete arches and welded mesh support by new design guidelines. 4. Educated qualified rock engineering personnel for the mining industry.

FULL-SCALE PROJECT

Mining industry and indigenous people: regulations, best practice and social innovation

Project leader: Luleå University of Technology, Karin Beland Lindahl
Project duration: October 2017–October 2020
Partners: CAMECO, Das Nedhe Development, English River First Nation, University of Northern British Columbia, University of Saskatchewan

Sweden has experienced an increased level of conflict over mine establishment, particularly in relation to indigenous land use. This project aims to develop tools to manage Swedish land use conflicts involving industry, indigenous communities and the state by drawing on Canadian comparisons and experience.
More specifically, it will compare social licensing (SLO) and mine establishment across Swedish and Canadian jurisdictions to explore the role of the regulatory frameworks and identify well-functioning practices in relation to indigenous rights and land use. Better knowledge about the role of institutions for SLO will enable Swedish policy makers to create conditions that support mutually beneficial interactions between company and community.

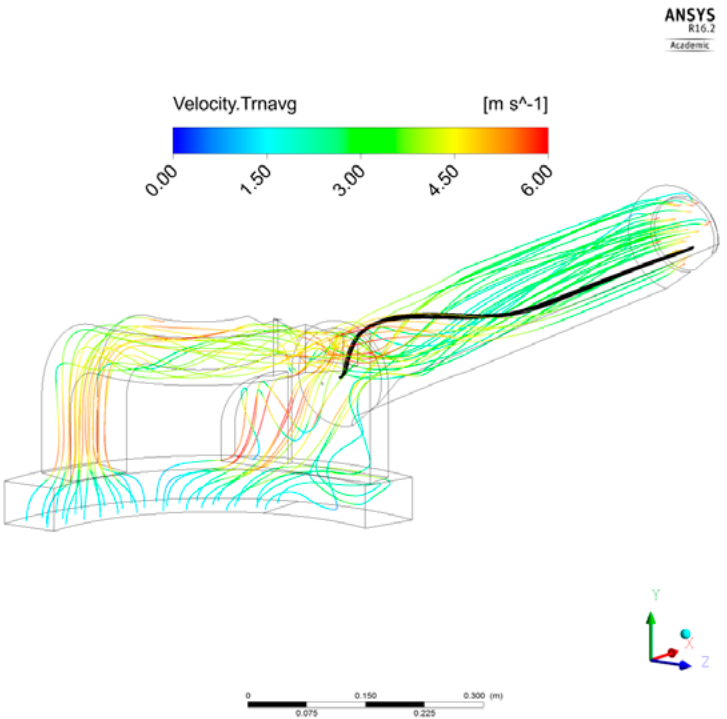
Photo: Boliden. Jeanette Hägglund

FULL-SCALE PROJECT

Walk the talk – sustainability management system for social acceptance

Project leader: Luleå University of Technology, Helena Ranängen
Project duration: June 2017–June 2020
Partners: Boliden, Svemin

The purpose of this project is to improve the Swedish mining industry's sustainability efforts by developing and implementing a sustainability management system (SMS) for social acceptance which, based on stakeholder dialogue creates, implements, evaluates and develops sustainable processes along the entire value chain. The project aims to test whether previous research, which is more conceptual by its nature, can be applied in practice. SMS will be integrated into the company's existing operational management systems and will thus make an important contribution to the empirical research on how CSR is practiced from an inside perspective. The project will be implemented through: 1. Literature reviews. 2. Interactive workshops. 3. Stakeholder surveys. 4. Stakeholder interviews. 5. Development and documentation of SMS. 6. Dissemination of results via national and international conferences and scientific publications.

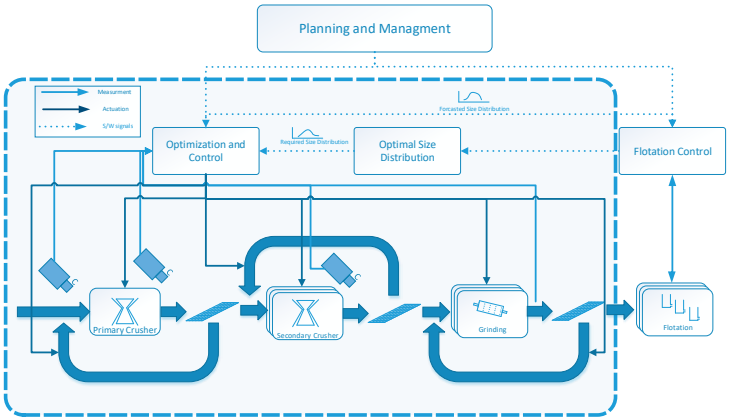


FULL-SCALE PROJECT

New digital 3D model of the Grate Kiln pellets process for reduced energy consumption and emissions

Project leader: Luleå University of Technology, Staffan Lundström
Project duration: August 2017–December 2020
Partners: LKAB, Taoshi Energiteknik

The main aim is to develop a new digital 3D model that can be used to control and optimise the flow field in rotary kilns for reduced energy consumption and environmental impact and increased pellet quality. Additional goals are: a general simulation methodology that can be used on any complex system involving fluid flow; increased understanding of the pelletising process regarding at least three flow phenomena; and a demonstration of how advanced experimental techniques can be used in harsh industrial environments. Implementation of the model can help reduce the environmental foot-print of mining and contribute to sustainability in terms of more optimal use of energy and reduced emissions, as well as increasing the quality of the pellets. The results will also form a basis for innovative solutions regarding in-situ flow control.

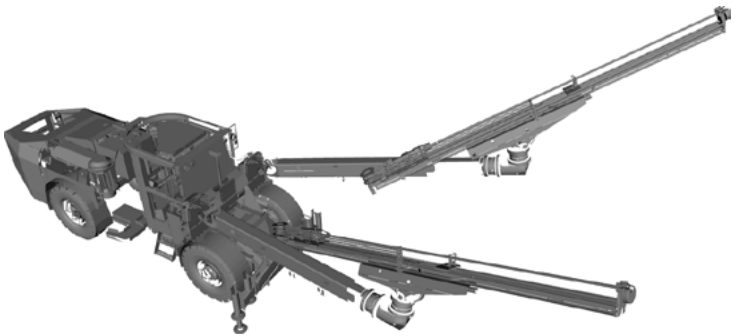


FULL-SCALE PROJECT

Efficient comminution operation (ECO)

Project leader: Luleå University of Technology, Andreas Johansson
Project duration: August 2017–June 2021
Partners: Innovative Machine Vision Pty Ltd, Optimation, Vale S.A.

Comminution (crushing and grinding) accounts for about 4 % of the world's energy consumption and the environmental impact from the production of tailings due to overgrinding can be significant. In this project, we consider the problem of improving efficiency in comminution chains in the presence of changes in ore properties, product demands, etc. This will be accomplished by collecting online measurements of variables such as ore size distributions and to change machine speeds and other variables continuously to achieve optimized operation. Advanced measurement equipment for measurement of size distribution of ore streams will be installed in a Brazilian mine facility. Aided by data from these, dynamic models for crushing and grinding processes will be developed. The models will be used for developing algorithms for optimised control of the comminution processes. The potential of these algorithms for process optimisation will be tested in simulation but also implemented in normal operation where possible.



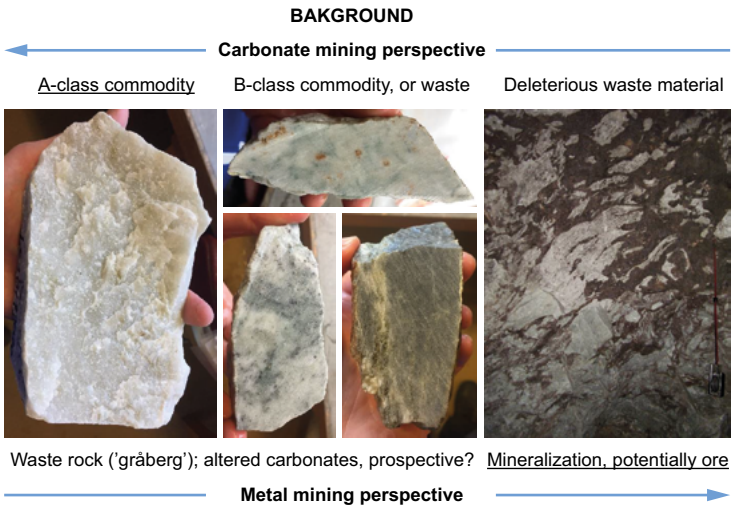
FULL-SCALE PROJECT

Tracking and control of articulated machines through remote sensing

Project leader: Örebro University, Todor Stoyanov
Project duration: August 2017–March 2021
Partners: Alfred Nobel Science Park, Atlas Copco Rock Drills, Zinkgruvan

A key enabling technology for remote machine operation is the ability to estimate and control the full machine state. In the project we will devise and implement novel methods for estimating the state of articulated manipulators using remote depth sensor measurements. We will verify the validity and utility of the state estimate by using it in a feedback controller. By removing all sensor hardware from the manipulator, we will greatly increase hardware robustness to damage and reduce repair and maintenance costs.

The project hopes to result in novel technology within the following objectives: reliable remote sensing in harsh mining environments; accurate manipulator tracking; and robust feedback control. The project will develop software modules for estimating the state of an articulated machine, using remote sensing.



FULL-SCALE PROJECT

VectOre – Exploration criteria for polymetallic sulphide mineralisation and industrial carbonates

Project leader: Luleå University of Technology, Nils Jansson
Project duration: August 2017–January 2021
Partners: Björka Mineral, Boliden

The project aims at improving exploration criteria for polymetallic sulphide deposits (Zn-Pb-Ag) and carbonate deposits (calcite and dolomite).
Both are spatially associated with marble units in Bergslagen and some of the best quality industrial carbonate deposits occur in alteration haloes related to nearby sulphide deposits. The main aim of the project is to understand the chemical, mineralogical and isotopic zonation of such alteration haloes.
The c. 40 km long marble occurrence in the Sala area will be investigated with emphasis on stratigraphy, structure, lithogeochemistry, stable isotopes and mineralogy. The distribution of mineral deposits will be related back to variations in the marble unit on a regional scale. Detailed studies will be conducted around known sulphide and carbonate occurrences in the Sala-Tistbrottet area. Our geochemical and mineralogical data will also be used to investiage the relationship between marble composition and key parameters of interest to the carbonate industry, such as lightness.

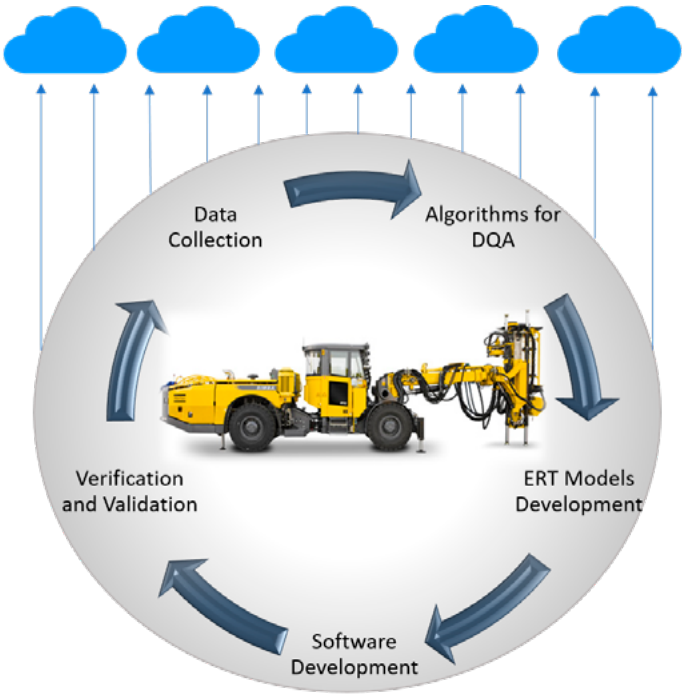
Photo: Fredric Alm / Alm & ME

FULL-SCALE PROJECT

Strategies and indicators for mine safety

Project leader: Luleå University of Technology, Jan Johansson
Project duration: June 2018–May 2021
Partners: Drillcon, Zinkgruvan Mining, Boliden Mineral, Cementa, LKAB, Bergteamet, Svemin

The purpose of the project is to improve workplace safety in the mining industry based on practices, strategies and principles gathered from Swedish and international mining companies. The goal of the project is to develop strategies and proactive indicators aimed at improving safety management and, contribute to making companies in the industry more attractive employers. The project will develop methods aimed at managing and controlling the work environment by, e.g., highlighting the safety effects of automation and providing an overview of safety in relation to contractors, focusing on safety management and injury prevention. More specifically, the project will provide a quantitative description of the safety situation in a number of Swedish and international mining companies, a description of the safety-related practices in a select number of companies, and an in-depth analysis of these practices and how they can be systematized in terms of proactive safety strategies and indicators.



FULL-SCALE PROJECT

Improving data quality for LCC predictions with cloud services

Project leader: Luleå University of Technology, Uday Kumar
Project duration: April 2018–March 2021
Partners: Boliden Mineral, Epiroc Rock Drills

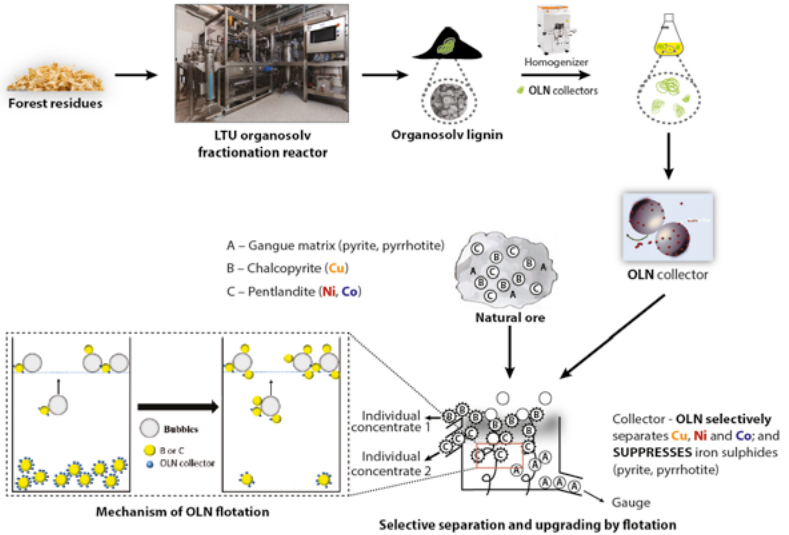
The aim of this project is to develop a framework for data quality analytics (DQA) of MAXIMO database, develop, validate and demonstrate an economic replacement time (ERT) model in the mining environment and to build a generic software that can be used to estimate the ERT of mining production machineries considering real operational parameters in mining environment.
The objectives are to measure and diagnose DQ problems, and develop application tools for improving the quality of MAXIMO data. Further objectives are to minimize the total ownership cost of production machineries and to develop, validate and demonstrate a decision-making tool for the ERT estimation of production machineries. The expected results include a practical optimization model based on the total discounted cost, results visualization and decision support, and a private cloud computing service developed and integrated into the project.

FULL-SCALE PROJECT

SO4-BIORED Demonstration of biological sulfate reduction in cold climate

Project leader: RISE Research Institutes of Sweden AB, Erika Lönntoft
Project duration: March 2019–November 2020
Partners: Boliden Mineral, Fortum Waste Solutions

The aim of SO4-BIORED is to offer an energy and resource efficient solution to reduce the water footprint from the Swedish mining industry. The goal is to demonstrate a sulfate reducing bioprocess pilot plant (TRL 6) with a reduction efficiency of 95 %. The main innovation of this project is the effective microbial consortia which has the ability to reduce sulfate in the cold climate prevailed in Swedish mines. The product, hydrogen sulfide, can precipitate metal ions which create a concentrated and stable product (metal sulfides), these can be reused and thereby create value. SO4-BIORED facilitates recirculation of water without creating new waste streams. The project will scale up the bioprocess for sulfate reduction at Boliden.

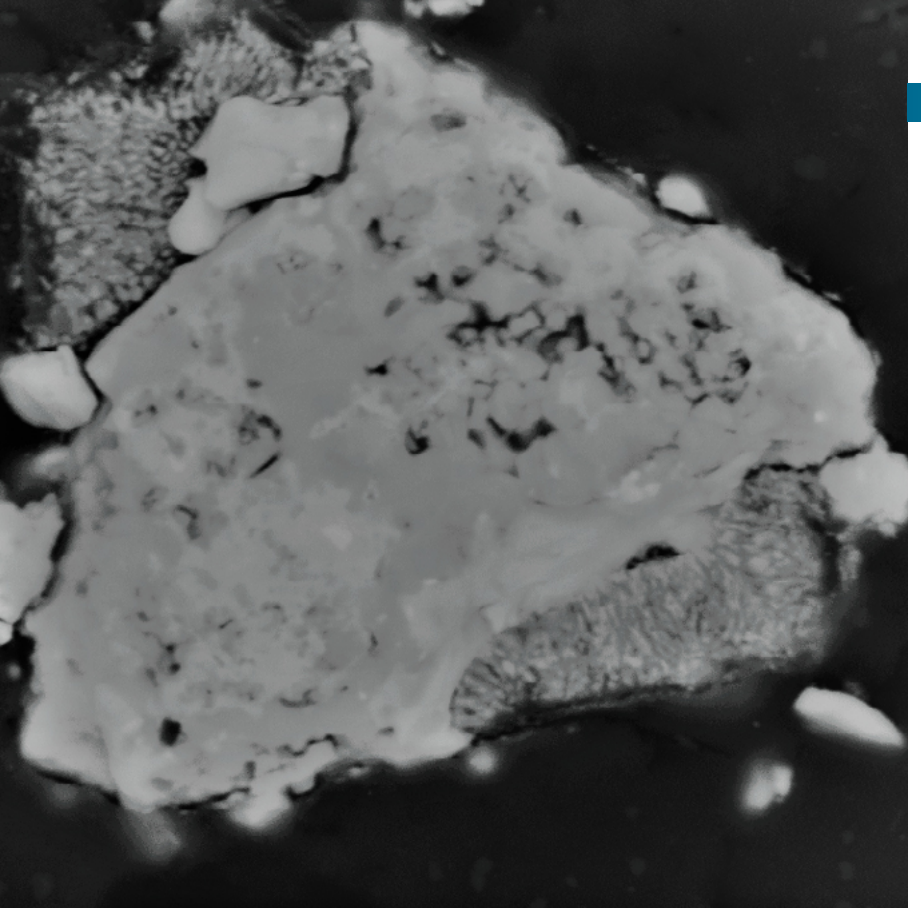


FULL-SCALE PROJECT

Organosolv lignin hydrophobic nanoparticles as low-carbon-footprint biodegradable flotation collectors

Project leader: Luleå University of Technology, Ulrika Rova
Project duration: May 2019–April 2022
Partners: Akzo Nobel Surface Chemistry, Boliden Mineral, Sveaskog förvaltnings

The project aim to demonstrate the technology of a novel sustainable flotation process for selective extraction of base metals from sulfide ores, based on total or partial replacement of fossil-based xanthate flotation collector derivatives with biobased, biodegradable hydrophobic nontoxic organosolv lignin nanoparticles. The production and use of lignin biodegradable nanoparticles as flotation collectors is expected to have a great impact on the development of sustainable mining processes with both low-environmental impact and low-carbon footprint. The project will establish the separation process and performance for treatment of finely dispersed sulfide polymetallic ores. The scale-up potential will be assessed, including environmental assessment.



FULL-SCALE PROJECT

Optimized roasting of complex copper sulphide concentrates for flexible raw material utilization

Project leader: Luleå University of Technology, Caisa Samuelsson
Project duration: April 2019–March 2022
Partners: Boliden Mineral (Smelters and Mines), SEMTECH Metallurgy

The overall objective of the project is to optimize the roasting of sulphide concentrates for copper extraction to achieve efficient removal of elements as arsenic (As) and antimony (Sb) for a flexible use of different concentrates. Thus the goal of this project is to establish methods that will aid in improving the capacity of the roasting process in respect to removal of impurity elements such as As and Sb. The work will be based on theoretic calculations, experimental studies in lab scale, pilot and/or full scale trials. Successful outcome from the project will in the short term enable adjusted raw material preparation, e.g mixing of concentrates and in the longer term enabling treatment of raw materials that today is not utilized and implementation of new measurement technology. The project is expected to result in; a test method, a validated process model and evaluated measurement techniques related to roasting of complex sulphide concentrates.

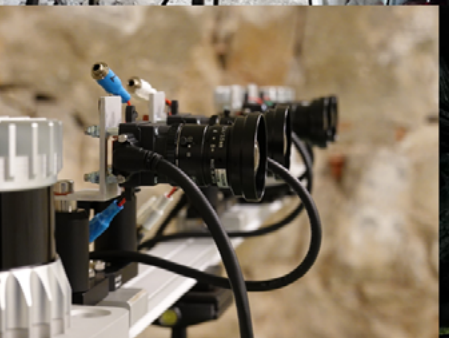
Photo: Epiroc/F. Pecora, Örebro University

FULL-SCALE PROJECT

Automated drill planning for multiple-boom rigs in underground mining

Project leader: Örebro University, Federico Pecora
Project duration: May 2019–April 2022
Partners: Alfred Nobel Science Park, Epiroc Rock Drills, Zinkgruvan Mining

A significant portion of underground mining operations is related to tunneling. This requires drilling and blasting rock to excavate tunnels that lead to sources of ore. Drilling is carried out by drill rigs equipped with multiple robotic arms. In current industrial practice, drilling is carried out manually by an operator steering the arms on the drill rig. This project will develop integrated motion planning, coordination, and control algorithms which will effectively render the processes of planning and of executing multi-arm motions fully autonomous. Via the methods developed in this project, time to completion of the drilling cycle will be drastically reduced, as the arms will be able to operate concurrently, intelligently optimizing and coordinating their motions. Project results will be demonstrated via research prototypes in Örebro University's labs, as well as on a real Epiroc Boomer deployed in a mine run by partner Zinkgruvan Mining.

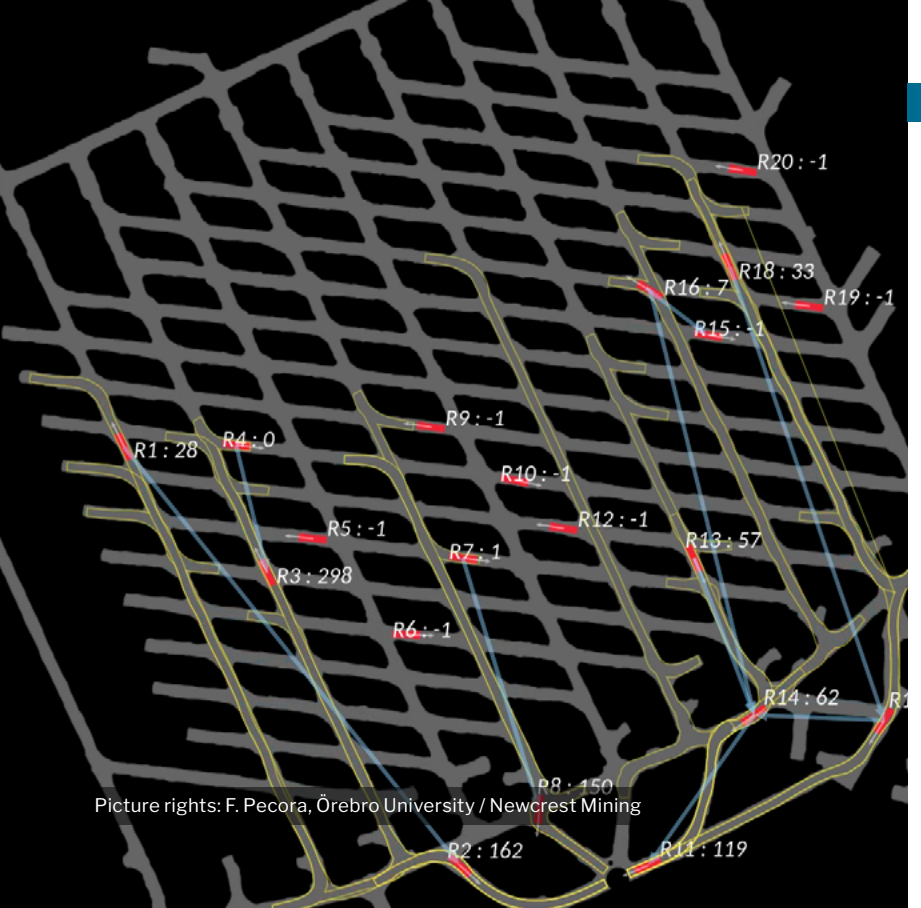


FULL-SCALE PROJECT

Systems for remote scaling

Project leader: Mid Sweden University, Mårten Sjöström
Project duration: March 2020–February 2021
Partners: Boliden Mineral, Jama Mining Machines

Remote operation of the hazardous scaling process in mining enables improved safety, productivity and more attractive workplaces. The project will employ a Remote Operation System for Scaling (ROSS) with visual and auditive feedback in an operational mine in order to assess durability, scaling performance, and quality of experience. Furthermore, an Augmented ROSS (AROSS) will be implemented in a mine-like lab with latest augmented telepresence technology to support the operator with enhanced and supplementary information.
The two systems will be compared. The ROSS will be applied to a Jama Scaler and tested in a production area in a Boliden mine, whereas the AROSS will be built and tested in a mine-like laboratory at Mid Sweden University.
The test results will then be analyzed and compared between the systems.
In a workshop, young women and men will generate ideas for the AROSS user interface. Thereafter, the ROSS and AROSS will be updated and further tested, and new results analyzed. The final systems will be demonstrated.



Picture rights: F. Pecora, Örebro University / Newcrest Mining

FULL-SCALE PROJECT

Automated planning and coordination of autonomous haulers in underground mines

Project leader: Örebro University, Federico Pecora
Project duration: March 2020–April 2023
Partners: Epiroc, Newcrest Mining

Most operations in underground mining deal with transporting rock through tunnels. This is achieved with Load-Haul-Dump vehicles (LHDs), large machines equipped with a high-capacity bucket that can transport several tons of rock. Today, LHD operations are planned manually, and LHDs are driven by human drivers. This project aims to develop Artificial Intelligence (AI) tools for automating the planning and coordination of fleets of LHDs. These will support two key aspects of fleet management: (1) LHD mission planning, execution and monitoring; and (2) system design and deployment. The mission planning, execution and monitoring tools (1) will be based on an existing library for multi-robot coordination, motion planning and control developed at Örebro University.
The library will be extended to guarantee the absence of deadlocks. A bespoke optimization process for computing efficient mission allocations will also be developed and integrated. The system design and deployment tool (2) will be built upon a 2D simulation engine developed at Örebro University.

FULL-SCALE PROJECT

Hydrogen Peroxide Emulsion

Project leader: AB Etken Teknologi, Tim Hunt
Project duration: March 2020–November 2020
Partners: Luleå University of Technology, Boliden Mineral

This project aims to explore the commercial viability of a bulk explosives based on Hydrogen Peroxide (HP) as opposed to the industry status quo, Ammonium Nitrate (AN). HP has many environmental and safety advantages over AN based explosives whilst still retaining key blast performance characteristics. It is expected that post blast environmental monitoring will show a complete change in the exhaust gas profile, removing toxic NOx and CO gas components. While the performance of HP explosives has been proven in the laboratory and controlled conditions, it must also be proven under real world operating conditions to validate commercial viability and subsequent implementation.
Trials will provide comparable blasting results to Boliden's current blasting practices. The trials will include mineral and chemical reactivity testing off site, post blast exhaust gas generation in a blast chamber at LTU and about 12 site based blasts at Boliden's Kankberg underground mine.

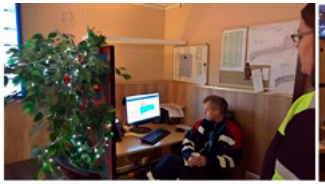
Photo: Per Sandström, SLU

FULL-SCALE PROJECT

MINEDEER

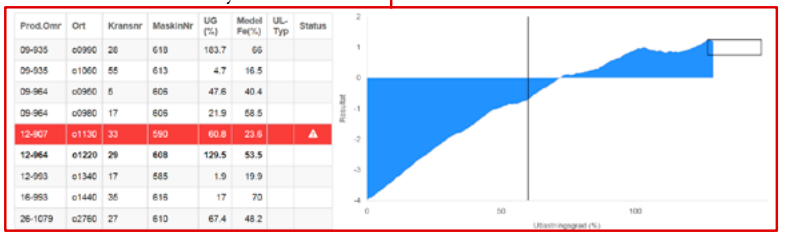
Project leader: Swedish University of Agricultural Sciences, Per Sandström
Project duration: April 2020–April 2023
Partners: Malå Sameby, Gällivare Skogssameby, Mausjaurs Sameby

The overall objective of this project is to increase and improve dialogue between mining industry, society and other stakeholders. The specific project aim is to develop tools and methods to gather new and better knowledge about impacts of mining activities on reindeer, reindeer husbandry and Sami culture to advance understanding among all involved land users. The knowledge-building processes are carried out through continuous work meetings between SLU, samebyar and Boliden. Through iterative processes, the university collects data and new results and presents them to the project team who provide support for further analyzes. The tools and methods developed will improve environmental impact assessments, planning and decision making for the agencies and stakeholders including mining companies, reindeer herding communities.



Mine IT systems

Mine control centre



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12-964	**o1220**	**29**	**608**	**129.5**	**53.5**		
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16-993	o1440	36	616	17	70		
26-1079	o2760	27	610	67.4	48.2		

PILOT PROJECT

Improved resource efficiency through dynamic loading control II

Project leader: Luleå University of Technology, Anna Gustafsson
Project duration: June 2019–November 2020
Partners: Agio system och kompetens i Skandinavien, LKAB

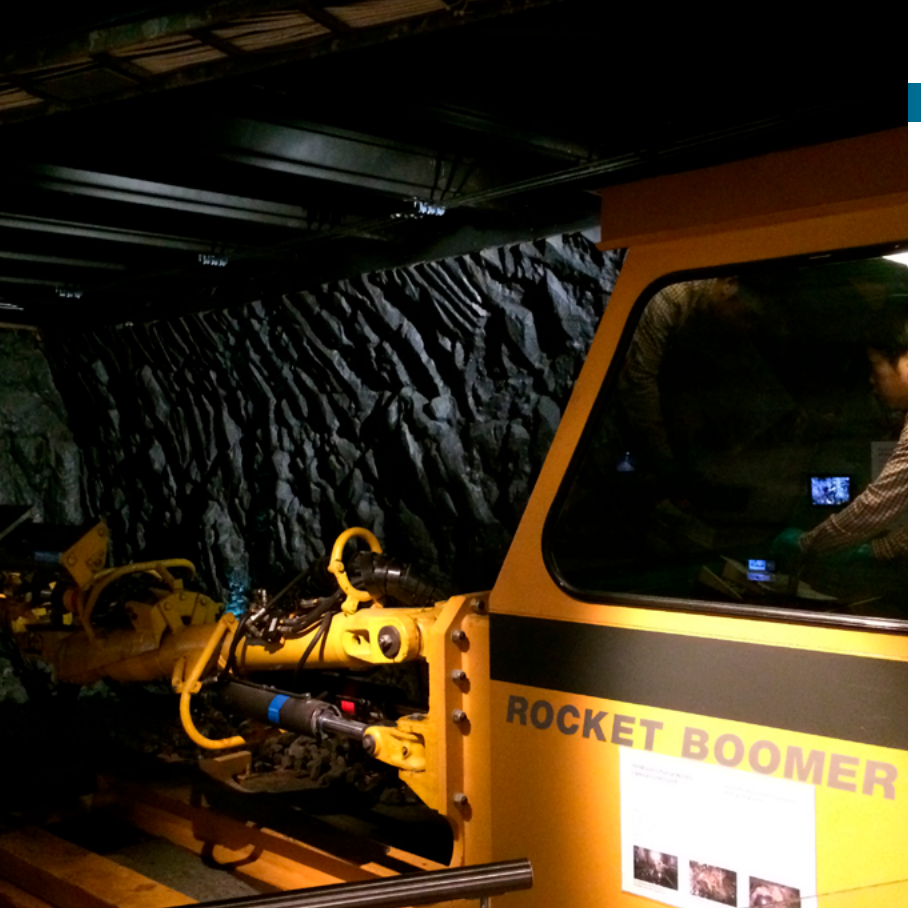
The aim of this pilot project is to improve loading and resource efficiency in sub-level caving (SLC) mines. The objectives of the project are to: Install and evaluate the new economic model for loading control in Giron (LKAB's Mine planning and information system). Validate the economic model through the developed probability model. Develop a new graphical user interface (GUI) for dynamic loading control in WOLIS (LKAB's wireless online loading and information system). Implement the GUI and economic model in WOLIS for selected LHDs.
Evaluate and modify the GUI in WOLIS. Optimized loading control with reduced ore loss and waste rock dilution, resource conservation and more efficient mining processes. The new draw control strategy simplifies and visualizes the overall draw point performance and helps mine personnel to make more informed decisions on how to load.

PILOT PROJECT

High resolution magnetic surveying using UAV

Project leader:Swedish Geological, Karl Westerlund
Project duration: March 2020–August 2021
Partners: Kaunis Iron, Luleå University of Technology

The overall purpose of the project is to test a UAV system purpose-built for regional magnetic surveys (“the Remote Mapper”) in the Swedish operational environment. This will be done based on a permit to fly “Beyond-Visual-Line-Of-Site” (BVLOS) with the use of radar for airspace control. The objective is to assess factors that may impact on survey implementation and data quality – primarily logistical issues, fulfilment of BVLOS permit conditions, and flight planning and magnetometer settings - with the ultimate aim to establish a commercial operation. Upon completion of the project, it is expected that the Nordic mining and exploration sector can be provided with a tool to acquire regional magnetic data of significantly higher resolution compared to conventional methods, and at a much lower cost. Furthermore, it is expected that the collection of high-resolution magnetic data across large areas will open up for a new level of ore geology research which, in turn, would enhance the knowledge on the structural setting and formation of ore deposits and lead to improved exploration strategies.

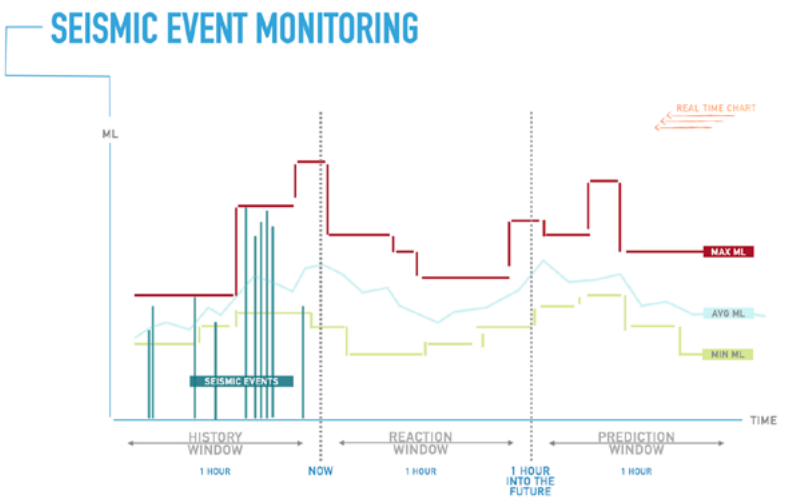


PRE-STUDIES

Sustainable lubrication of rock drilling

Project leader: Luleå University of Technology, Yijun Shi
Project duration: March 2020–August 2020
Partners: Epiroc Rock Drills, Sustainalube

This project will test the possibility of using glycerol based, fossil-free and environmentally friendly lubricants to replace mineral based lubricants for drilling head lubrication improving sustainability. Characterization and testing of the lubricants will be made at lab, pilot and in a full-scale drilling machine at Epiroc in Örebro. Planning of field tests will be made.

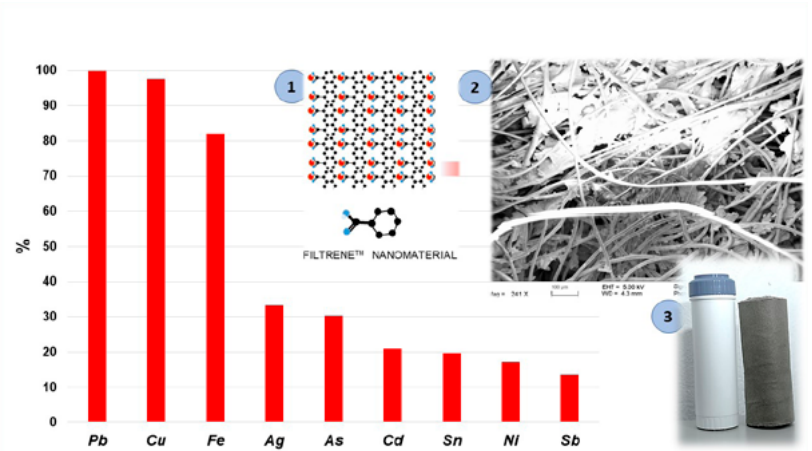


PRE-STUDIES

Feasibility study for seismicity forecasting in seismically active underground mines

Project leader: Luleå University of Technology, Savka Dineva
Project duration: March 2020–August 2020

The complexity of the physical phenomena in combination with spatial inhomogeneous and time dependent physical rock properties imply that classical methods for forecasting of natural earthquakes most likely are not applicable for the specific tasks of forecasting in mines. The main objective is to investigate and evaluate if beyond state-of-the-art techniques including Artificial Intelligence, Machine Learning and Big Data analyses can be utilized to identify parameters that have a potential for forecasting for mining-induced seismicity in a future full-scale project. The project will identify the most suitable methodologies and techniques for seismicity forecasting that could be applied in mines (based on literature review and some computer tests on small data samples).
The project will integrate expertise from different research areas within LTU through a new collaboration for analysis of the best practices in forecasting developed for natural earthquakes and other types of induced-seismicity and possible implementation for mining-induced seismicity and generate practical guidelines for warning in case of a forecasted seismic event. This project lays the basis for the preparation of a full-scale project.



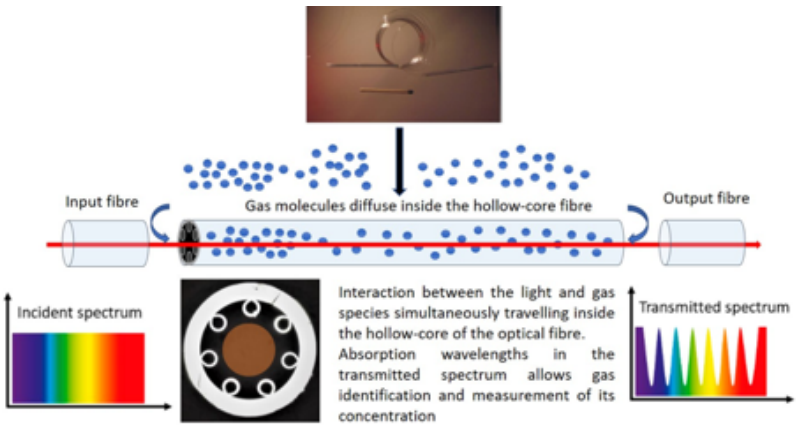
Efficiency (%) of the uptake of metal ions from the waste water using Filtrene solution developed by Grafren. Active material is functionalised graphene (marked as 1 in the inset), which is impregnated into a porous fiber structure (2) creating a filtering unit (3).

PRE-STUDIES

FILTRENE MINING Solution: Recovery of valuable metals from water stream in mining industry

Project leader: Grafren, Jenny Khranovska
Project duration: March 2020–August 2020
Partners: Swerim, Boliden

The aim of this project is to verify the technical and economic potential of FILTRENE technology for recovery of metal ions in mining industry. Grafren will prepare the FILTRENE sorbent and respective equipment for water filtering and metals collection. The objectives of the pre-study are to: analyse and experimentally identify the appropriate position for the installation of the FILTRENE solution; evaluate the technical efficiency and economic benefits of the FILTRENE solution upon operation in relevant environment. Successful execution of this pre-study project will verify more resource-efficient and economically viable approach based on FILTRENE solution and would pave the way to full-scale innovation project with the aim on adaptation of the solution for the mining industry.



PRE-STUDIES

Novel optical fibre gas sensors: application in harsh environment (NOVASENS)

Project leader: RISE Research Institutes of Sweden, Kenny Hey Tow
Project duration: March 2020–August 2020

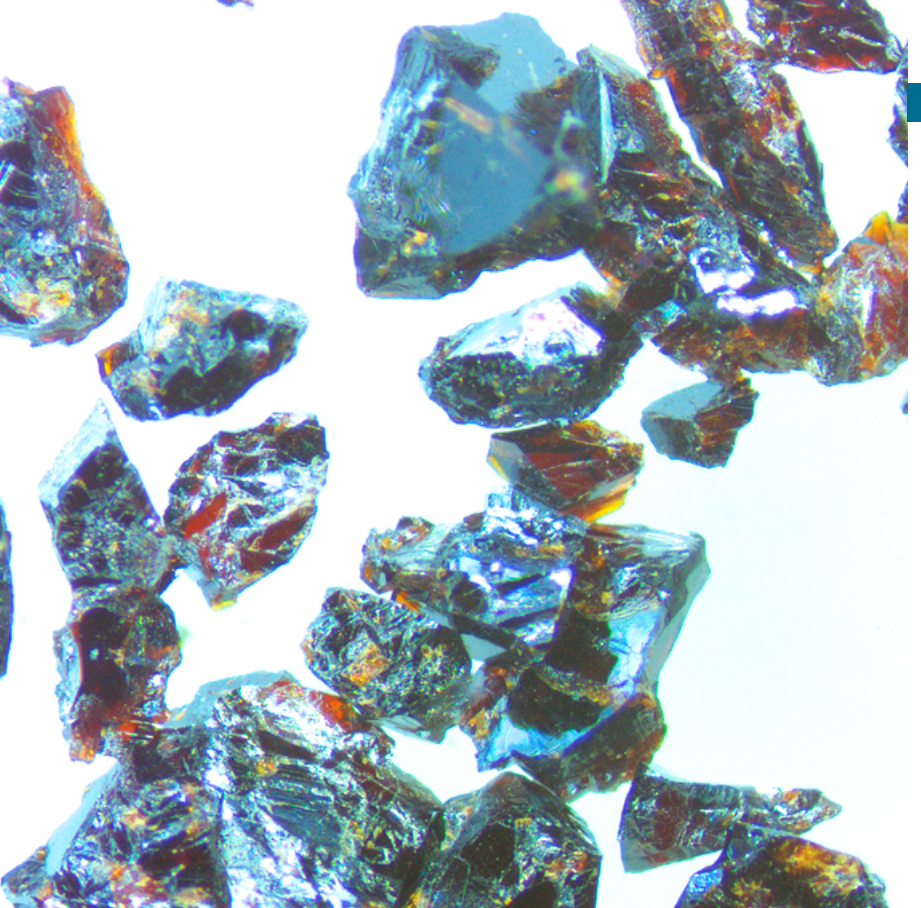
The goal of NOVASENS is to assess the use of a new specialty optical fibre, anti-resonant hollow-core fibre, for simultaneous, faster and more efficient monitoring of several gas species, which is essential to comply with the current occupational exposure limits and reduce the risk of explosion in mines. Furthermore it is essential for efficient control of heat treatment processes to ensure high product quality in the steel industry. We will also investigate the feasibility of developing a distributed optical fibre gas sensor system and its applicability to mining and metallurgy industry. Potentially appropriate specialty fibre, custom-made for gas sensing applications to meet requirements for a field test in industrial setting will be identified and model made for a specialty fibre, custom-made for to mining and steel production activities. The project will evaluate the feasibility of (quasi) distributed optical fibre gas sensing and identify future partners and plan for a full-scale project application.

PRE-STUDIES

Metallurgy of Dictyonema

Project leader: Geologica Consult, Emma Rehnström
Project duration: March 2020–September 2020
Partners: ScandiVanadium Sweden, RISE Research Institutes of Sweden

The project aims to develop a methodology for extracting vanadium from shale of the Dictyonema Formation that is economically sustainable and environmentally acceptable. Vanadium is a critical metal for green energy applications. The project goal is to develop an efficient method for extracting vanadium from alum shale, focusing on the application of POL (Pressure Oxygenation Leaching), for extraction in a closed system. This project builds on experimental analytical procedures. The success of the project depends on a high degree of flexibility following results from the different analyses performed. Experiments to be performed include: 1) Pressure oxygen leaching tests at variable conditions, 2) Characterization of the clay mineral vanadium host and 3) Surface analyses detection of vanadium. Geological and other details from known shale hosted vanadium deposits will be investigated as an integral part of the work.

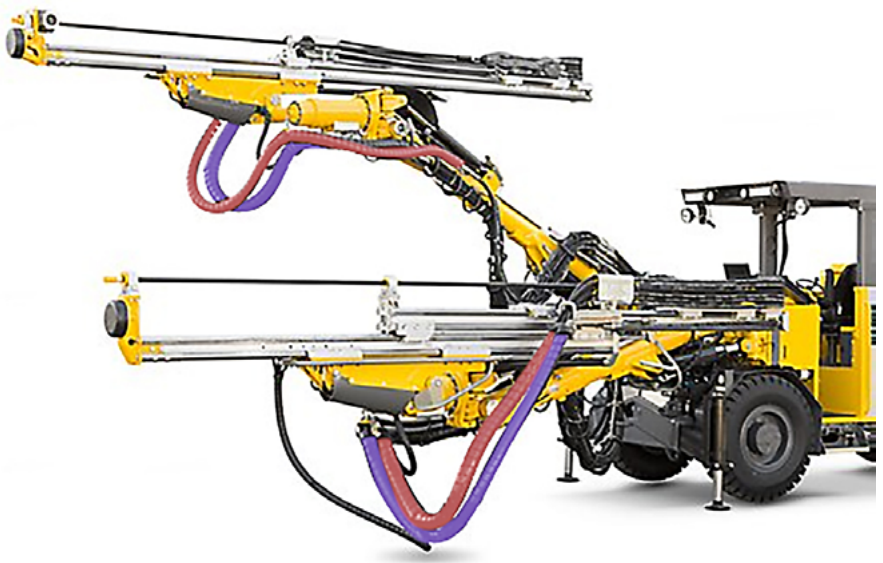


PRE-STUDIES

Utilizing the isotopic and trace element fingerprint of sphalerite for traceability applications

Project leader: Luleå University of Technology, Christina Wanhainen
Project duration: April 2020–September 2020
Partners: ALS Scandinavia

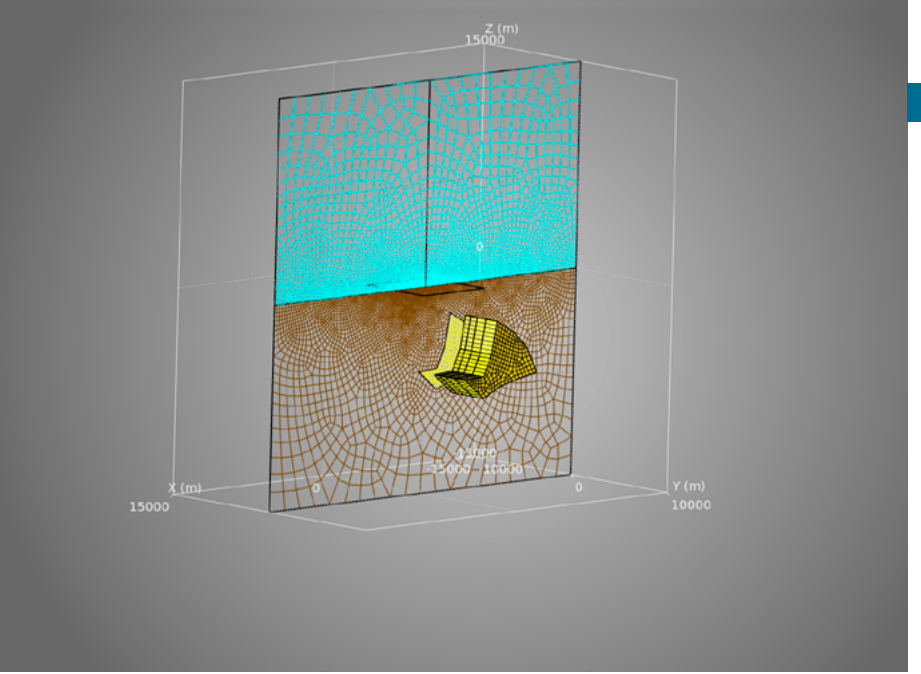
The project aims at collecting data and compile the first database on the trace element and metal isotopic composition of sphalerite from Zn-producing mines in Sweden. The resulting dataset will be evaluated using multivariate methods to define the analytical fingerprints of sphalerite from each deposit. The project will thus derive an independent traceability criteria which can be used for validating results based on other techniques, such as block-chain, or for assessing materials where block-chain data is not available. Expected effects are (among other) support-criteria for certifying Zn concentrates from Swedish mines and improved baseline isotopic and trace element data for tracing or constraining environmental pollutants related to Zn mining operations.



Predictive modeling of hydraulic hoses for underground mining

Project leader: Örebro University, Johannes Stork
Project duration: April 2020–September 2020
Partners: Epiroc Rock Drills

Most mining vehicles have hydraulic driven manipulators. The hydraulic fluid is transported over reinforced rubber hoses, which are often loosely attached and at risk of damage. This project is about modeling flexible hydraulic hoses that are connected to mining machines and aims to predict hose conditions under different machine configurations. In the long term, the results of this pre-study and following project will contribute to increased robustness and safety of underground drilling rigs, fewer maintenance operations, and more efficient and cost-effective ore extraction. This project will outline the accuracy of different models for predicting the future state of a hydraulic hose that undergoes deformations. In this project we will collect a dataset of representative deformations that a hydraulic hose undergoes while in operation and implement and configure state-of-the-art kinematic and dynamic models of a hydraulic hose. We will validate models on the collected dataset.



Spectral-element discretisation of ore body (yellow), host rock (brown) and air (cyan) showing plane cut at y = 0 m with projection of ore body onto plane, outer surface of ore body and transmitter loop at z = 0m (black square in x-y plane).

PRE-STUDIES

3D modelling of controlled-source electromagnetic fields adopted to mineral prospecting

Project leader: Uppsala University, Thomas Kalscheuer
Project duration: April 2020–September 2020

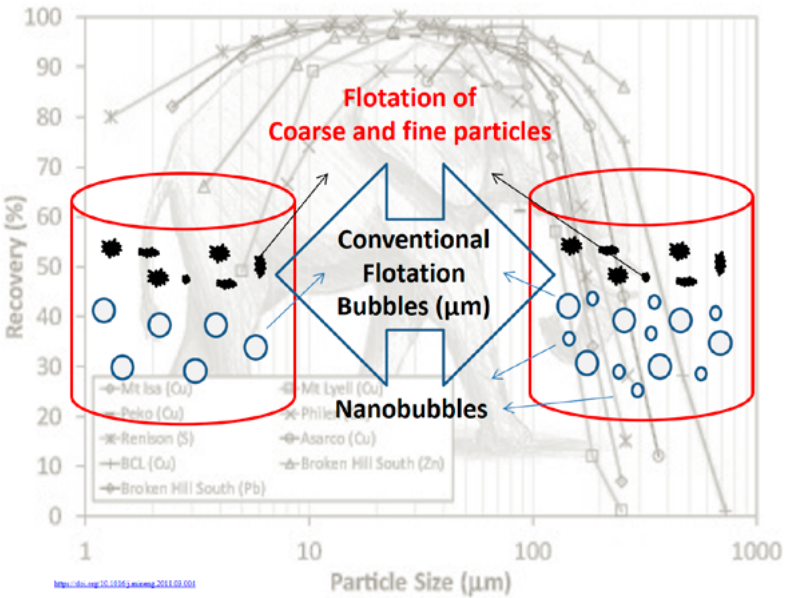
Ore exploration with electromagnetic (EM) measurements aims at ever greater depths (>1 km). The EM field is generated by an electric current in a 2 km * 2 km cable loop and is measured on the surface and in boreholes. However, computer modeling with simplifications of ore bodies as thin sheets in electrically insulating bedrock and of the varying current in the loop as a constant leads to unreliable models. We intend to improve the modeling with the spectral element method, a volumetric description of ore bodies and bedrock and an appropriate representation of the transmitter current. We will modify an existing program that uses the spectral element method and apply the program to model synthetic models with ore bodies to enable an accurate description of geometrically complex ore bodies and other structures in the bedrock and describe the transmitter current in an appropriate manner. In this way, we hope to contribute to improved models of ore bodies to reduce exploration costs. We will model EM fields for a number of synthetic models of ore bodies and other bedrock structures provided by Boliden AB.

PRE-STUDIES

Modelling for the selection of remediation strategies for TSF

Project leader: Luleå University of Technology, Christian Maurice
Project duration: April 2020–September 2020

The aim of the pre-study is to develop a strategy to design multilayer covers able to maintain the sealing layer close to water saturation and thereby to prevent oxygen transport. The success of the method is therefore dependent of the properties of i) the soil used in the cover ii) the cover design and iii) hydrological conditions at the site. The objective of the project is to build a numerical model to assess the function of the reclamation measures for tailings storage facilities and to be able to evaluate the performance of various reclamation scenarios. A numerical model predicting oxygen diffusion will be developed on a real case scenario planned for the Kittilä gold mine and the results from the development work done at LTU with green liquor dregs and till mixtures. The main activities of the project comprise a literature survey of models, training by École Polytechnique de Montréal for two PhD-students (financed by MSCSA-GEORES project) to take advantage of and apply EPM's experience of numerical modelling. Laboratory experiments will be done at LTU and EPM to evaluate of the properties of material available for the site.



PRE-STUDIES

ME - Mash the elephant

Project leader: Luleå University of Technology, Saeed Chelgani
Project duration: April 2020–September 2020
Partners: Boliden, LKAB

Nano bubble flotation can be considered as a green selective separation of ultrafine and coarse particles. Adding nano bubbles to conventional flotation conditions can widen the range of particle sizes that subjected for flotation separation. This pre-study investigates how the flotation efficiency of low-grade ores can be enhanced with lower energy, lower reagent consumption, and lower environmental impact via nano bubble flotation. The main tasks can be summarized as a compilation of successful applications, experimental: generation of nano bubbles (using hydrodynamic cavitation) in the presence of flotation reagents and study effects on different flotation parameters (bubble-particle detachment, and fine particle aggregation etc.). Literature survey and lab scale nano-bubble tests for different ores, consideration of design of flotation system and techno-economic assessment will be made.

PRE-STUDIES

AG-Test small scale tests for autogenous grinding scale-up

Project leader: Luleå University of Technology, Mehdi Parian
Project duration: April 2020–October 2020
Partners: Boliden

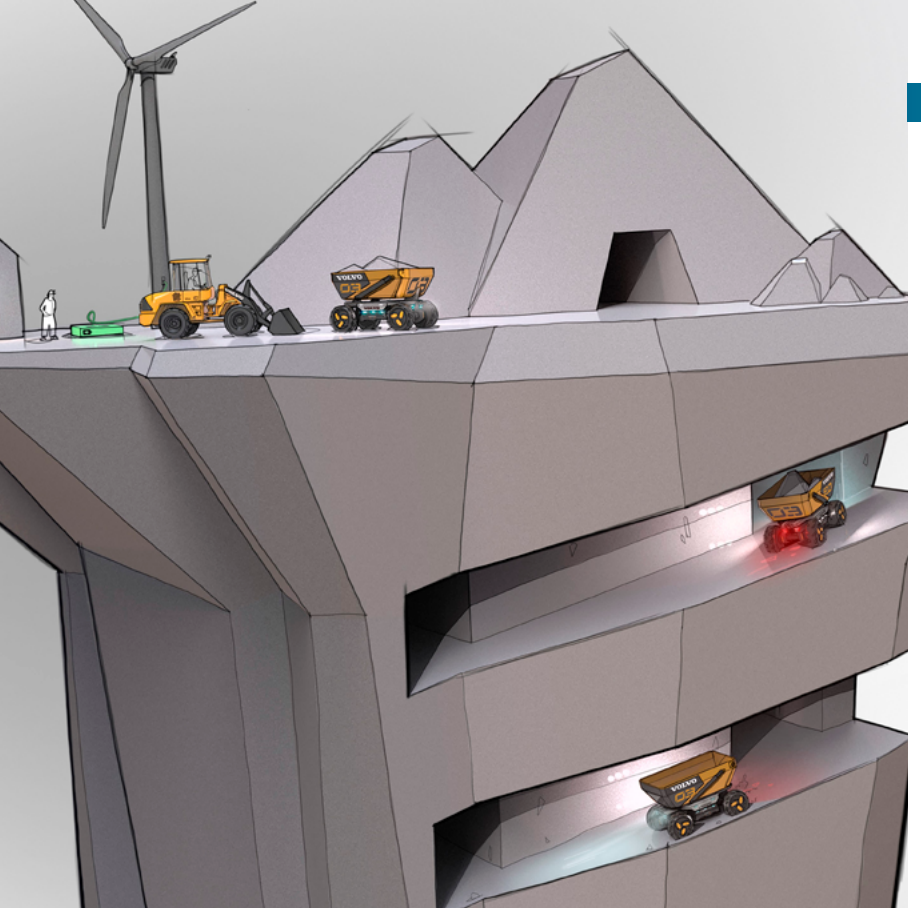
In mineral processing, grinding is generally done using rod, ball, autogenous, or semiautogenous mills. The fully autogenous grinding (AG) is the most cost and process efficient grinding by benefiting from eliminating steel grinding media and a superior choice for downstream processes such as flotation of some sulfide minerals that are sensitive to iron chipped away from the steel media. AG modeling, design and scale-up is still challenging and by some considered an engineering art. This pre-study project aims at identifying the state of the art and available test methods for up-scaling and operation and the path forward to systematically investigate dependency of ore properties and the breakage mechanism under realistic mill condition. In addition, the latest methods and technology available e.g. XCT (Xray computed tomography), micro-XRD (for analyzing residual stress) will be assessed to evaluate the behaviour of different pebbles in AG with samples of large stones from the partner´s premises and running indicative tests as well as analyzing the progression of micro-cracks into rock failure.

PRE-STUDIES

Evaluation of a drone-based method for safe and cost-effective monitoring of surface water flows in mine recipients

Project leader: IVL Svenska Miljöinstitutet, Ida Westerberg
Project duration: May 2020–October 2020
Partners: LKAB, Stockholm University

This pre-study aims to test and evaluate an innovative new method for improving the quality, safety and cost-effectiveness of surface water flow monitoring using drone imagery techniques. We will test and evaluate the ability of low-cost drone camera technology (so called structure from motion techniques) to provide high-quality input data for physically-based hydraulic flow modelling and its potential to thereby improve surface water flow monitoring. The project will test this new technology at a station monitoring one of the recipient water bodies of the LKAB Kiruna mine in northern Sweden. We will evaluate its potential for improving data quality, safe working environment, and cost-effectiveness in monitoring mine effects on local water bodies.



PRE-STUDIES

Off-road dynamic charging

Project leader: Volvo Construction Equipment, Anna Sannö
Project duration: March 2020–December 2020
Partners: Lund University

The project aims to evaluate whether the use of Off-road dynamic charging could enable a fully electrified mining operation. Objective for the project is to create system models for how dynamic charging can enable a fully electrified mining operation as well as investigate the conditions and partners for a technical demonstrator. The project includes modeling of an underground system based on machine use and various aspects of energy needs. A specification with system requirements will be prepared based on different energy solutions for mining. Modeling of different end customers' working cycles in rock quarry, above ground and underground mine will be carried out. Furthermore, the suitability of different charging solutions will be evaluated and a design of a charging system will be created based on customer application and work cycles.

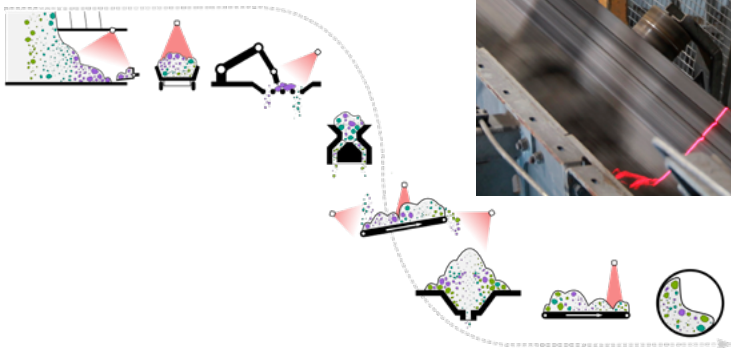
Photo: Veronika Geiger (DK)

PRE-STUDIES

Mining and metals in the transition to a sustainable society - An exhibition about current facts and figures

Project leader: Bergskraft Bergslagen, Lotta Sartz
Project duration: March 2020–August 2020
Partners: Georange, Teknikens hus, Geological Survey of Sweden, Federation of Swedish Farmers, Lovisagruvan

To be able to reach goals of Agenda 2030, we need to have a sustainable supply of metals, which are mined in a sustainable way, conflict free, environmentally sound and safe and with good working conditions. We need young people to engage, interact, and to have an impact on how we move forward. MineFacts, an EIT-RM financed project, assembled easily accessible, objective facts about mining, the mining industry and the permitting process with the purpose to communicate objective and fact-based information. This pre-study is about using this information to form the basis of an interactive exhibition named Metals4U. The aim is to develop specifications for design and manufacturing of interactive learning equipment about mining and the permitting process, with a focus on school children age 6–16.



STRATEGIC PROJECT

SMIG – Integrated smart testbeds for the mining industry

Project leader: Luleå University of Technology, Mats Johansson
Project duration: November 2019–July 2021
Partners: Boliden, Epiroc, ABB, Ericsson, BnearIT, Algoryx Simulations, SKB, Umeå University, Uppsala University, ThingWave

The degree of automation and digitalisation are constantly growing in the mining industry. Mining companies, for example, invest a lot into removing people from the production front, aiming at improving both safety and efficiency.
The SMIG testbed is for test and demonstration of intelligent mining technologies supporting innovation that are need for the mining industry in the future.
The development requires new solutions and products, solutions and products that need to be tested in reliable and efficient test beds. A first step of the project is to map the current situation to identify possibilities for test activities and product development. A first version of an integrated, smart test bed will be produced.
The new test bed must be able to handle several delicate problems. For example, the test bed should be able to take into account if there is competition between participating actors because all actors may not want to share all their results.
Other important aspects are related to business models to develop how the SMIG test bed will be financed and organised, and how can it support evaluation of new business models. The testbed will be demonstrated in a number of use cases.

STRATEGIC PROJECT

SIMS VR-mine in Teknikens Hus

Project leader: Stiftelsen Teknikens hus, David Dahlberg
Project duration: October 2019–June 2020

The purpose of this project is to awaken curiosity and show how a state-of-the-art mine works to society at large. Using developments from the EU project “Sustainable Intelligent Mining Systems”, SIMS, the project will create an exhibition at the science center, Teknikens hus, where visitors can gain a good understanding of how a modern mine works. The goal is to stimulate both boys’ and girls’ curiosity and interest in the mining industry and contribute to a more nuanced picture of the importance of mining for further development in society.

Photo: Truck: AKK Arcticcon/Pajala: PTE

STRATEGIC PROJECT

Mining and society

Project owner: Georange Ideella förening, Håkan Tarras Wahlberg
Project leader: AKK Arcticcon, Anna K Kostet
Project duration: October 2019–December 2020
Partners: Kaunis Iron, SGU, Svemin, Region Norrbotten, Luleå University of Technology

The purpose of the project is to identify and show the experiences and consequences that mining can have on the local community and on a regional level to create social acceptance and development. The project also intends to carry out activities that create enhanced understanding as well as positive results for gender equality, population structure and skills supply. The goal is to identify and develop activities to strengthen the community where mining is taking place, based on research and experience.

Photo: Ecogain

STRATEGIC PROJECT

The Swedish mining industry's current and future relationship with biodiversity

Project leader: Ecogain AB, Tove Hägglund
Project duration: October 2019–December 2020
Partners: Svemin

The aim of this project is to produce a description of the current situation and assessment of the future outlook of the Swedish mining industry's relationship with biodiversity at a comprehensive, strategic level. The goal is to produce a road-map for the Swedish mining industry on biodiversity issues.
The document will cover various aspects of biodiversity issues and include proposals for actions at different levels for how the industry should be able to reduce or completely avoid net losses of biodiversity in the future.

STRATEGIC PROJECT

Mines and minerals innovation summer

Project coordinator: LTU Business AB, Emil Svanberg
Project duration: December 2019–November 2020

The purpose is to arrange a national summer program where students work on thematic innovation cases within the mines and minerals value chain.
Four students divided into two teams complete two innovation cases in 2020. The innovation case has either been brought closer to the market or they have been dismissed, so-called fail-fast. The program and the innovation cases have been exposed to actors in the industry and in the innovation system.

STRATEGIC PROJECT

Tracemet – Traceability for sustainable metals and minerals

Project leader: IVL Svenska Miljöinstitutet, Erik Lindblom
Project duration: December 2019–December 2020
Partners: Svemin, RISE Research Institutes of Sweden, Boliden, LKAB, Elektrokoppar, SSAB, ABB, Scania, Volvo Group

This strategic project follows the successful project Traceability – for sustainable metals and minerals which was completed in May 2019. Tracemet will develop a pilot system to certify the origin of metals and minerals, the carbon footprint and the percentage of recycled materials - and make it traceable throughout the value chain. The system should be reliable, functional and distributed so that it can be used by various actors in the value chain. Such a system can drive the development towards a more sustainable metal production globally, by giving responsible producers a competitive advantage and improving the conditions and incentives for recycling metals and minerals. The TraceMet concept will be developed and evaluated for both steel and copper flows - two independent value chains. It will highlight opportunities and challenges for developing, implementing and using this type of traceable certification systems.
By spreading the results even outside the Swedish mining industry, interest and demand for this type of system solutions is expected to increase. This can lead to a positive spiral that, in the long run, will benefit responsible producers and thus contribute to more sustainable development.

Photo: Geopool

STRATEGIC PROJECT

Web training: environment and work environment for exploration drilling

Project leader: Svemin, Kerstin Brinnen
Project duration: September 2019–December 2020
Partners: Borrföretagen (Geotec)

The purpose is to provide a web-based training for drillers in both exploration drilling and other kinds of drilling. The goal is to increase knowledge and considerations of environmental and work environment aspects, thereby improving safety and environmental performance when drilling. It is possible, if required, to introduce certification linked to completed and approved education.

Photo: Niclas Dahlström, LTU Business

STRATEGIC PROJECT

Virtual Reality (VR) as a demonstrator and learning platform of sustainable, modern and innovative mining

Project leader: Luleå University of Technology, Hans Åhlin
Project duration: May 2020–May 2021
Partners: LTU, Boliden, LKAB, Epiroc, Tekniska museet, Teknikens hus

The project aims, by using a VR-mining environment, to reach out to young people to give them some basic knowledge and interest about the sustainable mining. In Sweden, there are 20 Science Centers and the environment is already used permanently in two of them (The Technical House in Luleå and in The Technical museum in Stockholm). The project will contact the other Swedish Science Centers and present the VR-environment. They will be offered the use of the VR-environment for free and the project will give them support and if needed education. The project will as well, according to input from the Science Centers, do minor updates on its VR-environment and the VR-education modules that were developed during the SIMS-project in 2017-2020. The overall goal for the project is to make young people interested in European sustainable innovative mines.
We want to get young people interested in working in the mining business and understand the need of sustainable mines as an enabler for the modern society.

SWEDISH MINING INNOVATION

CONTACT

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