SIP|STRIM PROJECTS 2018

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What is SIP STRIM?

The Strategic Innovation Programme for the Swedish Mining and Metal Producing Industry, SIP STRIM, has been running since 2013. The programme is funded by its stakeholders and partners, and by Vinnova, the Swedish Energy Agency and Formas.

The programme has its basis in the Strategic Agenda for the Swedish Mining and Metal Producing Industry (available for download at www.sipstrim.se), and all projects within the programme aim to realise the goals and vision stated in the agenda. Apart from innovation projects, the programme 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 full-scale innovation projects, pilot tests and demonstration projects. All projects are initiated by our various stakeholders and each full-scale 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 managers or SIP STRIM.

Contents

PILOT PROJECT

Test and evaluation of mechanical tunneling with TBS

Project leader: Urban Holmlund, Bergteamet AB, urban.holmlund@bergteamet.se
Project duration: 2017–2018

The project will assemble and test a Tunnel Boring System (TBS) with the overall goal of introducing the technology into the Nordic market by creating a reference tunnel and demonstrating the benefits at Äspö Hard Rock Laboratory. The project will evaluate the TBS method with the drilling and blasting technology as the reference method. An introduction of the TBS technology is expected to have the following effects:

- Increased efficiency with tunnel production of up to 12 m per day.
- Work towards automated tunnel production.
- Improved tunnel quality with reduced risk of rock-fall.
- Better work environment with less work at the tunnel front.
- Reduced environmental impact by minimising use of explosives.
- Better economy and production efficiency by minimising excess rock.
- Amore gender-neutral workplace.

Partners: Bergteamet AB, Svensk Kärnbränslehantering AB, Luleå University of Technology, Umeå University

Floating wetlands in mesocosms at the clarification pond to study nitrogen removal via plant uptake and denitrification. Photo: Frauke Ecke.

Mesocosms to study nitrogen processes in pond water and construction of bioreactor for nitrogen removal. Photo: Roger Herbert.

FULL-SCALE PROJECT

Reduction of nitrogen discharges in mining processes and mitigating its environmental impact – miNing II

Project leader: Frauke Ecke, Swedish University of Agricultural Sciences, frauke.ecke@slu.se
Project duration: 2014–2018

The expected result of miNing is the identification of biological treatment techniques that successfully remove reactive nitrogen from mine site drainage, so that recipient concentrations are maintained at levels that are in agreement with the legislation. The project develops a series of treatment systems that can be used independently or in combination for the purpose of removing nitrogen from mine discharge waters. The systems involve passive or semi-passive treatment methods that require a minimal amount of energy to maintain in operation. These systems rely on the activity of efficient microbial communities that transform nitrogen compounds to harmless nitrogen gas. The systems will be evaluated at LKAB's site in Kiruna and the treatment methods are expected to be applicable for mining in areas with cold climate.

Partners: LKAB, Boliden, Luleå University of Technology, Uppsala University, Nordic Rock Tech Centre AB

Photo: LKAB.

FULL-SCALE PROJECT

Improved resource efficiency through dynamic loading control

Project leader: Håkan Schunnesson, Luleå University of Technology, hakan.schunnesson@ltu.se
Project duration: 2014–2019

The goal of this project is to improve resource efficiency by designing a new draw control strategy. The project combines state-of-the-art, investigation of existing control models and procedures, workshops, data analysis, exploration of work procedures, interviews, model development and mine tests. The project will result in a new draw control strategy which is dynamic in nature. Bayesian statistics is being used to create a probabilistic model which can address the variation in the loading process such as side rock dilution, fragmentation, etc. The model aims at improving resource efficiency and sustainability by reducing both ore loss and side rock dilution, giving optimum extraction rate per production level and better control over the metal content.

Partners: Nordic Rock Tech Centre AB, LKAB, Agio, ABB, Boliden AB

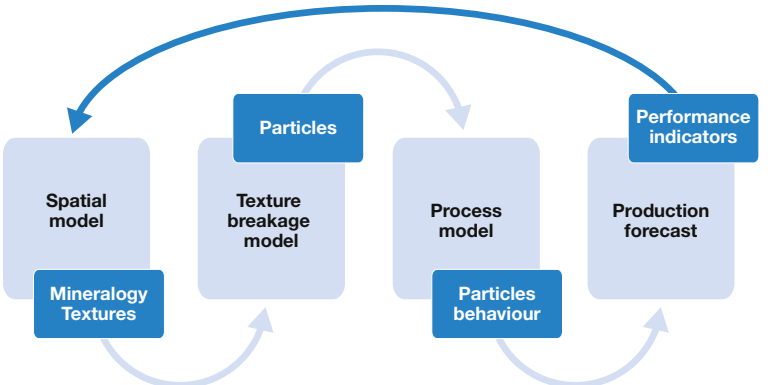
FULL-SCALE PROJECT

Utilisation of industrial residuals for prevention of sulphide oxidation in mine wastes

Project leader: Lena Alakangas, Luleå University of Technology, lena.alakangas@ltu.se
Project duration: 2014–2018

Sulphide oxidation is the main reason for generation of metalliferous water, and one of the most challenging environmental problems to solve. This project aims to reduce sulphide oxidation. The project is divided into three subprojects: **1.** Development of dry cover consisting of green liquor dredge (GLD) from the paper mill industries. The main objective was to evaluate if a blend of GLD and till can replace clayey till as a sealing layer. So far the results are positive. **2.** Inhibition of sulphide oxidation aims at reducing the oxidation in waste rock during operation. The results show a significant reduction of the sulphide oxidation and release of metals and metalloids when adding lime kiln dust and fly ash to the waste rock. Future research includes identification of secondary minerals and trace elements. **3.** Dissolution of secondary minerals under changed chemical conditions. The results show partial dissolution of secondary minerals and release of metals when oxygen concentration declines.

Partners: SSAB, Nordkalk, Boliden AB, Cementa, Dragon Mining, Processum, Luleå University of Technology



FULL-SCALE PROJECT

PREP – Primary resource efficiency by enhanced prediction

Project leader: Cecilia Lund, Luleå University of Technology, cecilia.lund@ltu.se
Project duration: 2014–2018

To improve primary resource utilisation, reduce waste and emissions, and to be more energy and water efficient, an accurate and reliable prognosis of all product and by-product flows and their composition is needed. Such a prognosis must be able to handle time-dependent variations like changes in ore quality, market fluctuations and changes in the process. The key to an enhanced production prediction lies in more detailed and uniform descriptions of the ore resource, plant feed and process streams. Key properties are minerals, their chemical composition, mass proportions and textures. Correspondingly the process models need to be taken to a particle and mineral liberation level. This enables the simulation of the entire mineral production chain from the heterogeneous primary resource via variable plant feed to the mineral processing plant in one platform. The project aims at the development of an integrated modeling and simulation environment for conducting a model based prognosis for enrichment of primary mineral resources.

Partners: Lundin Mining, LKAB, Boliden AB, Luleå University of Technology, Chalmers University of Technology, Outotec

FULL-SCALE PROJECT

HIFLOAT – Individual sizing of flotation cells

Project leader: Jan Rosenkranz, Luleå University of Technology,
jan.rosenkranz@ltu.se
Project duration: 2014–2018

Within flotation technology the general trend is towards very large cells, and today flotation cells of 100 m^3 and more are common. Scale-up is usually done by postulating geometrical similarity. Keeping the aspect ratio constant when increasing cell volume leads to a series of similar flotation cells. The design of flotation circuits then involves several cells of identical geometry within a bank in order to facilitate equipment design and maintenance. Increasing cell height, on the other hand, causes changes in the cell hydrodynamics that can't be neglected, e.g. the hydrostatic pressure increases, the paths of particle-bubble agglomerates get longer, and mixing action is no longer homogeneous. Also the froth layer can be deeper with taller cells and smaller diameters. Despite the evidence the effects of these changes on the flotation process have not been systematically investigated. Within this project, a lab-scale and a mobile pilot-scale flotation cell will be designed with options for changing cell height.

Partners: LKAB, Boliden AB, Luleå University of Technology

FULL-SCALE PROJECT

Development of a new methodology for evaluating rock support performance in seismically active mines

Project leader: Erling Nordlund, Luleå University of Technology,
erling.nordlund@ltu.se
Project duration: 2014–2018

Increased mining depth is associated with increasing stress magnitudes which often results in mining-induced seismicity. This project develops new methods for evaluating the damage potential that use all available information about (i) the source of the seismic event obtained from the seismic network in the mine, and (ii) the consequences of the seismic loading in terms of damage to the underground openings and the rock support. The objective is to reduce the number of production disturbances caused by poorly understood rock mass and rock support response, thereby decreasing the risk for personnel injury and production losses. The proposed new methods are based on two different principles of collection and use of available information: (i) forensic investigation immediately after a seismic event, thereby reducing the loss of information and "contamination" of the site, and (ii) comprehensive monitoring combining the information from the mine-site seismic system.

Partners: Lundin Mining, LKAB, Boliden AB, Luleå University of Technology

Dynamisk falltestrigg.

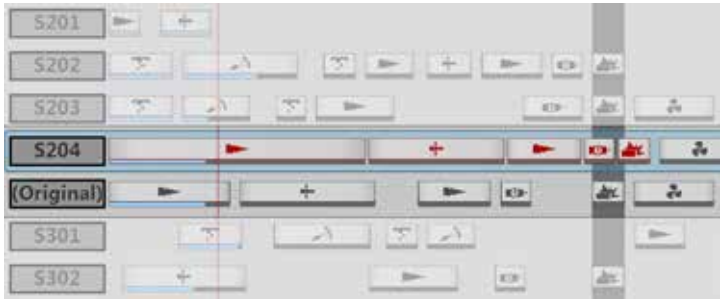
FULL-SCALE PROJECT

Development of a test method and facility for generic rock bolt performance tests

Project leader: Mats Karlberg & Lars Sandberg, Swerea Mefos,
lars.sandberg@swerea.se
Project duration: 2015–2018

Deep level mining will increase dramatically during the coming future. In combination with increased safety focus, an increased market need for rock supporting systems to secure underground excavations in the future is expected. Rock bolts are categorised into friction, two-point anchored and grouted types. Due to the trend of deeper mining also the risk for squeezing and rock bursts are getting much more frequent. Energy absorption and dynamic load capacity are two aspects are important properties a future rock bolt must provide in order to perform well. This project aims to make tests of different types of rock bolts comparable. The project will deliver a basis for standardisation and a prototype for dynamic test of all types of rock bolts.

Partners: Galvano TIA AS, Northern Mining Products AB, RUUKKI Sverige AB, Swerea Mefos AB



FULL-SCALE PROJECT

Optimised medium range mine planning

Project leader: Jan Nyqvist, ABB, jan.nyqvist@se.abb.com
Project duration: 2015–2017

Scheduling of mine operations is complicated by the large variations of input parameters, which in, addition is constantly changing, leading to a tedious task which demands managing of several hundreds of activities per week. Scheduling and planning tools exist for single processes alone, but no tool has been constructed to coordinate all processes and including real-time information. Such a solution would have a large implication for in-mine resource and production optimisation through timely management of real-time delays mitigating the risk of unplanned stops in production through early rescheduling, yielding lower operation costs due to better utilisation of resources.

This project aims to build and demonstrate a working prototype of a tool, designed to coordinate real-time information and actions of mining processes, to optimise the scheduling of resources used in mining.

Partners: ABB, Boliden Mineral AB, Luleå University of Technology, Nordic Rock Tech Centre AB

Photo: Boliden.

FULL-SCALE PROJECT

Innovative quality assured fayalite slag products (IQSLAG)

Project leader: Caisa Samuelsson, Luleå University of Technology,
caisa.samuelsson@ltu.se
Project duration: 2016–2019

The aim of this project is to develop new circular use of the fayalite slag from base metal smelters and to assure the environmental quality of present and new slag products. This will need extensive development work and collaboration between mining, mineral and metallurgical industry, construction companies and development of measurement techniques. A fundamental understanding of mechanisms occurring in the processing of liquid slag will enhance the possibility to modify the slag with the purpose to produce tailor-made products based on the slag. Understanding of the long term leaching mechanisms of solidified slag products and the influence of ambient conditions, ageing, will give valuable information for a sustainable use of material.

Partners: Luleå University of Technology, Nordkalk, Boliden Mineral AB, PEAB, XORE AB

FULL-SCALE PROJECT

Development of closing and reopening criteria for seismically active mines

Project leader: Savka Dineva, Luleå University of Technology, savka.dineva@ltu.se
Project duration: 2016–2019

A typical problem related to deep mining is mining-induced seismicity which in principal means that events similar to earthquakes occur as a result of the mining and the resulting stress re-distribution. This project aims to combine all available state-of-the-art knowledge and experience worldwide with high-quality unique data for seismic event parameters, local stress changes, and damage due to seismic event (rockbursts) and develop criteria specific for underground mines in Sweden that can be used for closing or re-opening of specific areas in case of increased seismic risk.

Partners: Luleå University of Technology, LKAB, Boliden AB

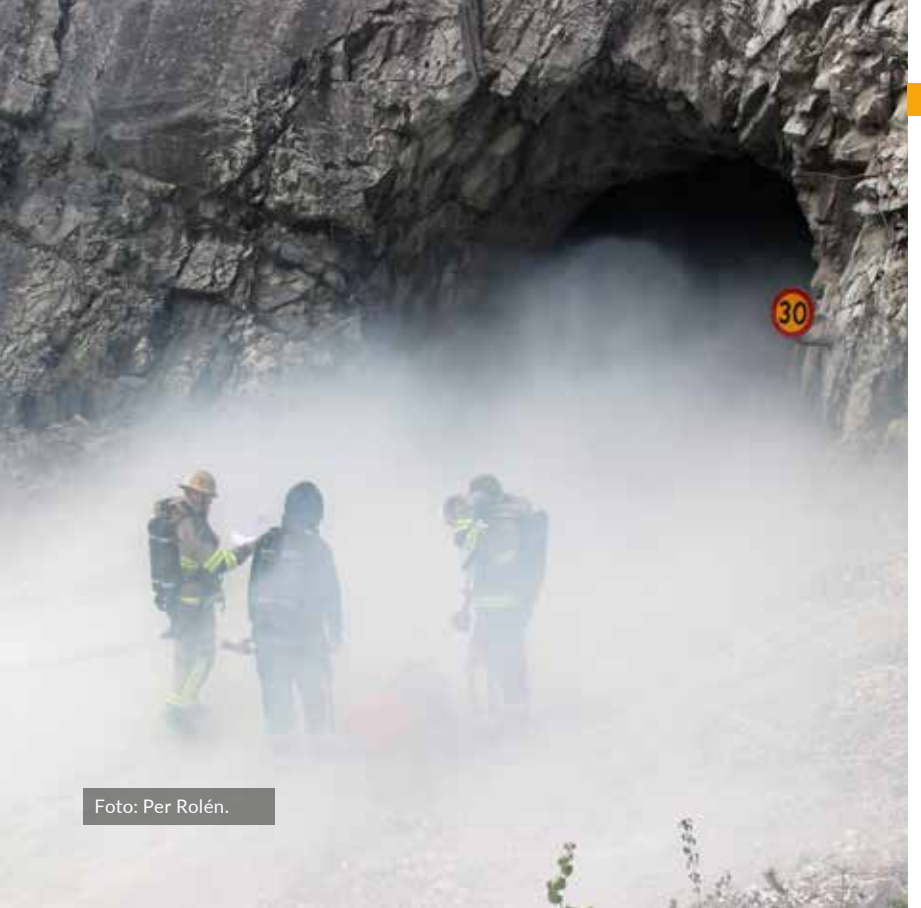


Foto: Per Rolén.

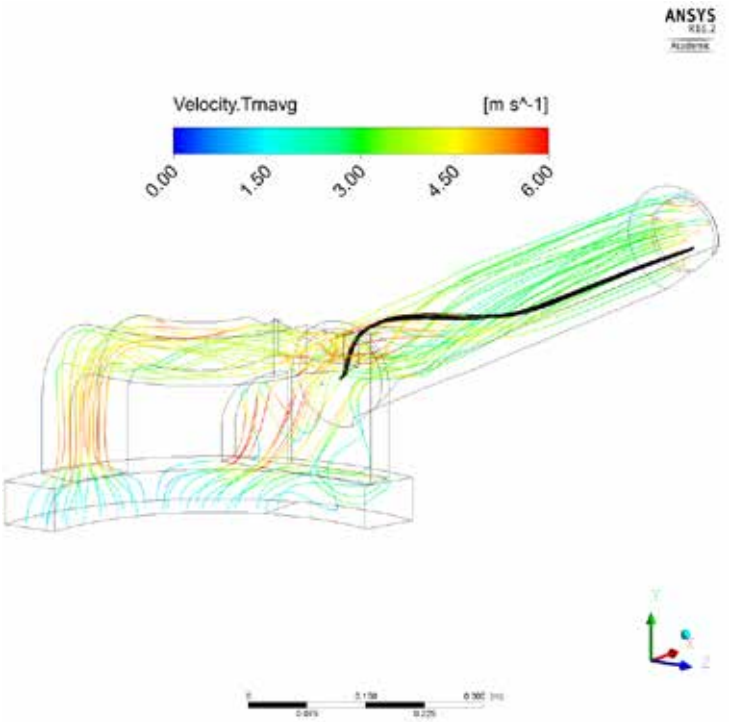
FULL-SCALE PROJECT

SafePos II – Safety positioning for the mining industry II

Project leader: Haukur Ingason, RISE Research Institutes of Sweden AB, haukur.ingason@ri.se
Project duration: 2016–2018

The project focuses on better possibilities for positioning and connectivity during fire and rescue operations in mines. The project comprises development of relevant technology, adaption towards visualisation systems used in mines, investigation of possibilities for and development of new first responder technology in order to facilitate movement, BA-surveillance, and information exchange between the scene of fire and the command and control center by using the improved positioning and connectivity systems.

Partners: Luleå University of Technology, Skellefteå kommun, LKAB, Dräger Safety, Boliden AB, Alecom, SP, Interspiro, Mobilaris, SICS Swedish ICT



FULL-SCALE PROJECT

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

Project leader: Staffan Lundström, Luleå University of Technology,
staffan.lundstrom@ltu.se
Project duration: 2017–2020

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.

Partners: Luleå University of Technology, LKAB, Taoshi Energiteknik AB

Photo: Niklas Juhojuntti

FULL-SCALE PROJECT

Walk the talk – sustainability management system for social acceptance

Project leader: Helena Ranängen, Luleå University of Technology,
helena.ranangen@ltu.se
Project duration: 2017–2020

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.

Partners: Luleå University of Technology, Boliden AB, Svemin

Illustration: J Rojmar.

FULL-SCALE PROJECT

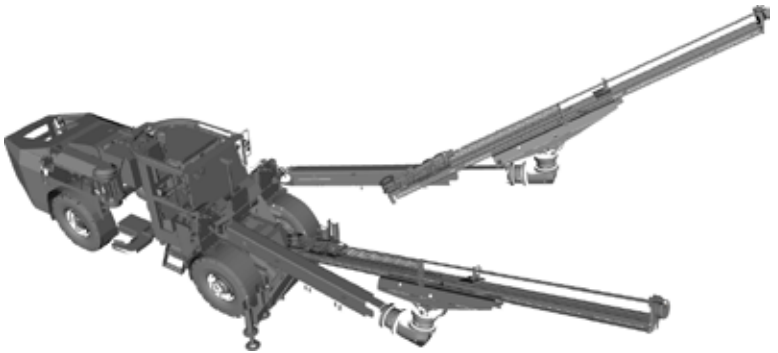
Field test of FBG-based sensor system – beneficial for industry and society

Project leader: Linda Sharp, Maskinteknik i Oskarshamn AB,
linda@maskinteknikab.se
Project duration: 2017–2019

The project intends to further the development process, to get closer to product and commercialisation of an FBG-based sensor system for measuring bedrock movements. The project has three main objectives: 1) to further develop and manufacture an FBG-based sensor system, 2) to field test the sensor system in the Äspö Hard Rock Laboratory for one year to verify its stability and reliability, and 3) to develop a plan for commercialisation.

The project is managed by the company in close collaboration with the project group and a reference group consisting of numerous stakeholders and experts from the mining, infrastructure, and nuclear waste storage industries. When the project is completed, the sensor system should have reached TRL 5–6.

Partners: Maskinteknik i Oskarshamn AB, Svensk Kärnbränslehantering AB (SKB), RISE Acreo AB, SKB Näringslivsutveckling AB, Oskarshamns kommun



FULL-SCALE PROJECT

Tracking and control of articulated machines through remote sensing

Project leader: Todor Stoyanov, Örebro University, todor.stoyanov@oru.se
Project duration: 2017–2020

A key enabling technology for remote machine operation is the ability to estimate and control the full machine state. In the this 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.

Partners: Örebro universitet, Alfred Nobel Science Park, Atlas Copco Rock Drills, Zinkgruvan AB

Photo: Lars deWall.

FULL-SCALE PROJECT

Face-to-Mill

Project leader: Daniel Johansson, Luleå University of Technology,
daniel.johansson@ltu.se
Project duration: 2017–2019

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.

Partners: Luleå University of Technology, Atlas Copco, Boliden AB, Forcit Sweden AB

Photo: Khushie singh (CC BY-SA 4.0)

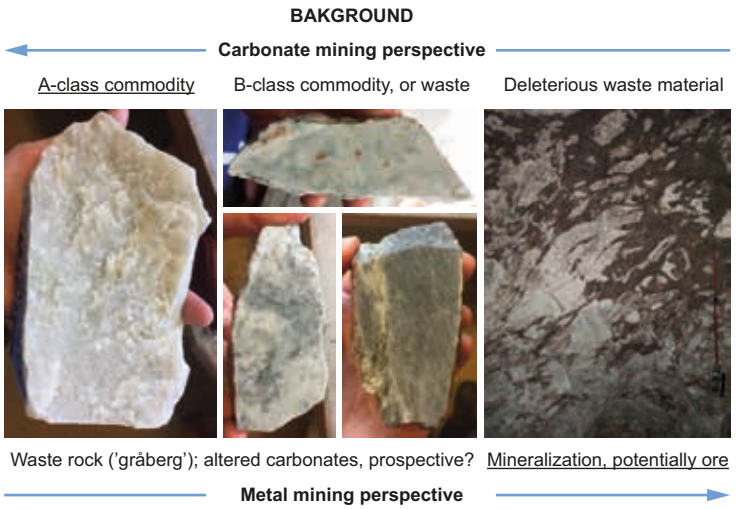
FULL-SCALE PROJECT

Face-to-Surface II – Improved production efficiency in sublevel caving

Project leader: Håkan Schunnesson, Luleå University of Technology, hakan.schunnesson@ltu.se
Project duration: 2017–2019

The objective of the project is to increase production capacity and reduce production cost for sublevel caving mines by optimising fragmentation, using optimised blast hole sizes, improved chargeability, a new technique for boulder handling and improved overall production planning. The research methodology combines state-of-the-art investigation, machine monitoring, borehole filming and video recording, using data mining and big-data analysis, interviews and field tests. The project will develop production tools for material characterisation for charging support. The project will also provide a deeper understanding of how hole sizes influence ground vibrations. The project will develop procedures for how production planning can be improved by better rock mass characterisation and generate a better and deeper understanding of how mobile boulder breakers can reduce production disturbances.

Partners: Agio system och kompetens i Skandinavien AB, Atlas Copco, Luleå University of Technology, LKAB



FULL-SCALE PROJECT

VectOre – Exploration criteria for polymetallic sulphide mineralisation and industrial carbonates

Project leader: Nils Jansson, Luleå University of Technology, nils.jansson@ltu.se
Project duration: 2017–2020

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.

Partners: Luleå University of Technology, Björka Mineral AB, Boliden AB

FULL-SCALE PROJECT

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

Project leader: Karin Beland Lindahl, Luleå University of Technology,
karin.beland.lindahl@ltu.se
Project duration: 2017–2020

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.

Partners: Luleå University of Technology, CAMECO, Das Nedhe Development, English River First Nation, University of Northern British Columbia, University of Saskatchewan

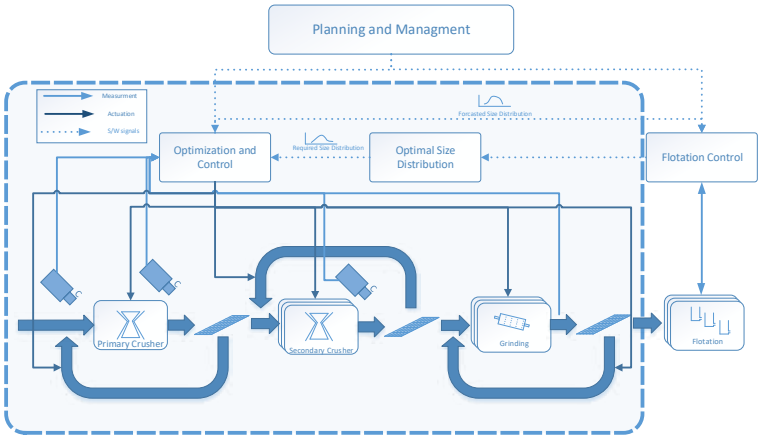
FULL-SCALE PROJECT

Estimation of the risk of rockfall and optimisation of rock reinforcement in deep underground mines

Project leader: Erling Nordlund, Luleå University of Technology,
erling.nordlund@ltu.se
Project duration: 2017–2020

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.

Partners: Luleå University of Technology, Lundin Mining, Boliden AB, LKAB



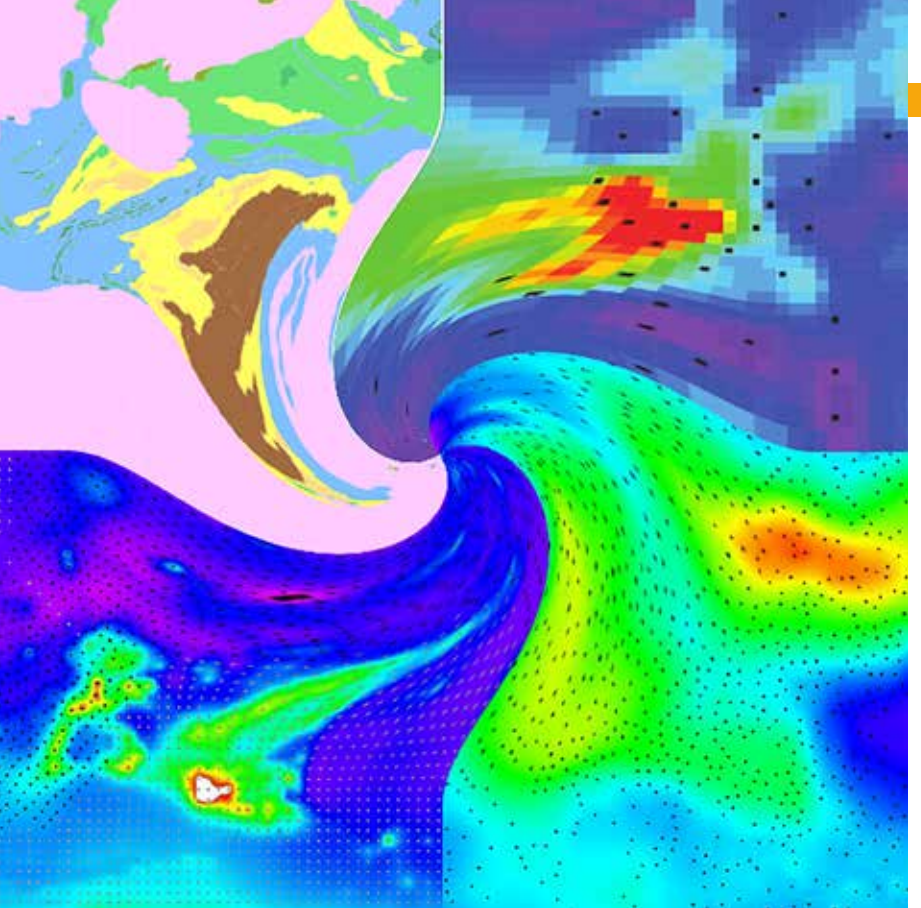
FULL-SCALE PROJECT

Efficient comminution operation (ECO)

Project leader: Andreas Johansson, Luleå University of Technology, andreas.johansson@ltu.se
Project duration: 2017–2020

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 will 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 optimised 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.

Partners: Luleå University of Technology, Innovative Machine Vision Pty Ltd, Optimation AB, Vale S.A.



FEASIBILITY STUDY

Integrated inversion for vintage geophysics in mining exploration

Project leader: María de los Angeles García Juanatey, Uppsala University, maria.garcia@geo.uu.se
Project duration: 2017–2018

Nowadays, integrated inversion (referring to approaches involving joint, cooperative or constrained modelling) of different data sets offer more accurate geological models by taking advantage of the complementary nature of diverse geophysical data sets. Beside being more accurate, the models are also consistent with each other forming a Common Earth Model. The improved accuracy of the models will also be observed at depth, where models from integrated inversion approaches have better resolution. As geological models become more reliable, drill hole locations can be more sparse and better located, meaning that the total amount of drilled holes can be reduced. In this project, we want to test the feasibility of using this technology on existing geophysical data sets given the means to create a petrophysical relationship to link them.

Partners: Uppsala University

SIHDS drill rig at Wassara.
Photo: Monika Ivandic.

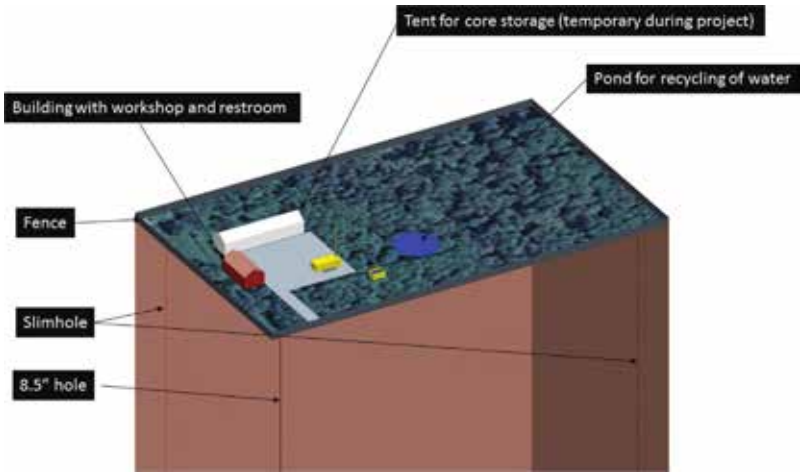
FEASIBILITY STUDY

Seismic imaging with hammer drilling as source: SIHDS

Project leader: Christopher Juhlin, Uppsala University, christopher.juhlin@geo.uu.se
Project duration: 2017–2018

The project is testing if the signals from the Wassara hammer can be used for seismic imaging of the surrounding rock. The reason for this is twofold: The hammer is expected to generate stronger seismic signals than normal diamond bit coring. Furthermore, LKAB Wassara already has a measurement while drilling system in place that records the drill bit signature at the rig site. A preliminary test was carried out next to the Wassara factory while drilling to about 270 m. Correlation of the pilot signal from the hammer with the signals recorded on the surface generated useful data that are currently being analysed. It is expected that further processing can lead to useful seismograms that can provide information on the surrounding rock and help to determine when to change from hammer drilling to core drilling in future exploration projects.

Partners: Uppsala University, LKAB Wassara AB



FEASIBILITY STUDY

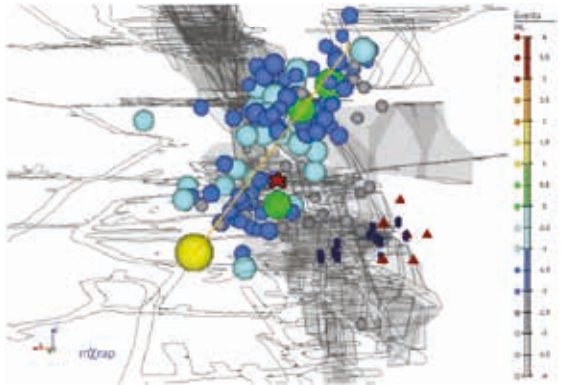
Innovative exploration drilling and data collection test center: I-EDDA-TC

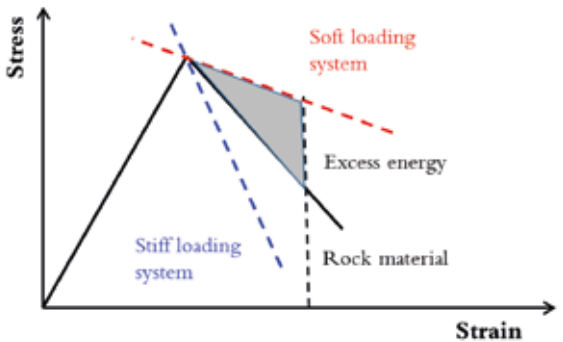
Project leader: Christopher Juhlin, Uppsala University, christopher.juhlin@geo.uu.se
Project duration: 2017–2018

The project investigated the feasibility of establishing a test center where industry and researchers can test new exploration drilling methods, new data acquisition methods while drilling and new data acquisition instruments related to exploration drilling. Epiroc (formerly Atlas Copco) has an ideal location for such a test center next to its factory in Örebro.

Two main results have come out of the study: 1. A suitable locality has been identified to establish the I-EDDA test center, by taking into consideration different factors that affect the suitability of the chosen locality; 2. An application for financing to establish the test center has been sent to EIT RawMaterials. If the application is successful, logistics and support surrounding the test center will be built on the groundwork of the I-EDDA Network of Infrastructure (www.iedda.eu), providing a high impact aspect to the project. I-EDDA researchers will provide drilling and data acquisition technology and ideas that will allow new products and services to be tested and verified.

Partners: Uppsala University, Atlas Copco Rock Drills AB





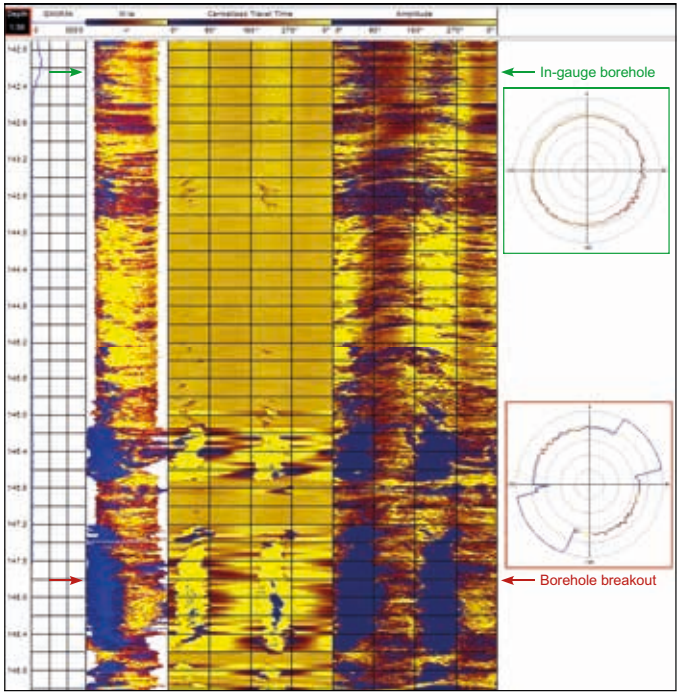
FEASIBILITY STUDY

Development of a numerical modeling method for assessing the risk of seismically induced damage in deep mines

Project leader: Ping Zhang, Luleå University of Technology, ping.zhang@ltu.se
Project duration: 2017–2018

The purpose of the project is to improve mining safety, decrease damage to mine infrastructure and mining equipment, decrease production disturbances and reduce ore losses caused by dangerous rockburst events. The detailed objectives are to: develop a numerical modelling methodology for assessing burst potential at deep underground mines, develop modelling-based burst assessment procedure for given Swedish underground mine settings, and improve the understanding of unstable failures of rock and discontinuities that lead to rockbursts in Swedish underground mines. The expected results will comprise a calibrated numerical modelling methodology at mine scale, and a modelling-based burst assessment procedure for given Swedish underground mine settings.

Partners: Luleå University of Technology, Lundin Mining, LKAB



Example of borehole televiewer data from one of the boreholes in Malmberget from the logging analysing program WellCAD.

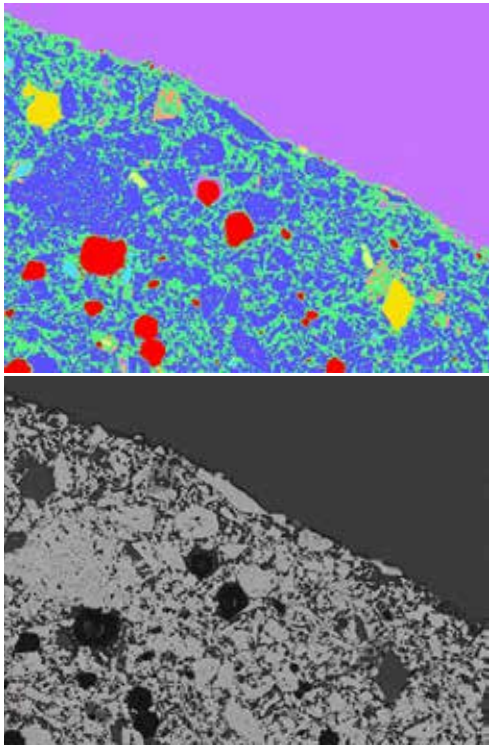
FEASIBILITY STUDY

Estimation of the stress state from stress-induced failures and data from drill core

Project leader: Maria Ask, Luleå University of Technology, maria.ask@ltu.se
Project duration: 2018

The aims of this pre-study are to: 1. Constrain the state of stress from stress-induced failure (SIF) and drill core data from 1.0–1.8 km depth in the LKAB mine in Malmberget. Problems in operation for traditional methods start to occur at these depths. The results will be validated against other stress measurement methods. 2. Consider the influence of structures and geochemistry for the estimation of the stress magnitudes. 3. If possible, prepare for a full-scale innovation or pilot project on constraining the state of stress in using SIFs and drill core data. The plan is to test and develop a new, cost-effective method for constraining the state of stress at greater depths, and to validate the results against e.g.hydraulic injection data. This will lead to improved safety, and provide critical data for the design of deeper level mining.

Partners: Luleå University of Technology, Fracsinus Rock Stress Measurements AB



Iron ore pellets before and after segmentation using machine learning.

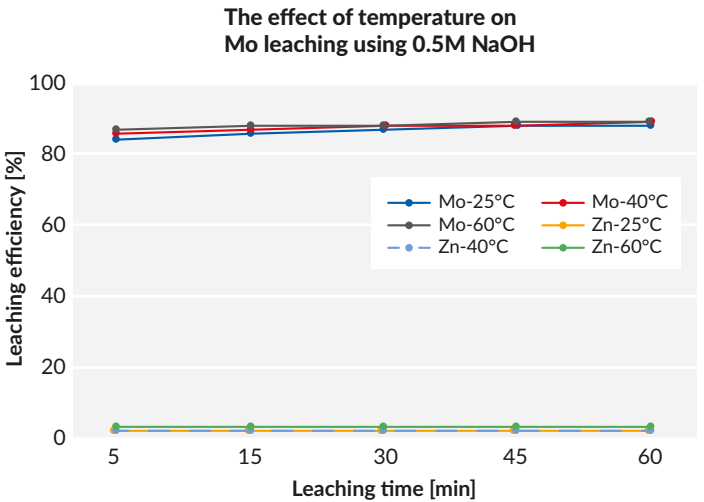
FEASIBILITY STUDY

Quantitative characterisation of iron ore pellets with optical microscopy and machine learning

Project leader: Martin Simonsson, Ductus Preeye AB,
martin.simonsson@preeye.se
Project duration: 2017–2018

The goal was to evaluate the potential of a system with quantitative characterisation of iron ore pellets based on automated microscopy, image analysis and machine learning. A relevant dataset with annotated microscopic images with iron ore pellets was created by optical microscopy experts. This was then used to train and evaluate a number of classifiers. After the training, the system could reliably identify a number of relevant phases like hematite, magnetite and metallic iron. The results matched well the information gathered manually, and contributed more information than previous systems. Some phases proved difficult to evaluate even for optical microscopy experts. The potential for this new approach is considered to be very large, and could contribute to labour reduction and increased knowledge. Code optimisation and user interface development were assessed as prerequisites for a commercial system.

Partners: Ductus Preeye AB, LKAB



FEASIBILITY STUDY

Extraction of molybdenum as an added value in steel production

Project leader: Martina Petranikova, Chalmers University of Technology, martina.petranikova@chalmers.se
Project duration: 2017–2018

The goal of the project was to study the possibility of recovering molybdenum from steel making dusts by alkaline leaching followed by solvent extraction. The process design aimed to separate molybdenum from zinc, since zinc is an unwanted element in the steel making process. A molybdenum product can be utilised in the steel production as alloying additive or used for other applications. The goal of the project was successfully achieved. The project determined the optimal conditions for the selective leaching and solvent extraction process together with the parameters required for potential up-scaling. Determination of optimal leaching conditions can provide crucial technological parameters for the selective recovery of molybdenum from steel making dust instead of the landfilling. Development of a solvent extraction process for separation of molybdenum and zinc will increase the recovery efficiency for both metals and will improve the re-utilisation possibilities for molybdenum in the steel making sector.

Partners: Chalmers University of Technology, MEROX AB

Photo: Örjan Johansson.

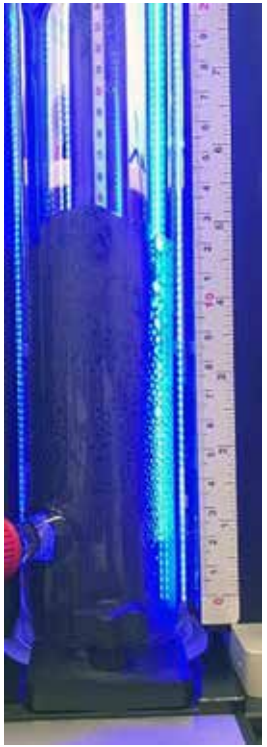
FEASIBILITY STUDY

Energy efficient and intensified leaching with ultrasound controlled cavitation

Project leader: Örjan Johansson, Luleå University of Technology,
orjan.johansson@ltu.se
Project duration: 2017–2018

This project aim to further develop a method based on ultrasound controlled cavitation to improve the recovery rate in a leaching process. Initial results increased the yield by 21% compared with traditional leaching. The aim of this new project is to maximise the yield via a better optimised reactor tube, a longer exposure time, a re-design of the nozzle for flow initiation of cavitation bubbles, and using a higher process temperature. This means multiplying the added energy to the material to be leached in a further developed reactor geometry, optimised excitation signal and an increased cavitation intensity (increased static pressure). The aim is also to involve a manufacturer of process equipment. The result is expected to give a yield comparable to or better than existing autoclave technologies.

Partners: Luleå University of Technology



Mineral froth building up during an experiment using the dynamic foam analyzer. Photo: Marie Ernstsson.

FEASIBILITY STUDY

MinFroth – Characterisation of froth in mineral flotation of sulphide ores

Project leader: Marie Ernstsson, RISE Research Institutes of Sweden AB, marie.ernstsson@ri.se
Project duration: 2017–2018

The objective of this pre-study is to provide and demonstrate an effective approach for characterisation of froth in mineral flotation. The approach focuses on using a portable dynamic foam analyzer for froth characterisation of samples taken from different steps in the mineral flotation processes. For an increased understanding, the froth characterisation will be combined with analyses of different material fractions, e.g. analyses of particle size and chemistry, in order to increase the knowledge about froth formation in mineral flotation. An approach for characterisation of froth in mineral flotation can show possibilities for more efficient optimisation of froth formation in different process steps, which can provide several industrial benefits, both environmental and economical. The focus here is on mineral flotation of sulphide ores, but note that the possibility to optimise froth formation in a more effective way is of general interest for mineral flotation of different type of ores.

Partners: RISE Research Institutes of Sweden AB, Boliden Mineral AB

Phoenix drone concept (indoor version, collision avoidance system and propeller protection not shown). Composite materials that can sustain up to 1000 °C. Internal cooling and heat shields for external components would be used. The motor-to-motor span is under 50 cm.

FEASIBILITY STUDY

Phoenix mine drone

Project leader: Pau Mallol, Inkonova AB, pau.mallol@inkonova.se
Project duration: 2017

The project has focused on three areas for the development of the Phoenix mine drone.

1. Propeller aerodynamics: Simulation models were validated against in-house bench tests with a computerized thrust test bench for different rotational speeds at stationary air conditions. We intend to extend the blades and increase the angle of inclination to compensate for the reduced drag force at high temperatures.

2. New drone concept: A new drone design concept with two central propellers and a streamlined shape to minimize the heat transfer will give a better performance without increasing the drone size.

3. Increasing the reliability of the drone and developing the anti-collision system: The reliability and the base of Phoenix has been tested as well as the underground-adapted collision avoidance system necessary for navigating in unknown environments. Most of the components have been characterized and a custom motherboard has been created.

Partners: Inkonova AB, F. Bagheri (GoVirtual AB), Stefan Wallin

Photo: Lena Abrahamsson.

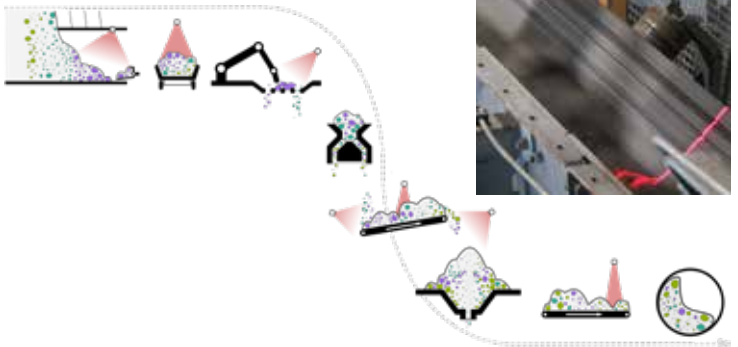
STRATEGIC PROJECT

Diversity, gender equality and attractive workplaces in the Swedish mining industry

Project leader: Kristina Johansson, Luleå University of Technology,
kristina.johansson@ltu.se
Project duration: 2017–2018

The purpose with this project is to identify, develop and describe a number of major project proposals and partnerships that address some of the short to medium term goals identified in STRIM 2017–2020. The project begins by recapitulating research and innovation needs. Then, interactive activities are conducted that collect participants from companies, subcontractors and contractors, academia as well as authorities and associations, with the purpose of generating and developing a number of possible topics and themes in need of further research. Finally, we will collect, analyse and communicate the results of the activities. The topics and themes generated are expected to address several of the industry's challenges, thereby leading to positive changes, of which the development of more attractive, socially sustainable and equal workplaces, organisations and innovation systems are the most important.

Partners: Luleå University of Technology



STRATEGIC PROJECT

SMIG – Integrated smart testbeds for the mining

Project leader: Anders OE Johansson, Nordic Rock Tech Centre AB,
anders.oe.johansson@sip-piia.se
Project duration: Phase one 2017–2018, Phase two 2018–2020

SMIG is a joint project between SIP STRIM and SIP PiiA. The project will run four years and is a result of the Swedish government's initiative *Innovation partnership programmes* and the programme *Connected industry and new materials.* [1] In SMIG, mining companies, suppliers of mining equipment and systems, specialised SMEs, universities and institutes will together develop a test bed based on various existing, ongoing and new test initiatives that will be integrated and the testbed will also be demonstrated in a number of use cases. The SMIG testbed is for test and demonstration of intelligent mining technologies supporting innovation that are need for the mining industry in the future.

[1] http://www.government.se/articles/2016/07/innovation-partnership-programmes--mobilising-new-ways-to-meet-societal-challenges/

Partners: Boliden AB, LKAB, Atlas Copco, Sandvik, Volvo CE, ABB, Ericsson, IBM, BnearIT, DataDuctus, Mobilaris. Optimation, Oryx Simulations, Algoryx Simulations, Bergteamet, SKB Äspö, Luleå University of Technology, Umeå University, UMIT Research Lab, Uppsala University

STRATEGIC PROJECT

Zero base measurement and sustainability database

Project leader: Håkan Tarras-Wahlberg, Swedish Geological AB,
hakan.tarras-wahlberg@swedishgeological.com
Project duration: 2017–2019

The purpose of the project is to build a sustainability database covering the Swedish mining industry and measure a zero-base of the effects of the SIP STRIM programme in relation to the programme's outcome goals. Expected results are a sustainability database and completed zero-base measurement of the SIP STRIM programme.

Partners: Swedish Geological AB, Luleå University of Technology

STRATEGIC PROJECT

MINDI Mining Industries Data Initiative

Project leader: Johan Hedlin, Nordic Rock Tech Centre AB,
Project duration: 2017–2018

The projcet aims to help mining companies and their machinery and system vendors contribute to increased mining productivity by developing knowledge and promoting the application of a computerised approach, such as to carry out faster and more accurate monitoring of processes and subprocesses, with increased quality. The result should be shorter lead time from event to action and faster access to accurate data at the right time and place for the organisation. At the end of the project, participating mining companies will have developed a strategy and architecture for managing data in their organisation. Participating companies have increased their knowledge and understanding of how to utilise their data resources, enabling them to streamline their business. Richer and continuously updated geological models provide a better understanding of the rock and ore body. All stakeholders will benefit from well-described principles for how data can be exchanged and who owns data, business principles, etc. between different organisations.

Partners: LKAB, Boliden, Epiroc, ABB, Nordic Rock Tech Centre AB, Luleå University of Technology

Photo: Epiroc.

STRATEGIC PROJECT

Roadmap for a fossil-free mining and mineral industry

Project leader: Erika Skogsjö, Svemin, erika.skogsjo@svemin.se
Project duration: 2017–2018

The aim of the project is to support the Swedish mining, metals and mineral producing industry in its goal of being fossil-free in 2045. The roadmap will help define and set milestones for the investments, technology development, and critical supporting conditions in society needed to complete the transition. The industry, with support from research and project management partners, will undertake a participatory process to establish the current status, describe the future vision for the industry, and specify the development pathways for crucial innovation areas such as mining equipment, vehicles, and processing of ores. Outputs from the Roadmap process will contribute to the cross-industry initiative Fossil-Free Sweden, and the final Roadmap will be the basis for ongoing work both within the industry and with stakeholders and partners in society.

Partners: Svemin, RISE

Photo: Gustaf Anderson, Svemin.

STRATEGIC PROJECT

Exploring alternative sustainable futures for the Swedish mining industry

Project leader: Erika Skogsjö, Svemin, erika.skogsjo@svemin.se
Project duration: 2017–2019

The purpose of the project is to highlight the role of the mining and mineral producing industry in society's sustainable social transformation. This is done in a co-creation-process together with various relevant stakeholders in society, analysing the importance of a more sustainable mining and mineral producing industry in a sustainable society and the challenges and opportunities the sector and its customers are faced with. The goal is more systemic knowledge of the role of the future mining and mineral industry can play in the transition to a sustainable development, and based on that a strategic activity programme which will let the sector contribute even more to a sustainable social development. The project is run by Svemin and SEI, with participation from both industry and relevant community actors and stakeholders. The expected effects are that the mining and mineral industry should be able to contribute even more to society's sustainable transformation, and all the 17 goals in the UN sustainable development agenda.

Partners: Svemin, Stockholm Environment Institute

STRATEGIC PROJECT

Traceability – for sustainable metals and minerals

Project leader: Frida Höjvall, RISE, frida.hojvall@ri.se
Project duration: 2018–2019

The main objective of the project is to present possible processes for traceability that relevant stakeholders will review and, based on the conclusion, select a feasible process that is appropriate and meets the requirements on a transparent and trustworthy traceability system.

The project will analyse how chain of custody models and approaches can be developed, with support from modern technology, for tracing the life cycle journey of copper. It will describe the properties that can be traced by the different models and compare implementation requirements in terms of costs, tracing procedures and market acceptance. To ensure the trust on the market and protect the certificates from falsification, the applicability of blockchain technologies will be investigated. Copper is chosen as a first user case in this project because the metal is mined in Sweden and is an export metal. The goal of the project is to have stakeholders agree on a concept ready to be tested in a pilot study as a next step.

Partners: Svemin, RISE, Luleå University of Technology, Boliden, LKAB

PROJECTS APPROVED IN 2018

FULL-SCALE PROJECTS

Strategies and indicators for mining safety
Project leader: Jan Johansson, Luleå University of Technology,
jan.johansson@ltu.se
Project duration: June 2018 – May 2021

Improving data quality for LCC predictions with cloud services
Project leader: Uday Kumar, Luleå University of Technology, uday.kumar@ltu.se
Project duration: April 2018 – March 2021

FEASIBILITY STUDIES

Stochastic mine design
Project leader: Mathieu Gosselin, Gosselin Mining,
mathieu.gosselin@mail.mcgill.ca
Project duration: March–September 2018

Innovative DTH drill monitoring – a pre study
Project leader: Håkan Schunnesson, Luleå University of Technology,
hakan.schunnesson@ltu se
Project duration: April–September 2018

Lignin-based hydrophobic nanoparticles for sustainable flotation processes (LIGNOFLOT)
Project leader: Pavlos Christakopoulos, Luleå University of Technology,
pavlos.christakopoulos@ltu.se
Project duration: March–August 2018

Numerical modeling of blasting and gravitational flow in sublevel caving mines
Project leader: Changping Yi, Luleå University of Technology,
changping.yi@ltu.se
Project duration: March–September 2018

Performance and wear prediction in pipe mills
Project leader: Pär Jonsén, Luleå University of Technology, par.jonsen@ltu.se
Project duration: March–October 2018

Digital Mining Hub Bergslagen
Project leader: Pär Lundström, Alfred Nobel Science park, par@alfrednobelsp.se
Project duration: April–December 2018

Digital twins for increased efficiency in mineral technology processes
Project leader: Magnus Evertsson, Chalmers University of Technology,
magnus.evertsson@chalmers.se
Project duration: April–October 2018

MachineHealth: Towards healthy machines and predictive maintenance with AI
Project leader: Amy Loutfi, Örebro University, amy.loutfi@oru.se
Project duration: April–November 2018

Purification of tellurium using ionic liquid extraction
Project leader: Johanne Mouzon, Luleå University of Technology,
johanne.mouzon@ltu.se
Project duration: June–December 2018

Preliminary study – Hybrid model for particle decomposition in DEM
Project leader: Johannes Quist, Stiftelsen Fraunhofer Chalmers centrum för industrimatematik,
johannes.quist@fcc.chalmers.se
Project duration: March–November 2018

SURVEYOR: Examination of ventilation systems in foundries with robots and stationary sensors
Project leader: Victor Hernandez Bennett, Örebro University,
victor.hernandez@oru.se
Project duration: May–October 2018

Innovative binding agents for efficient recycling of residues from steelworks
Project leader: Elsayed Mousa, Swerea Mefos, elsayed.mousa@swerea.se
Project duration: March–September 2018

Distributed acoustic optical fiber sensor for conveyor belts health monitoring
Project leader: Carolina Franciscangelis, RISE Acreo AB,
carolina.franciscangelis@ri.se
Project duration: May–November 2018

On-line monitoring of chemical composition of iron ore with laser-based optical spectrometry
Project leader: Arne Bengtson, Swerea KIMAB AB, arne.bengtson@swerea.se
Project duration: March–September 2018

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