



# SIP | STRIM

Annual report  
2017

# An exciting and inspiring year for innovation within the mining and metal-producing industry

2017 was the fourth year for SIP STRIM and we have during this year started to see the outcome of all the innovation activities both within individual projects and from the programme as a whole.

Twenty new projects were granted during 2017 and two of these were within the new innovation area *Social license to operate*. We also approved our first pilot project: *Test and evaluation of mechanical tunneling with TBS*.

The innovation conference Bergforsk-dagarna, arranged jointly by the Bergforsk foundation and STRIM, had the theme *Smart Green Mine*. It attracted many participants both on site in Luleå and as followers

of the online feed. Presentations are still available online.

In 2017 we intensified our work on internationalisation and leverage and we now see our first international collaboration projects within the programme. This is something that we wish to broaden in the years to come. We also introduced funds for leverage for all SIP STRIM projects and, so far, more than 10 projects have used the funds to apply for international funding to lever their project.

During 2017, the joint collaboration project with SIP PiiA, *Integrated smart testbeds for the mining industry SMIG*, was launched. The project will run for three years and it is a result of the Swedish government's initiative on collaboration projects with the theme "online industry and new materials". In SMIG, suppliers of mining equipment and systems, specialised SMEs and universities will together develop a test bed where system of systems, technologies and functions are tested.

Finally, I would like to thank everyone that participated in SIP STRIM during 2017. I hope that we can take one step further towards making this sector even more competitive and sustainable through innovation during 2018.

*Charlotte Andersson*  
Programme Director 2015–2017



# Why research and innovation?

The world around us is constantly changing. Corporate customers want better products at a lower cost and citizens want safer jobs with less environmental impact.

Companies survive only if they are competitive, that is, create profits that can be used for investments in better products and smarter processes.

But the reason for research and innovation is not only to solve today's problems, but also to solve the problems you think may arise in the future. With research, we build skills, not least at universities. Good research and good education often go hand in hand; With good research and education, we get well educated engineers that companies can employ – and that know how to commission and conduct research.

## Why collaboration?

An individual company cannot be the best at everything, but through sound collaboration one can achieve a higher quality of work, gain access to skills that the company lacks, and share resources that make the work more efficient.

In general, external collaboration is of extra importance, since this often keeps everybody more alert – you want to be attractive even for future interesting collaboration.

## World-class research and innovation collaboration

It has been stated in various contexts and by several policy makers that minerals and metals, as well as energy supplies, are crucial to Swedish welfare. In order to take advantage of the potential that exists both nationally and regionally for the development of these commodities, long-term

research and innovation efforts are needed together with industry.

Thanks to the dedication of several people within industry and strong support from Vinnova, a strategic innovation programme for the Swedish mining and metal producing industry was started in 2013 – SIP STRIM became a reality.

We are now in the second programme period 2017–2020 and can conclude that we have a comprehensive project portfolio that spans the entire value chain. The projects have already helped to strengthen the technology leadership position and international competitiveness of the Swedish mining industry. Strong education, research and innovation environments have been created and Swedish participation in international initiatives within the EU is successful.

It is with great confidence that we look forward to continued cooperation within the Swedish mining cluster where SIP STRIM is a significant hub.

*Kent Tano, Principal R&D Expert, LKAB  
Chairman of the Board*



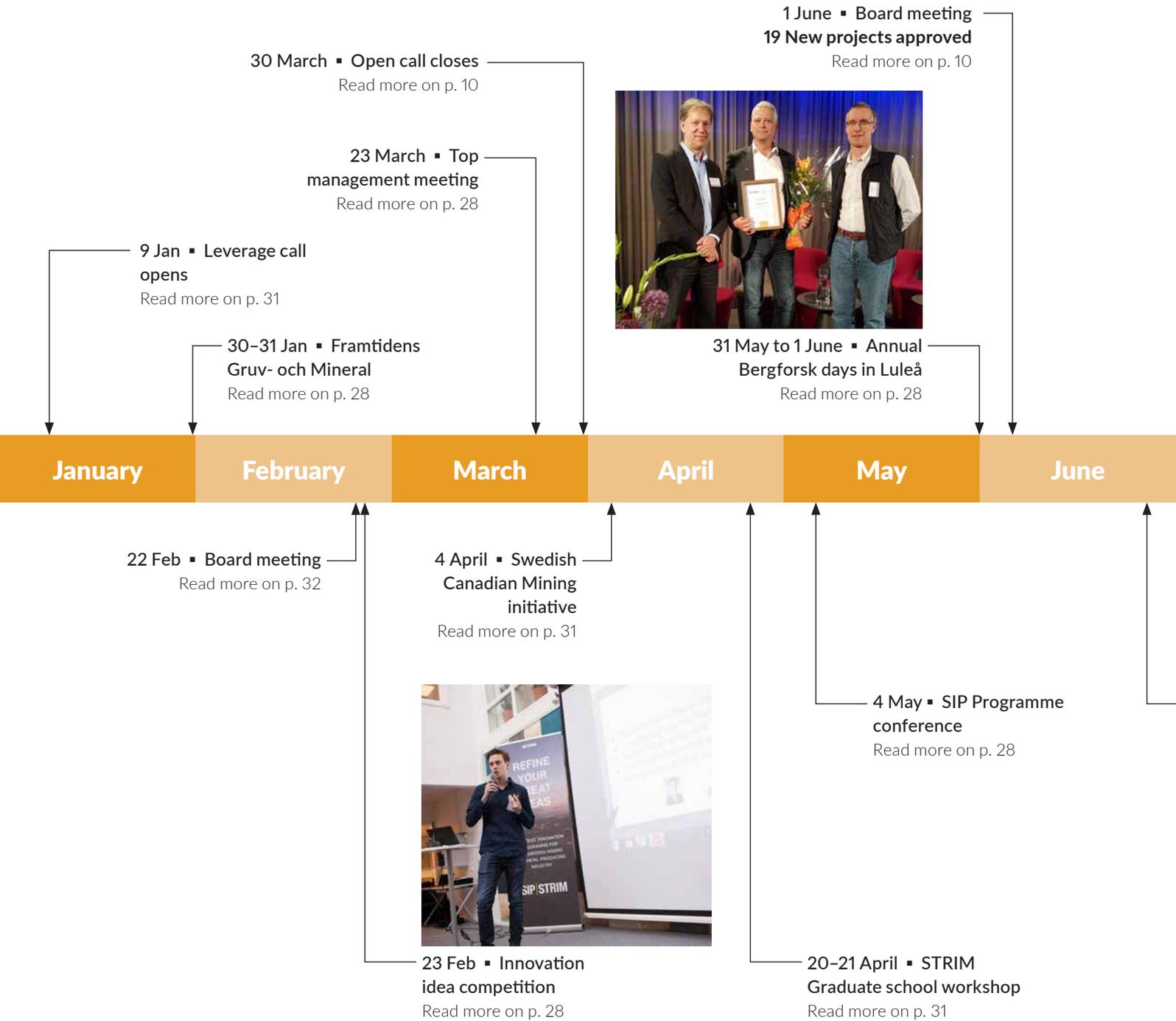


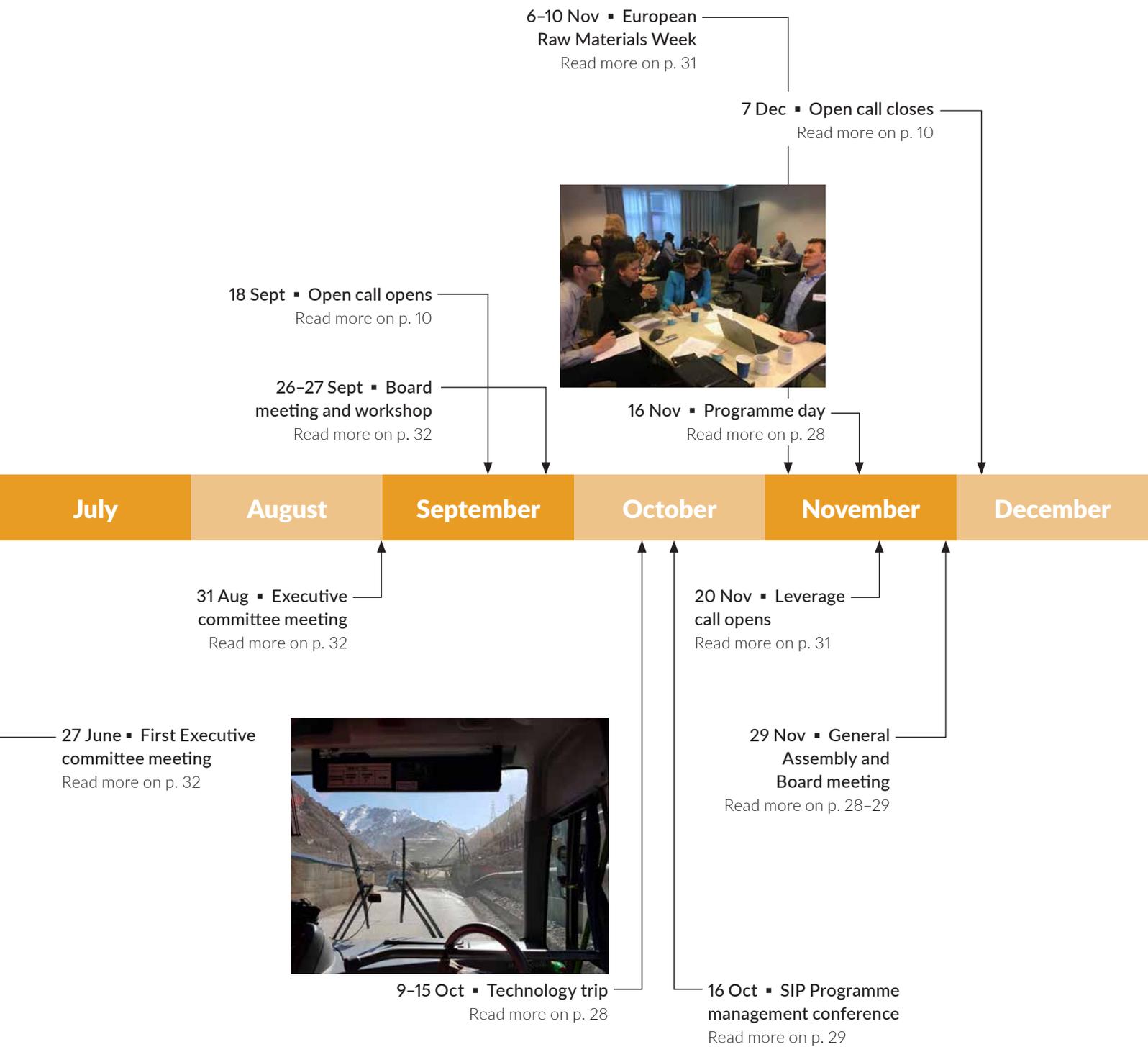
The destination for the annual technology trip in October was Chile. The photograph shows a part of the El Teniente mine owned by Codelco. Photo: Niclas Dahlström.

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# The year at a glance







One of the strategic projects completed during 2017 was Future industrial development platform - Arena Pajala which aimed at establishing a long-term commercially viable test bed at the site of the Kaunisvaara mine. Photo: Northland Resources.

# What is STRIM?

The strategic innovation programme STRIM (Strategic innovation programme for the Swedish mining and metal producing industry) is part of a joint investment in strategic innovation areas (SIP) by Sweden's innovation agency Vinnova, Formas and the Swedish Energy Agency. Half of the funding in the programme originates from the agencies and half comes from the stakeholders active within the programme.

## **In answer to societal challenges**

The focus on strategic innovation areas aims at creating opportunities for international competitiveness and sustainable solutions to global societal challenges, such as access to raw materials and a sustainable commodity production.

Actors in industry, academia and other organisations collaborate within the programme, and anyone who wishes to contribute to the overall aim and objectives of the programme are invited to submit applications for financing.

## **Strong industry and a sustainable extraction of metals**

The aim of STRIM is to strengthen the sustainability and competitiveness of the Swedish mining and metal producing industry. This is achieved by creating opportunities for collaboration between academia, institutes, large and small companies as well as NGOs.

The Swedish mining and metal producing industry is already in the forefront when it comes to sustainability and efficiency in exploration, mining, extraction and refinement. To continuously improve the competitiveness, a strategic research and innovation agenda was developed (first edition 2013, second edition 2016). The agenda is a roadmap in which the vision for nine identified focus areas are described. All activities within STRIM aim to realise the visions of the agenda.

## **Activities**

The programme uses four different tools to reach the visions of the agenda:

- innovation projects,
- education activities,
- symposiums and meetings,
- internationalisation.

# Innovation projects

Calls for innovation projects are opened regularly. The proposed projects should contribute to a more sustainable and competitive Swedish mining and metal producing industry, for instance through technical advancements. So far, six open calls have resulted in the initiation of 83 projects since the start of the programme in 2013.

The SIP STRIM programme funds three types of projects: feasibility studies, full-scale projects and pilot projects. In addition, the programme office may initiate individual projects in areas of particular interest.

All project proposals are evaluated by an external assessment board which leaves a recommendation to the Board of STRIM. After a thematic review, the Board of STRIM leaves a recommendation to Vinnova, which takes the formal decision on funding of projects.

STRIM has a project portfolio which reflects the current and future challenges within the sector, with a majority of projects related to mining. Many of the projects focus on automation and digitisation.

## Calls during 2017

During 2017 two open calls have closed. The first open call closed on March 30 and resulted in proposals for 27 feasibility studies, 18 full-scale projects and two pilot projects at a total sum of 78 million SEK. Of these proposals, ten full-scale projects, nine feasibility studies and one pilot project to a total sum of 45 million SEK were approved.

The second open call closed on December 7 and the evaluation will be done in 2018.

## Projects approved in 2017

The projects approved during 2017 are listed below with the pilot project first, followed by full-scale projects and feasibility studies. More detailed information about all projects can be found on the STRIM webpage: [www.sipstrim.se](http://www.sipstrim.se).

### Test and evaluation of mechanical tunneling with TBS

**Project manager:** Urban Holmlund, Bergteamet

**Subsidy from STRIM:** SEK 10 000 000

**Total budget:** SEK 34 758 000

**Project duration:** 2017-10-01–2018-11-30

**Consortium:** Epiroc AB, Svensk Kärnbränslehantering AB, Luleå University of Technology, Uppsala University, Bergteamet AB

### Efficient comminution operation (ECO)

**Project manager:** Andreas Johansson, Luleå University of Technology

**Consortium:** Innovative Machine Vision Pty Ltd, Optimization AB, Vale S.A., Luleå University of Technology

**Subsidy from STRIM:** SEK 4 995 000

**Total budget:** SEK 10 975 000

**Project duration:** 2017-08-01–2020-06-30

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

**Project manager:** Karin Beland Lindal, Luleå University of Technology

**Consortium:** Luleå University of Technology, Cameco, Das Nedhe Development, English River First Nation, University of Northern BC, University of Saskatchewan

**Subsidy from STRIM:** SEK 3 234 900

**Total budget:** SEK 6 521 000

**Duration:** 2017-10-01–2020-10-31

### From word to action – sustainability management system for social acceptance

**Project manager:** Helena Ranängen, Luleå University of Technology

**Consortium:** Boliden Mineral AB, Svemin, Luleå University of Technology

**Subsidy from STRIM:** SEK 1 660 100

**Total budget:** SEK 3 324 000  
**Project duration:** 2017-06-01–2020-06-30

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

**Project manager:** Håkan Schunnesson, Luleå University of Technology

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

**Subsidy from STRIM:** SEK 2 847 000

**Total budget:** SEK 5 695 000

**Project duration:** 2017-07-01–2019-06-30

### **Face-to-Mill**

**Project manager:** Daniel Johansson, Luleå University of Technology

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

**Subsidy from STRIM:** SEK 3 382 800

**Total budget:** SEK 7 760 000

**Project duration:** 2017-07-01–2019-06-30

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

**Project manager:** Linda Sharp, Maskinteknik i Oskarshamn AB

**Consortium:** Oskarshamns kommun, RISE Acreo AB, Maskinteknik i Oskarshamn

**Subsidy from STRIM:** SEK 1 494 500

**Total budget:** SEK 3 393 000

**Project duration:** 2017-07-01–2019-07-31

### **Tracking and control of articulated machines through remote sensing**

**Project manager:** Todor Stoyanov, Örebro University

**Consortium:** Alfred Nobel Science Park, Atlas Copco Rock Drills, Brokk, Örebro University

**Subsidy from STRIM:** SEK 4 569 300

**Total budget:** SEK 10 147 000

**Project duration:** 2017-08-01–2020-08-31

### **VectOre – Exploration criteria for polymetallic sulphide mineralisation and industrial carbonates**

**Project manager:** Nils Jansson, Luleå University of Technology

**Consortium:** Björka Mineral AB, Boliden Mineral AB, Luleå University of Technology

**Subsidy from STRIM:** SEK 2 760 000

**Total budget:** SEK 5 520 000

**Project duration:** 2017-08-01–2020-06-30

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

**Project manager:** Erling Nordlund, Luleå University of Technology

**Consortium:** Lundin Mining, Boliden AB, LKAB, Luleå University of Technology

**Subsidy from STRIM:** SEK 4 462 000

**Total budget:** SEK 9 299 000

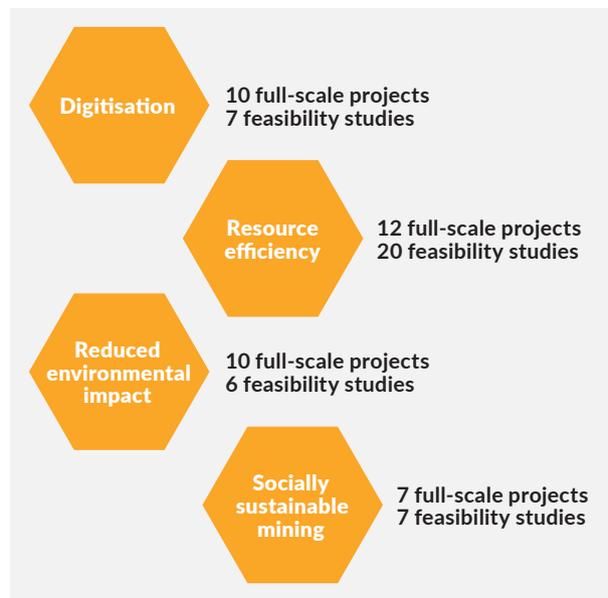
**Project duration:** 2017-08-01–2020-07-31

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

**Project manager:** Staffan Lundström, Luleå University of Technology

**Consortium:** LKAB, Taoshi Energiteknik AB, Luleå University of Technology

The funded projects cover the full value chain and address all well-known important challenges for our industry.



**Subsidy from STRIM:** SEK 2 400 000  
**Total budget:** SEK 4 800 000  
**Project duration:** 2017-08-01–2020-07-31

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

**Project manager:** Ping Zhang, Luleå University of Technology  
**Consortium:** Lundin Mining, LKAB, Luleå University of Technology  
**Subsidy from STRIM:** SEK 480 000  
**Total budget:** SEK 580 000  
**Project duration:** 2017-08-01–2018-01-31

**Extraction of molybdenum as an added value in steel production**

**Project manager:** Martina Petranikova, Chalmers University of Technology  
**Consortium:** Chalmers University of Technology  
**Subsidy from STRIM:** SEK 500 000  
**Total budget:** SEK 550 000  
**Project duration:** 2017-08-01–2018-01-31

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

**Project manager:** Martin Simonsson, Ductus PreEye AB  
**Consortium:** Ductus PreEye AB, LKAB  
**Subsidy from STRIM:** SEK 174 000  
**Total budget:** SEK 277 000  
**Project duration:** 2017-06-01–2018-01-31

**Energy efficient and intensified leaching with ultrasound controlled cavitation**

**Project manager:** Örjan Johansson, Luleå University of Technology  
**Consortium:** Luleå University of Technology  
**Subsidy from STRIM:** SEK 500 000  
**Total budget:** SEK 595 000  
**Project duration:** 2017-08-01–2018-02-28

**MinFroth – Characterisation of froth in mineral flotation of sulphide ore**

**Project manager:** Marie Ernstsson, RISE  
**Consortium:** RISE, Boliden Mineral AB

**Subsidy from STRIM:** SEK 500 000  
**Total budget:** SEK 750 000  
**Project duration:** 2017-08-01–2018-02-28

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

**Project manager:** Maria Ask, Luleå University of Technology  
**Consortium:** Luleå University of Technology, FracSinus Rock Stress Measurements AB  
**Subsidy from STRIM:** SEK 497 000  
**Total budget:** SEK 539 000  
**Project duration:** 2017-07-01–2018-05-31

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

**Project manager:** Christopher Juhlin, Uppsala University  
**Consortium:** Uppsala University, Atlas Copco Rock Drills AB  
**Subsidy from STRIM:** SEK 342 500  
**Total budget:** SEK 433 000  
**Project duration:** 2017-08-01–2018-02-28

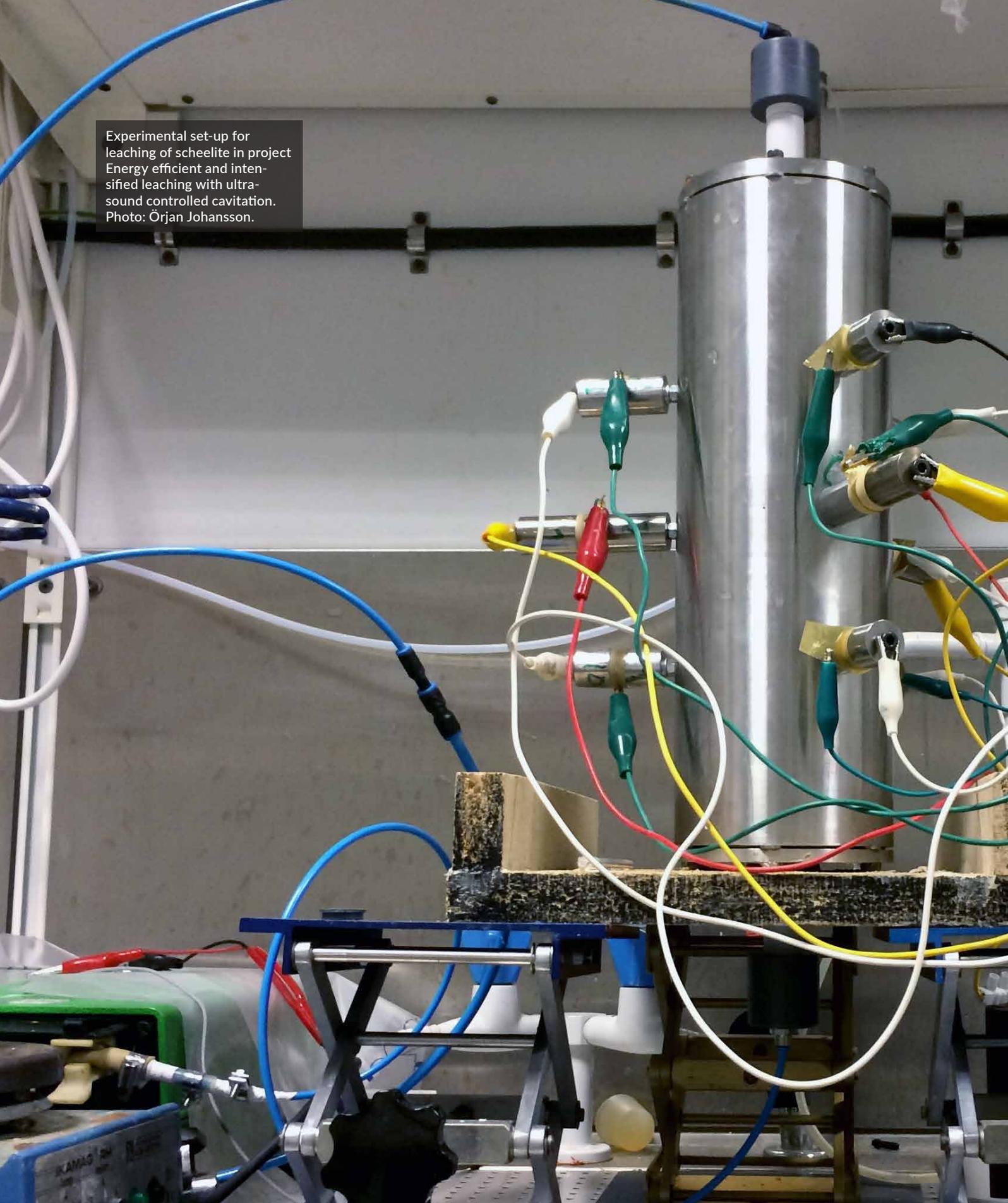
**Phoenix mine drone**

**Project manager:** Pau Mallol Parera, Inkonova AB  
**Consortium:** Inkonova AB  
**Subsidy from STRIM:** SEK 500 000  
**Total budget:** SEK 1 399 000  
**Project duration:** 2017-06-01–2017-12-31

**Seismic image with hammer drilling as source: SIHDS**

**Project manager:** Christopher Juhlin, Uppsala University  
**Project consortium:** Uppsala University, LKAB Wassara AB  
**Subsidy from STRIM:** SEK 486 000  
**Total budget:** SEK 636 000  
**Project duration:** 2017-08-01–2018-02-28

Experimental set-up for leaching of scheelite in project Energy efficient and intensified leaching with ultrasound controlled cavitation. Photo: Örjan Johansson.



### **Ongoing projects from previous years**

#### **Using by-products for prevention of sulphide oxidation in mine waste**

**Project manager:** Lena Alakangas, Luleå University of Technology

**Consortium:** SSAB, Nordkalk, Boliden Mineral AB, Cementa, Dragon Mining, Processum, Luleå University of Technology

**Subsidy from STRIM:** SEK 5 750 000

**Total budget:** SEK 13 502 000

**Project duration:** 2014-08-01–2018-06-30

#### **Improved resource efficiency through dynamic loading**

**Project manager:** Håkan Schunnesson, Luleå University of Technology

**Consortium:** RTC, LKAB, Agio, ABB, Boliden Mineral AB, Luleå University of Technology

**Subsidy from STRIM:** SEK 4 800 000

**Total budget:** SEK 11 856 000

**Project duration:** 2014-07-01–2019-06-30

#### **HIFLOAT – Individual sizing of flotation cells**

**Project manager:** Jan Rosenkranz, Luleå University of Technology

**Consortium:** Boliden Mineral AB, LKAB, Luleå University of Technology

**Subsidy from STRIM:** SEK 2 250 000

**Total budget:** SEK 5 945 000

**Project duration:** 2014-07-01–2018-06-30

#### **PREP**

**Project manager:** Cecilia Lund, Luleå University of Technology

**Consortium:** LKAB, Chalmers University of Technology, Northland, Outotec, Zinkgruvan, Boliden Mineral AB, Luleå University of Technology

**Subsidy from STRIM:** SEK 4 550 000

**Total budget:** SEK 15 616 000

**Project duration:** 2014-09-01–2018-12-31

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

**Project manager:** Erling Nordlund, Luleå University of Technology

**Consortium:** Lundin Mining, LKAB, Boliden Mineral AB, Luleå University of Technology

**Subsidy from STRIM:** SEK 4 850 000

**Total budget:** SEK 13 280 000

**Project duration:** 2014-09-01–2018-02-28

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

**Project manager:** Mats Karlberg, Swerea Mefos AB

**Consortium:** Galvano TIA AS, Northern Mining Products AB, Ruukki Sverige AB, Swerea Mefos AB

**Subsidy from STRIM:** SEK 3 230 000

**Total budget:** SEK 5 885 000

**Project duration:** 2015-09-01–2018-03-31

#### **Optimised medium range mine planning**

**Project manager:** Jan Nyqvist, ABB

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

**Subsidy from STRIM:** SEK 3 700 000

**Total budget:** SEK 8 100 000

**Project duration:** 2015-09-01–2018-02-28

#### **Innovative quality assured fayalite slag products**

**Project manager:** Caisa Samuelsson, Luleå University of Technology

**Consortium:** Nordkalk, Boliden, PEAB, XORE AB, Luleå University of Technology

**Subsidy from STRIM:** SEK 4 351 000

**Total budget:** SEK 8 114 000

**Project duration:** 2016-08-01–2019-07-31

#### **SafePos II – Safety positioning for the mining industry II**

**Project manager:** Haukur Ingason, RISE Research Institutes of Sweden AB

**Consortium:** Luleå University of Technology, Skellefteå Kommun, LKAB, Dräger Safety, Boliden, Alecom, SP, Interspiro, Mobilaris, SICS Swedish ICT, RISE Research Institutes of Sweden AB

**Subsidy from STRIM:** SEK 1 920 000

**Total budget:** SEK 3 200 000

**Project duration:** 2016-10-01–2018-09-30



A vehicle used within the project MLOC+ in the Kristineberg mine. It is equipped with "Mass-localisation" RFID antenna (large white antenna on the roof) and a special VPX computer (inside, not visible). Photo: Arne Gylling.

**Development of closing and reopening criteria for seismically active mines**

**Project manager:** Savka Dineva, Luleå University of Technology

**Consortium:** LKAB, Boliden, Luleå University of Technology

**Subsidy from STRIM:** SEK 4 155 000

**Total budget:** SEK 6 925 000

**Project duration:** 2016-09-01–2019-08-31

**MLOC+**

**Project manager:** Arne Gylling

**Consortium:** Luleå University of Technology, Boliden Mineral AB, Mobilaris, Rubico Consulting AB, iGW Europe AB

**Subsidy from STRIM:** SEK 2 977 000

**Total budget:** SEK 5 302 000

**Project duration:** 2016-08-01–2018-01-31

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

**Project manager:** Frauke Ecke, Swedish University of Agricultural Sciences

**Consortium:** Swedish University of Agricultural Sciences

**Subsidy from STRIM:** SEK 5 526 000

**Total budget:** SEK 17 733 000

**Project duration:** 2014-07-01–2018-12-31

## Strategic projects

### Social License to Operate

**Project manager:** Lennart Gustafsson, Georange Consortium; Georange, Luleå University of Technology

**Subsidy from STRIM:** SEK 1 499 999

**Project duration:** 2016-11-01–2017-10-31

**Purpose and goal:** In the work of operationalising the term SLO, we have assumed some established headings from a research perspective. These headings are: The history and development of the concept; the SLO concept's role in Sweden; what does an SLO contain; how does SLO relate to state and regulations; SLO and the local community; SLO and sustainable development; and the usefulness of the SLO concept in a Swedish context. In the process of establishing a "Meeting place STRIM", 13 longer interviews have been conducted.

**Structure and implementation:** The project was divided between two partners, Georange as the main project manager and responsible for the work with "Meeting place STRIM", and Luleå University of Technology as research coordinator. Through this arrangement we have succeeded in carrying out the activities described in the project application. However, we did not succeed in implementing "Meeting place STRIM" since a review of signed-up participants revealed that important parties were missing. The seminar was therefore cancelled. However, a joint arrangement between Georange and the Sami Parliament for a similar meeting place is currently planned.

**Results:** SLO is a diffuse, obscure and contested term. We, instead, propose the heading "Relationships with surrounding society", which reflects the contents of the current chapter on SLO. In the process of developing a foundation for "Meeting place STRIM", a number of efforts were made by stakeholders. A seminar or workshop was planned for 170919 in Luleå. A review of signed-up participants revealed that important parties were missing, and therefore the seminar was cancelled. However, a joint arrangement between Georange and the Sami Parliament is currently planned.

### Future industrial development platform – Arena Pajala

**Project manager:** Åsa Allan, Pajala municipality

**Consortium:** Pajala municipality

**Subsidy from STRIM:** SEK 300 000

**Project duration:** 2016-10-31–2017-05-31

**Purpose and goal:** We want to create Arctic Tests AB, a prominent test bed in an arctic environment focusing on critical minerals and the building of a sustainable community. A successful preliminary study was completed. Establish a long-term commercially viable test bed through government funding of SEK 20 million per year over five years.

**Structure and implementation:** Conduct workshops and interview stakeholders. Get letters of intent (LOI) from those who show an active interest.

**Results:** Foundation of Arctic Tests AB with Luleå University of Technology as the principal. The government invests SEK 20 million per year for five years. The project is driven forward according to the recommended schedule.

### Method development to create more commercially successful applications and projects

**Project manager:** LTU Business

**Consortium:** LTU Business, RISE

**Subsidy from STRIM:** SEK 980 000

**Project duration:** 2016-12-01–2017-12-31

**Purpose and goal:** Through testing and development of a new model to create more commercially successful applications and innovation projects, the project aimed to create an analytical methodology made available as digital aids that will benefit the innovation power of SIP STRIM, the commercialisation understanding of researchers, and also society's usage of innovation. The project fulfilled its purpose through the development of method IDD, quality assurance through three successful test cases (obtaining funding) and digitisation of the methodology available to the project target group.

**Structure and implementation:** The project has been run as a collaboration between SIP STRIM's programme office, LTU Business and RISE. LTU Business has led the main parts of development: implementation test case, development of methodology and digitisation of the same. RISE has served as a tech-

nology and research-focused counterpart, that has validated and tested methodology, trained internal staff in methodology, and disseminated the results of the project. The composition of partners has enabled a wide range of stakeholders to influence the project's direction and quality assurance.

**Results:** The project has resulted in methodology and the work procedure Innovation Due Diligence, for assessing commercial potential, and the associated digitally adapted educational material available at [www.innovationduediligence.com](http://www.innovationduediligence.com). An expected effect of this, the first consolidated method of structuring the analysis of early innovation ideas, is that more potentially successful projects receive funding, and that the quality of innovation projects increase by taking into account commercial requirements and addressing these as a more integrated part of research projects.

**Pre-study: Industry synergies – circular economy**

**Project manager:** Luleå University of Technology

**Consortium:** Luleå University of Technology, Stena Metal, Chalmers University of Technology

**Subsidy from STRIM:** SEK 230 000

**Project duration:** 2016-12-01–2017-06-30

**Purpose and goal:** The preliminary study has led to the conclusion that there is an interest in cross-sectoral projects, but that the framework for this type of project needs to be clarified. Many of the solutions are local solutions, i.e. a solution that fits in northern Sweden may not fit in southern Sweden, and depend on which local actors are available. For the solution to be economical, transport distances and logistics are a limiting factor.

**Structure and implementation:** The project has been implemented with the overall ambition to map the interest in cross-sectoral projects with regard to the use of residues and material flows in Swedish heavy industry. By gathering expertise from the different industries that reflects the Strategic innovation programmes Metallic Materials, STRIM and Re:Source in a workshop, various issues emerged that could demonstrate cross-sectoral projects. Representatives from the various industries and also academic partners were present. The results have been summarised in a report.

**Results:** The project has developed specific proposals for various cross-sectoral project areas that the Strategic innovation programmes can use for specific calls, and also examples of specific projects that would be strategic in new calls and as strategic projects.

**MINDI Mining Industries Data Initiative**

**Project manager:** Nordic Rock Tech Centre AB

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

**Subsidy from STRIM:** SEK 500 000

**Project duration:** 2017-11-01–2018-07-31

**Purpose and goal:** The MINDI programme will 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 a larger part of the organisation.

**Structure and implementation:** The MINDI programme is organised in several projects. These are usually no longer than 6–8 months, and may include subprojects. In addition to the projects, there is a high level group and project manager. The programme has started with the first Data Market project, which is scheduled to be completed by Q1 2018. When this is done, work will commence on projects 2 and 3, Predictive maintenance and Shared 3D model of ore body.

**Expected results:** Participating mining companies 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.

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

**Project manager:** Luleå University of Technology

**Consortium:** Luleå University of Technology

**Subsidy from STRIM:** SEK 502 500

**Project duration:** 2017-05-01–2018-05-31

**Purpose and goal:** The strategic research and innovation agenda for the Swedish mining and metal manufacturing industry (STRIM 2017–2020) contains visions for nine research and innovation areas. This project focuses on the areas of Attractive Workplaces and Equality and Diversity in the Mining Industry. The purpose 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.

**Structure and implementation:** The project begins by recapitulating research and innovation needs, and planning interactive activities. In a workshop that collects participants from mining companies, subcontractors and contractors, academia as well as authorities and associations, we will generate a number of possible projects and partnerships. Design teams with participants from all groups will then act as platforms for the implementation of these projects and partnerships. Finally, we will collect, analyse and communicate the results of these activities.

**Expected results:** The projects and partnerships generated by the project 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.

### **Zero base measurement and sustainability database**

**Project manager:** Håkan Tarras-Wahlberg, Swedish Geological AB

**Consortium:** Luleå University of Technology, Swedish Geological AB

**Subsidy from STRIM:** SEK 1 043 000

**Project duration:** 2017-10-01–2019-12-31

**Purpose and goal:** The purpose 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.

**Structure and implementation:** The project has the following structure: 1) Inception workshop for CPI, Q1 2018. 2) Inception report, Q2 2018. 3) Midway report, Q4 2018. 4) Final report, Q4 2019.

**Expected results:** Expected results are a sustainability database and completed zero-base measurement of the SIP STRIM programme.

### **Joint project SMIG**

SMIG – Integrated smart testbeds for the mining, is a joint project between SIP STRIM and SIP PiiA. The project will run three years and it is a result of the Swedish government's initiative on collaboration projects with the theme "online industry and new materials". In SMIG, suppliers of mining equipment and systems, specialised SMEs and universities will together develop a test bed where system of systems, technologies and functions are tested.

**Project manager:** Nordic Rock Tech Centre AB.

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

**Project budget Step 1:** SEK 3 000 000

**Project duration Step 1:** 2017-06-01–2018-07-31

# Projects completed in 2017

During 2017 the eight first started full-scale projects were evaluated through interviews with the project leaders in order to assess the activities within SIP STRIM.

The overall opinion of the project leaders is that their projects produced very clear results. All projects were characterised by a close collaboration between researchers and companies. This indicates that the research carried out was clearly relevant to industry which provides good conditions for implementation of the results.

The vision of SIP STRIM can be summarised in the following way: To strengthen the international competitiveness and sustainability of the Swedish mining and metal producing sector, including mining and recycling companies, academia and technology providers. To foster leading centres and clusters for research, innovation and education that become European centres of excellence and where domestic and international participants may develop sustainable solutions for the future.

Even if the focus of the evaluated projects was very varying, the results from the projects clearly contribute to the vision above in a number of ways:

- Innovative products, systems, processes, equipment and methods have been developed.
- A test environment has been established.
- The number of collaborating partners on a national and international level, including the participation of small and medium-sized enterprises, has increased significantly.

All projects that were completed during 2017 are presented in this section with brief summaries.

## **Multi-scale 4-dimensional geological modelling of the Gällivare area**

**Project manager:** Tobias Bauer, Luleå University of Technology

**Consortium:** Boliden Mineral AB, LKAB, Luleå University of Technology

**Subsidy from STRIM:** SEK 4 700 000

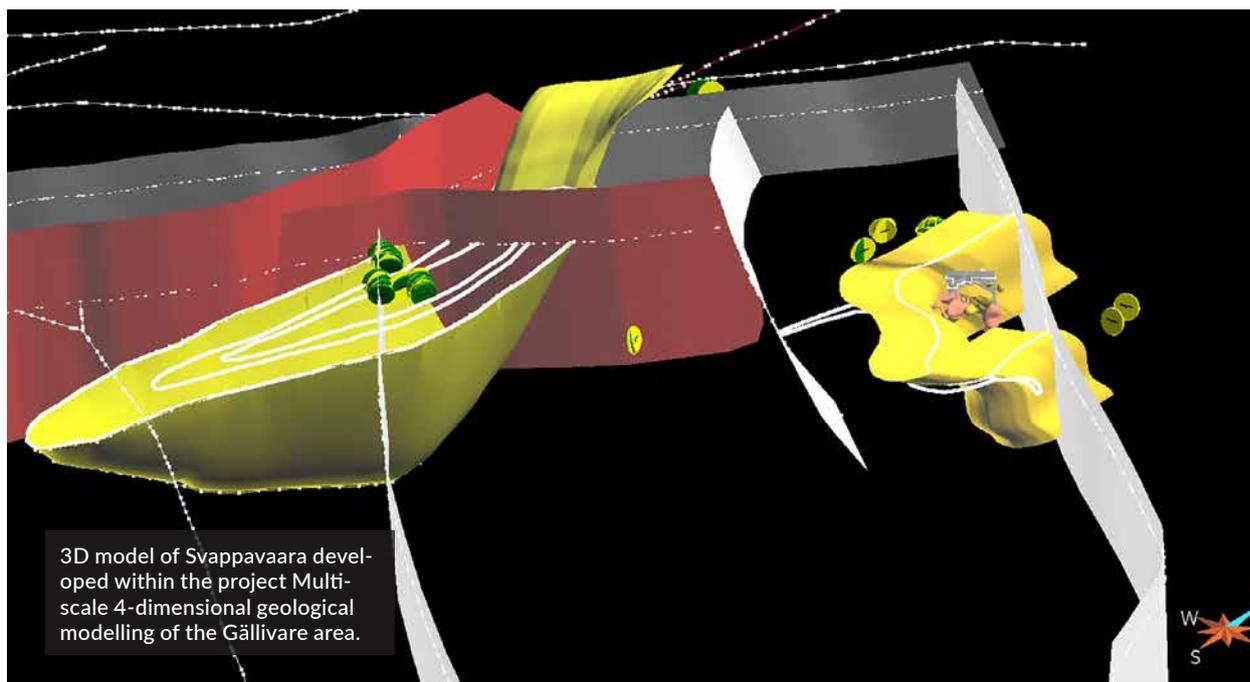
**Total budget:** SEK 9 400 000

**Project duration:** 2013-09-01–2017-09-30

**Purpose and goal:** The primary purpose of this research project was to increase the understanding of structural geometries, relationships and control on ore formation and ore body transposition in the Gällivare area. Based on structural geological field work in combination with geochemistry, age dating and geophysical modeling, geological 3D models and conceptual 4D models have been constructed. Through this we managed to get a better understanding of the regional tectonic history with local-scale ore-forming processes and subsequent deformation of ore bodies.

**Structure and implementation:** The project was divided into four sub-projects: 1. Regional, semi-regional and local structural relationships and structural control of ore deposits in the Gällivare area. 2. Regional, semi-regional and local re-evaluation of geophysical data. 3. Multi-scale geological 3D modelling. 4. Multi-scale 4D modelling. Prospectivity has not been modeled in three dimensions but has been done at a conceptual level. The planned project structure was followed in broad terms.

**Results:** The project managed to sort out the structural geometries and to visualise them in three-dimensional models. The project could also show which factors control the ore formation and deformation in the area and interpret ore-controlling deformation zones. This leads to a more focused prospecting in the Gällivare area. New areas with high ore potential have also been identified. The results also support production-related issues in Malmberget, Svappavaara and Aitik through improved predictability of the structures.



### Efficient mining – Face-to-surface

**Project manager:** Håkan Schunnesson, Luleå University of Technology

**Consortium:** Boliden Mineral AB, LKAB, Luleå University of Technology

**Subsidy from STRIM:** SEK 5 470 000

**Total budget:** SEK 13 630 000

**Project duration:** 2013-09-01–2017-02-28

**Purpose and goal:** The Strategic innovation programme for the Swedish mining and metal producing industry (STRIM) aims at strengthening the mining sector's competitiveness and contributing to a sustainable development. This project has significantly reduced production costs, improved resource efficiency and improved characterisation of the ore.

**Structure and implementation:** The project Face-to-surface has been implemented as two individual projects, one surface project and one underground project with essentially different applications. This broad approach and the significantly different technical conditions have not been ideal from a project implementation perspective, and have brought a lot of extra administrative work. The research work carried out

in production environments, however, meant that the results have industrial relevance and have a shorter way to applications.

**Results:** The Face-to-surface project focused on the goals More efficient and competitive processes, equipment and methods, Resource efficiency and Increased energy efficiency in the STRIM agenda. The project has demonstrated how significant savings can be achieved by optimising fragmentation. The influence from rock mass properties, mainly structural information such as cracks, fractures, voids, etc., has been used to optimise the charging and blasting operation. Loading and transport efficiency have been increased for both surface and underground operations.

### Conceptual modelling and prospecting criteria for stratiform Zn-Pb-Ag-(Cu) mineralisations in Bergslagen

**Project manager:** Nils Jansson, Luleå University of Technology

**Consortium:** Boliden Mineral AB, Lovisagruvan AB, Zinkgruvan Mining AB, Luleå University of Technology

**Subsidy from STRIM:** SEK 2 550 000

**Total budget:** SEK 5 899 000

**Project duration:** 2014-07-01–2017-07-31

**Purpose and goal:** The project has developed new exploration criteria and a revised genetic model for stratiform Zn-Pb-Ag deposits in Bergslagen. The emphasis has been on constraining the stratigraphic and structural context, as well as geochemical and mineralogical vectors to ore. This type of knowledge is a prerequisite for discovering new mineralisation at active mines such as Zinkgruvan and Lovisa, and new deposits in other parts of Bergslagen. The results of the project are beneficial to future exploration work in the area and may stimulate new discoveries.

**Structure and implementation:** The project illustrates the importance of integrating geochemical and mineralogical data with detailed stratigraphic and structural analysis during exploration. Combining these in several study areas has led to an improved understanding of the nature of the ore-forming systems. Data integration has e.g. led to improved knowledge on the mechanisms of sulphide precipitation, elemental dispersion and redox variations on the seafloor, the importance of syn-sedimentary structures, as well as how prospective stratigraphic intervals can be identified.

**Results:** The results allow prospective areas to be narrowed down with more precision than before, to which future exploration efforts can be focused. The zonation models developed, as well as geochemical and geological criteria, allow geochemical anomalies to be evaluated and followed-up with better accuracy. The results indicate that volcanic processes were of secondary importance to the establishment of calm, anoxic sedimentary basins for forming stratiform Zn-Pb-Ag deposits and associated stratabound Cu-(Co-Ni) deposits. This drastically affects exploration strategies.

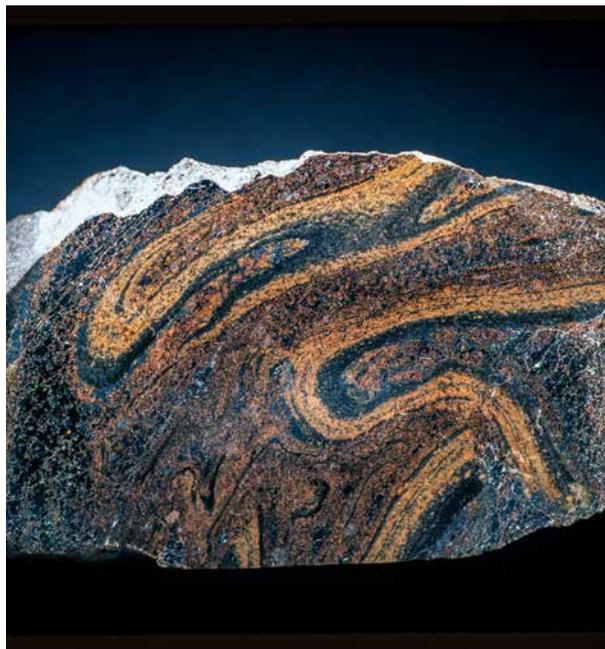
### **Improved control of toxic fumes from blasting**

**Project manager:** Daniel Johansson, Luleå University of Technology

**Consortium:** Boliden Mineral AB, Forcit Sweden AB, LKAB Kimit AB, Luleå University of Technology

**Subsidy from STRIM:** SEK 1 106 000

**Total budget:** SEK 2 018 000



The project Conceptual modelling and prospecting criteria for stratiform Zn-Pb-Ag-(Cu) mineralisations in Bergslagen involved both field work and data integration.

Photo: Nils Jansson.

**Project duration:** 2015-07-01–2017-03-31

**Purpose and goal:** This project aimed to improve knowledge on the generation of toxic fumes from the detonation of commercial explosives in rock. The main objective is to reduce personnel exposure to the toxic fumes. The project focuses on blasting in open pit and underground. The general objective is to support the Swedish mining industry, contractors and explosives manufacturers with findings and recommendations for the use of explosives.

**Structure and implementation:** The research project was carried out by researchers in co-operation with technical staff from industrial partners. It was divided in two workpackages: detailed studies in laboratory and full-scale tests in a mining environment.

**Results:** To minimise personnel exposure to toxic fumes and optimise the time for safe re-entry into areas where the blast occurred. A further objective is to achieve an improved adaptation of explosives to rock conditions which in itself contributes to

reduced emissions of toxic fumes and their impact on environment. By achieving these goals one can get improved sustainability, increased productivity (through optimised ventilation times) as well as provide support for the development of new explosives.

### **Innovative deep exploration Ifk**

**Project manager:** Klas Hjort, Uppsala University  
**Consortium:** Atlas Copco Rock Drills AB, Boliden Mineral AB, LKAB, Orexplora AB, Uppsala University

**Subsidy from STRIM:** SEK 4 000 000

**Total budget:** SEK 10 975 000

**Project duration:** 2015-07-01–2017-09-30

**Purpose and goal:** The project is the first phase of three with the long-term goal of improving the workflow and creativity of geologists through new geophysical sensors and geochemical analysis at the borehole. In the short term, the goal has been to create the conditions for this by developing relevant new technology. The goal has been met with results shown in models, in a probe capable of keeping cryocold and the design of a probe with cryostat, and the very good development of the capacity of the Orexplora instrument.

**Structure and implementation:** Atlas Copco was expected to contribute largely through membership of the DET-CRC, which was denied them. However, they have taken great responsibility in benchmarking and have worked closely with the other partners with interviews and workshops. Half-yearly meetings have been held with all partners. Field studies by Uppsala University have been carried out at Boliden and LKAB together with their staff. There was a much greater cooperation between Boliden, Orexplora and Uppsala University than was budgeted. We perceive that the project design has worked well despite the changed conditions for Atlas Copco.

**Results:** The results of the model work show the benefits of a high-resolution audio magnetotelluric probe for deep geophysical analysis. The generation of both a probe capable of keeping cryocold long enough and a robust design for a probe with cryostat, as well as the most amazing structural and mineralisation information that geologists get from Orexplora's

instrument, has had the result that all partners and especially companies want to continue their development work.

### **Enhanced mining safety by rock bolt monitoring**

**Project manager:** Jens Eliasson, ThingWave AB

**Consortium:** ThingWave AB

**Subsidy from STRIM:** SEK 400 000

**Total budget:** SEK 400 000

**Project duration:** 2016-03-01–2017-03-31

**Purpose and goal:** The primary aim of the project was to develop a prototype system for testing in the mining environment and to carry out lab and field tests in a mine. Secondary objectives were to expand the ThingWave network and to have good communication with mining companies, suppliers to the mining industry, and academic institutions in Sweden as well as abroad. The project's goal is more than achieved with the completed lab and field tests, expanded network of contacts with industry and academia in Sweden but also abroad.

**Structure and implementation:** The project began by initiating talks with bolt manufacturers, mining companies, and suppliers and consultants to conduct field tests. At the same time as technology development has taken place, much emphasis has been given to meeting stakeholders in Sweden and abroad. After conducted lab and field tests, the results have been presented to many mining companies and bolt suppliers with great interest as a result. The tests had to be delayed due to external factors but could be performed anyway. During the project, a dialogue with mine engineers, business advisors and experts in IoT has been important to get feedback.

**Results:** The project has developed a prototype system used in lab and mining tests. We have also identified partners around the world and started discussions with them. ThingWave has participated in several exhibitions, for example Euro Mine Expo in Skellefteå, IoT World Event in San Jose, California, the Industrial Internet Summit in Sydney, EIT/SIP STRIM meeting in Luleå, etc. As a direct result of this project, ThingWave will within the next 12 months have at least three active mine installations as well as collaboration with international enterprises and universities.

### **Environmentally friendly, oil-free lubricants**

**Project manager:** Yijun Shi, Sustainalube AB

**Consortium:** Sustainalube AB

**Subsidy from STRIM:** SEK 400 000

**Total budget:** SEK 900 000

**Project duration:** 2016-06-01–2017-04-30

**Purpose and goal:** The purpose and the goals of this project have been to investigate and validate using Sustainalube's lubricants in applications related to raw materials and mining. Sustainalube's lubricants have been tested in several applications, proven functionality and some positives have been identified in comparison with traditional oil-based alternatives.

**Structure and implementation:** The project has been conducted together with collaborating partners and together have Sustainalube's lubricants been tested, evaluated and developed.

**Results:** The result and anticipated outcome is that this project has been a basis both for development of new environmentally friendly solutions for lubricants, as well as showing its validity and proof-of-concept. Further interest has been generated which has lead to further collaboration in development.

### **Roadmap for reducing accidents in the Swedish mining industry**

**Project manager:** Jan Johansson, Luleå University of Technology

**Consortium:** Svemin, Luleå University of Technology

**Subsidy from STRIM:** SEK 500 000

**Total budget:** SEK 768 000

**Project duration:** 2016-09-01–2017-02-28

**Purpose and goal:** The pre-study investigated the accident development and safety initiatives in two Swedish mining companies during the last 30 years. We also studied the accident trend in general for the Swedish mining industry. The pre-study suggests future research for further reducing the accident rate, i.e. to create a roadmap for the future.

**Structure and implementation:** We divided the study into four parts. In the first part, we outlined the previous research on accidents and safety indicators. The second part examined the available statistics. The third contained an interview study with representatives from two Swedish mining companies and focused on the changes that may have contributed to

the decline in the accident rate. In the fourth, we analysed the results and made suggestions on the focus areas suitable for the main study.

**Results:** The results show that the accident rate within the Swedish mining industry has dropped significantly over the last 30 years and that this is usually attributed to extensive changes in technology, requirements for systematic safety management and new forms of organisation. This applies to both companies investigated. The industry is still in need of evaluation of the relative impact of these changes as well as how the different factors have influenced each other.

### **ReLoad: Robot-aided long-term autonomous drilling**

**Project manager:** Todor Stoyanov, Örebro University

**Consortium:** Atlas Copco Rock Drills AB, Mälardalen University, Örebro University

**Subsidy from STRIM:** SEK 499 000

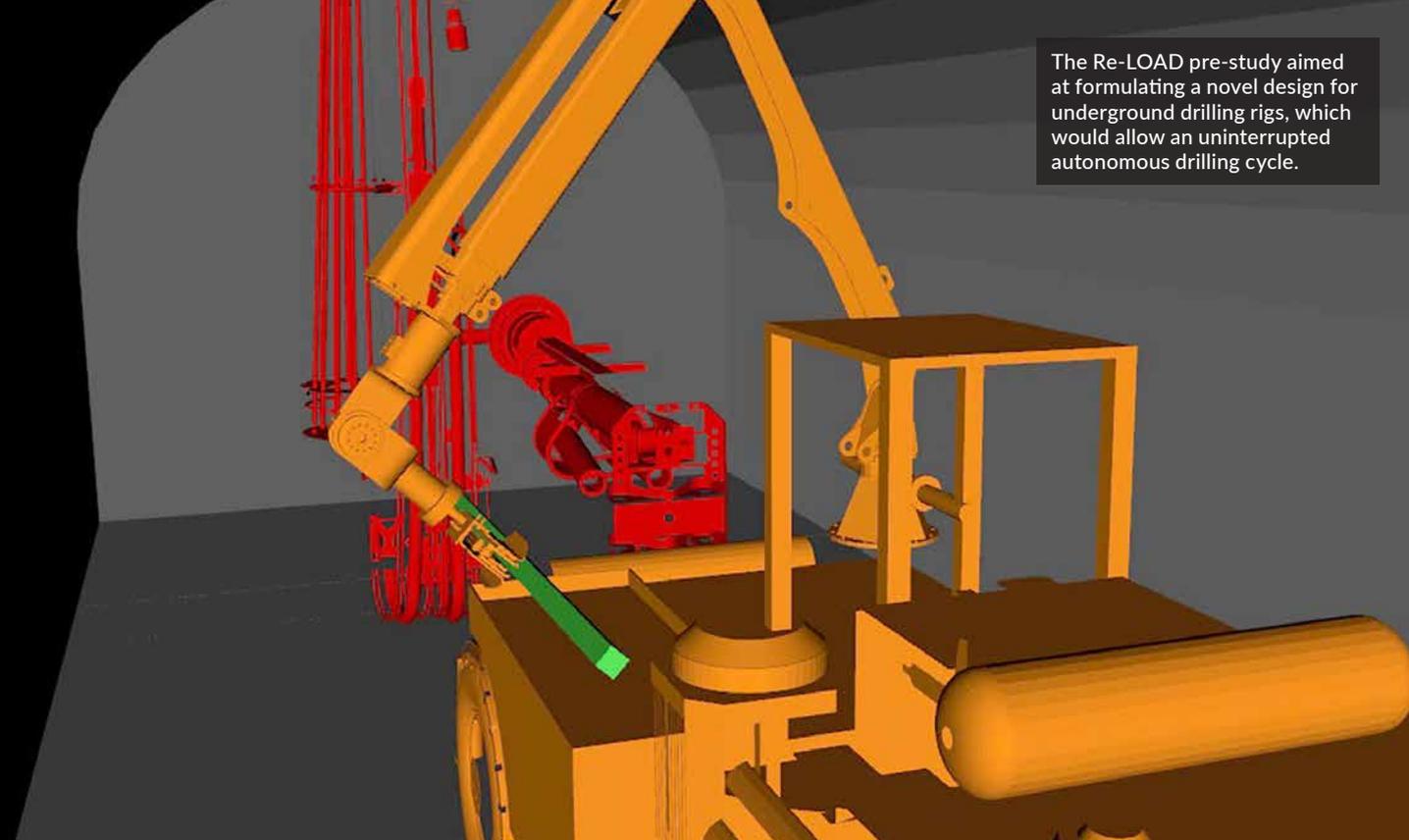
**Total budget:** SEK 842 000

**Project duration:** 2016-09-01–2017-02-28

**Purpose and goal:** The pre-study resulted in a concept configuration of a drilling rig with autonomous reloading capacity. The design was verified both using kinematic simulations, as well as a part of a mock-up laboratory set-up. The developed software and the obtained results will be used to inform future full-scale concept implementation.

**Structure and implementation:** The design of the pre-study as two complementary exploration directions has resulted in a comprehensive work-cycle simulation. Through these two components we were able to estimate expected reloading times per bolt and expected success rate of reloading for different vehicle configurations. This has resulted in a baseline for future concept designs and full-scale implementations.

**Results:** The concept vehicle designed within the project would be capable of supplying new bolts to a drilling rig, under a predetermined set of conditions. The proposed technology would be feasible to implement, and has been proven under simplified laboratory conditions.



The Re-LOAD pre-study aimed at formulating a novel design for underground drilling rigs, which would allow an uninterrupted autonomous drilling cycle.

### Removal of NO<sub>x</sub> from flue gases in pelletising plants – evaluation of two possible alternatives

**Project manager:** Linda Sandström, RISE Energy Technology Center AB

**Consortium:** LKAB, RISE Energy Technology Center AB

**Subsidy from STRIM:** SEK 500 000

**Total budget:** SEK 555 000

**Project duration:** 2016-08-01–2017-02-28

**Purpose and goal:** The project objective was to evaluate two technologies (LoTOx and SCR) for reduction of NO<sub>x</sub> emissions from flue gases, with the aim to identify the most suitable purification technology for possible future installations at pelletising plants. Relevant properties of the flue gases have been compiled, plants visits have been performed and well defined process concepts have been developed in cooperation with experts and suppliers. Due to lack of knowledge concerning the LoTOx technology, it is currently only possible to recommend considering SCR installations at selected plants.

**Structure and implementation:** The project has been performed in cooperation with LKAB staff and suppliers and experts within SCR and LoTOx. Process concepts, economic assessments and benefit analyses have been made. Strengths, weaknesses, risks and possibilities of each technology have been discussed and these have been analysed based on technical, energy and environmental (both external and working environment) aspects. This work will facilitate the judgement of which of the technologies is overall more suitable for installation at the pelletising plants of LKAB.

**Results:** The LoTOx technology is currently not assessed to be ready for full scale installation according to the suggested process concepts. Hopefully the results of this project will help in the planning of future work concerning LoTOx, so that the uncertainties regarding the technology can be sorted out. Process concepts for SCR have been developed within the project. SCR installations are currently judged to be interesting for further evaluation at primarily two of the plants, and this project is anticipated to facilitate future work due to the identification of critical aspects.

### **Sustainable and energy efficient leaching of metals by ultrasound controlled cavitation**

**Project manager:** Örjan Johansson, Luleå University of Technology

**Consortium:** Luleå University of Technology

**Subsidy from STRIM:** SEK 500 000

**Total budget:** SEK 595 000

**Project duration:** 2016-09-01–2017-02-28

**Purpose and goal:** Controlled ultrasound cavitation has the potential to increase both leaching recovery and kinetics and can be utilised on minerals and by-products known to be difficult to leach (scheelite concentrates and speiss). The goal is to modify and optimise a scalable ultrasound cavitation reactor to obtain an energy efficient leaching process at lower temperature and under atmospheric pressure. Important factors are resonance amplification, excitation frequencies, cavitation intensity, temperature, and particle size distribution in the material that is to be leached.

**Structure and implementation:** The project aims at optimising an ultrasound controlled cavitation reactor. Important factors are to create homogenous slurry of the particle to be leached and the leaching reagents. The excitation signal is adapted to the reactors optimum frequency response and the size of the cavitation bubbles with the particle size distribution of the material that is leached. Optimisation of process parameters as flow, temperature, cavitation intensity and the signals frequency distribution is decisive for an energy efficient leaching. The experimental analysis was performed in four steps.

**Results:** Results are expected to show that ultrasound controlled cavitation can render a more efficient leaching process provided that the process has been optimised regarding acoustic performance, geometric configuration of the reactor, controlled flow of the slurry and proper adaptation of the process parameters for the material to be leached. The best test result increases the yield by 50% using an electric input power of 100 kWh/kg scheelite concentrate. The results are expected to generate an established cooperation with two industrial partners for implementation on a pilot scale.

### **Zinc metal extraction from alkaline battery waste by pyrochemistry**

**Project manager:** Burcak Ebin, Chalmers University of Technology

**Consortium:** Chalmers University of Technology

**Subsidy from STRIM:** SEK 495 000

**Total budget:** SEK 495 000

**Project duration:** 2016-09-01–2017-02-28

**Purpose and goal:** A pyro-chemical process with low CO<sub>2</sub> emission for the extraction of zinc from spent alkaline batteries was developed. The process efficiency increased and the carbon footprint sharply decreased when H<sub>2</sub> gas was used as a reducing agent. The waste feeding amount determined as the critical factor to control the efficiency in the case of scale-up the process, if horizontal static furnace is preferred. Gas analyses revealed that the exhaust gas of the process was dominated by CO and CO<sub>2</sub>, but other minor gases, which can be treatable, were also detected in the exhaust gas flow.

**Structure and implementation:** The project investigated the extraction of zinc from battery waste by a developed pyro-chemical process and systematically analysed the effects of the type and amount of the reducing agent, process time and waste feeding amounts to optimise the conditions for high recovery amount and low CO<sub>2</sub> emission. Energy consumption and exhaust gas emission of the optimised process were analysed. The process carbon footprint is less than the lowest value of industrial zinc process considering that using green energy sources. The zinc particles has submicron size and it is a market-ready product.

**Results:** The zinc recovery amount reached 99% at 950 °C for 60 minute process time by adding carbon as a reducing agent. Although extra carbon increased the zinc recovery, the CO<sub>2</sub> gas emission of the process also rose. When H<sub>2</sub> gas was used, 99.7 and 99.8% of the zinc extracted from the waste at 950 °C for 45 and 60 minute process times, respectively, and the CO<sub>2</sub> emission was minimized. Zinc and manganese oxide particles were prepared in the process. The project results show that industrial scale pyro-chemical process can be economically and environmentally feasible for the recovery of zinc from spent batteries.

### **Extraction of tellurium as a volatile fluoride**

**Project manager:** Johanne Mouzon, Luleå University of Technology

**Consortium:** Luleå University of Technology

**Subsidy from STRIM:** SEK 500 000

**Total budget:** SEK 503 000

**Project duration:** 2016-09-01–2017-02-28

**Purpose and goal:** In this project, we aimed at validating the concept of extracting tellurium by an innovative method called liquid-gas separation: the LIGEX process. This process requires fluorination of tellurium into a volatile fluoride. The goals were therefore to identify the most promising fluorination routes depending on the starting material and to perform fluorination of tellurium at lab scale. Both goals were achieved. A promising method to fluorinate tellurium oxide was identified and developed experimentally.

**Structure and implementation:** The project consisted of two parts: 1. Calculations of thermodynamic equilibria in order to evaluate the possibility of fluorinating tellurium in metallic (such as in Boliden's copper telluride) or oxide form with hydrogen fluoride (HF) or fluorine. 2. An experimental study on the fluorination of tellurium oxide  $\text{TeO}_2$  with HF. Two different methods were tested, namely direct fluorination with anhydrous HF and dissolution in a diluted aqueous solution of HF containing fluoride salts of alkali metals. Only the second method was successful.

**Results:** Tellurium in the starting material must be already oxidised in order to ease fluorination. We managed to fluorinate tellurium oxide  $\text{TeO}_2$  into  $\text{TeF}_5^-$  ions in water solutions. However, it is not sufficient in order to obtain volatile  $\text{TeF}_6$  with the LIGEX process. Therefore, this method must be developed further by using  $\text{TeO}_3$  instead of  $\text{TeO}_2$  in an attempt to form  $\text{TeF}_7^-$  ions. It should be possible to extract these ions in aqueous solution by solvent extraction and to subsequently release  $\text{TeF}_6$  with high purity, which would be of high scientific and innovative impact.

### **FloccFines – Flocculation of fine particles in mineral flotation of copper-lead-zinc sulphide ores**

**Project manager:** Marie Ernstsson, RISE Research Institutes of Sweden AB

**Consortium:** Boliden Mineral AB, RISE Research Institutes of Sweden AB

**Subsidy from STRIM:** SEK 500 000

**Total budget:** SEK 720 000

**Project duration:** 2016-09-01–2017-03-31

**Purpose and goal:** There are several industrial advantages with a cost and time effective way to evaluate new flocculants in mineral flotation. The main objective of this project was therefore to demonstrate an effective approach to identify potential flocculants for selective flocculation of hydrophilic mineral fine particles. The approach used is based on using a combination of techniques, with focus on measuring interaction forces between hydrophilic mineral surfaces, combined with both flocculation tests of mineral fines and surface chemical characterisation for increased understanding.

**Structure and implementation:** The project included seven work packages. The aims of WP1–2 were to select materials and study literature. In WP3 preparation tests and characterisation of samples were performed. The procedure on how to perform flocculation tests of fine hydrophilic PbS particles was developed in WP3. Different materials to use in the AFM were tested to get adsorption of depressant. Since the AFM system under the chosen conditions was not robust enough, even with a lot of efforts, the planned work with flocculants in WP4–6 could not be performed. The project results were summarised at the final meeting (WP7).

**Results:** In this project, AFM was evaluated to measure interaction forces between hydrophilic minerals (with adsorbed depressant). Results show that interaction forces can be measured, but the system is not robust enough to add flocculants in a next step, so further method development is needed. In addition, a procedure on how to perform flocculation tests of fine hydrophilic PbS particles was developed. The procedure was optimised for several parameters with the aim to keep the hydrophilic fines in dispersion long enough before settling, to be able to detect the effect when adding flocculants.

### **Designed collectors for selective flotation**

**Project manager:** Anna-Carin Larsson, Luleå University of Technology

**Consortium:** Boliden Mineral AB, Luleå University of Technology

**Subsidy from STRIM:** SEK 500 000

**Total budget:** SEK 700 000

**Project duration:** 2016-09-01–2017-02-28

**Purpose and goal:** The aims were to synthesise a new collector with two functional xanthate headgroups to test selectivity for Cu-Ni sulphides in one of Boliden's ores compared with PAX used today. A method to produce the collector in larger scale (1 kg) were to be developed. Flotation tests with the collector were to be made in lab scale on pure minerals and on selected ores from Boliden's mine in Kevitsa. The synthesis method was developed and optimised, flotation tests were performed both on pure minerals and on ores from Kevitsa and Kylylahti, and the results were compared with the currently used collector (PAX).

**Structure and implementation:** Different versions of the collector with different distances between xanthate groups were synthesised in small scale. One version was chosen for larger scale synthesis. NMR was used to control purity, intermediates and end product. Hallimond flotation was used with different collector versions to study differences in recovery for pure sulphide minerals at different pH and collector concentrations. Lab scale tests on the new collector was performed on ores with different composition from Kevitsa and Kylylahti. The results were compared with present flotation protocol as reference.

**Results:** A method for upscaling collector production was developed and optimised regarding number of steps, max volume, choice of reagents and solvents. Unit operations not suitable for upscaling were removed. Flotation tests on pure minerals showed c. 80% recovery for chalcopyrite, galena and pentlandite for all versions of the collector. Sphalerite and pyrrhotite gave less recovery (40% and 25%). Tests on recovery and Cu/Ni selectivity for ores from Kevitsa and Kylylahti showed that the new collector was neither better nor worse than the references.

**Data driven innovative production drilling**

**Project manager:** Håkan Schunnesson, Luleå University of Technology

**Consortium:** Luleå University of Technology

**Subsidy from STRIM:** SEK 489 000

**Total budget:** SEK 489 000

**Project duration:** 2016-09-01–2017-02-28

**Purpose and goal:** The Strategic innovation programme for the mining and metal producing sector aims to strengthen the competitiveness of the mining sector and contribute to sustainable development. This project clearly shows the importance of optimising the key unit operations and how modern, automated, data-driven information can be analysed, interpreted and enable significant improvements as in this case prior chargeability information.

**Structure and implementation:** The project was carried out as a "proof of concept" study in a fully industrial environment, which meant that the results have industrial relevance and have a shorter way to an application. In this case, we believe that the potential for an innovative new application in the mining industry is possible.

**Results:** The project focused on the theme "More efficient and competitive processes, equipment and methods" in the STRIM agenda. The project has demonstrated how rock properties in detail can be determined by utilising drilling parameters that continuously are logged during production drilling. This provides a better and more detailed knowledge of rock properties since information is collected from all the production holes. In this case, the project has demonstrated how this information can be used to optimise charging and blasting.

# Symposiums and meetings

STRIM arranges several seminars and meetings each year. Some of these are primarily intended to inform and facilitate communication between different projects and project members. Other meetings invite anyone interested in the research and innovation undertaken within the STRIM programme.

## **Framtidens Gruv- och Mineral 30–31 January**

SIP STRIM participated at the Swedish conference Future Mine and Mineral in January. SIP STRIM presented the programme and coordinated a session on innovation along with EIT RawMaterials NCLC and Luleå University of Technology.

## **Innovation idea competition, 23 February**

In February, an innovation idea competition was arranged together with EIT RawMaterials NCLC in Luleå. This was the third time the competition was arranged. Nineteen participants pitched their innovation ideas and there were about 70 participants in total. Two winners were elected: Innan AB and Widefind.

## **Top management meeting, 23 March**

A top management meeting between industry, academia and the Ministry of enterprise was jointly arranged with Bergforsk.

## **SIP Programme conference, 4 May**

In May, SIP STRIM participated in a national conference on innovation cooperation organised by the Government Offices, Vinnova, the Swedish Energy Agency and Formas. Around 400 people from industry, the public sector and the academy participated. The SIP STRIM programme presented a successful project focusing on interaction and leverage, and participants at the conference were also given the opportunity to try the VR environment of Innan AB, the winner of the innovation idea competition in 2017.

## **Bergforskdagarna, 31 May to 1 June**

The conference Bergforskdagarna is the annual innovation conference for the Swedish mining and metal

producing industry. The conference is arranged jointly by the Bergforsk foundation and SIP STRIM, and the theme for 2017 was *Smart Green Mine*. Around 150 participants attended the conference on site in Luleå, and more than 350 participants followed the online feed.

At the conference, all ongoing SIP STRIM projects were presented. All presentations are still available online at [www.bergforsk.se](http://www.bergforsk.se).

## **Technology trip, 9–15 October**

Part of the STRIM board, with representatives from Boliden, LKAB, Epiroc, RISE, Svemin and Vinnova, together with representatives from Bergforsk and the Ministry of Enterprise travelled to Chile in October.

The group visited three mining operations: Gabriela Mistral (Codelco), Minera Centinela (Antofagasta Minerals) and El Teniente (Codelco). The smelter at El Teniente was also visited. At each operation a site visit was conducted, and also meetings and discussions with mine managers and staff.

The group also participated at the Swedish Mining Initiative in Santiago, where Ing-Marie Andersson Drugge (Boliden), Matthias Wimmer (LKAB), Olav Kvist (Epiroc) and Jenny Greberg (STRIM) made presentations and Staffan Sandström (Boliden) and Olav Kvist (Epiroc) participated in a panel debate.

The group also met with the Minister of Mining of Chile, Aurora Williams, and with representatives from Corfo. Corfo is the Chilean economic development agency that works to improve the competitiveness and the productive diversification of the country by encouraging investment, innovation and entrepreneurship. Corfo presented the Innovation strategy and Green growth strategy of Chile, the Chilean

National Mining Innovation Program Alta Ley, and the National Innovation Program in Solar Energy.

### **SIP Programme management conference, 16 October**

At the programme management conference, all seventeen strategic innovation programmes meet to share information, discuss strategies and to network. The 2017 conference was held in Stockholm.

### **Programme day, 16 November**

The programme day is an opportunity for project leaders and other participants in SIP STRIM projects to meet and share information with each other. It is also a possibility for the programme office to share useful information to project participants.

The programme day in 2017 gathered 40 participants in Luleå. During the day, SIP STRIM and the opportunities available to those participating in the programme were presented, mostly for the benefit of new project members.

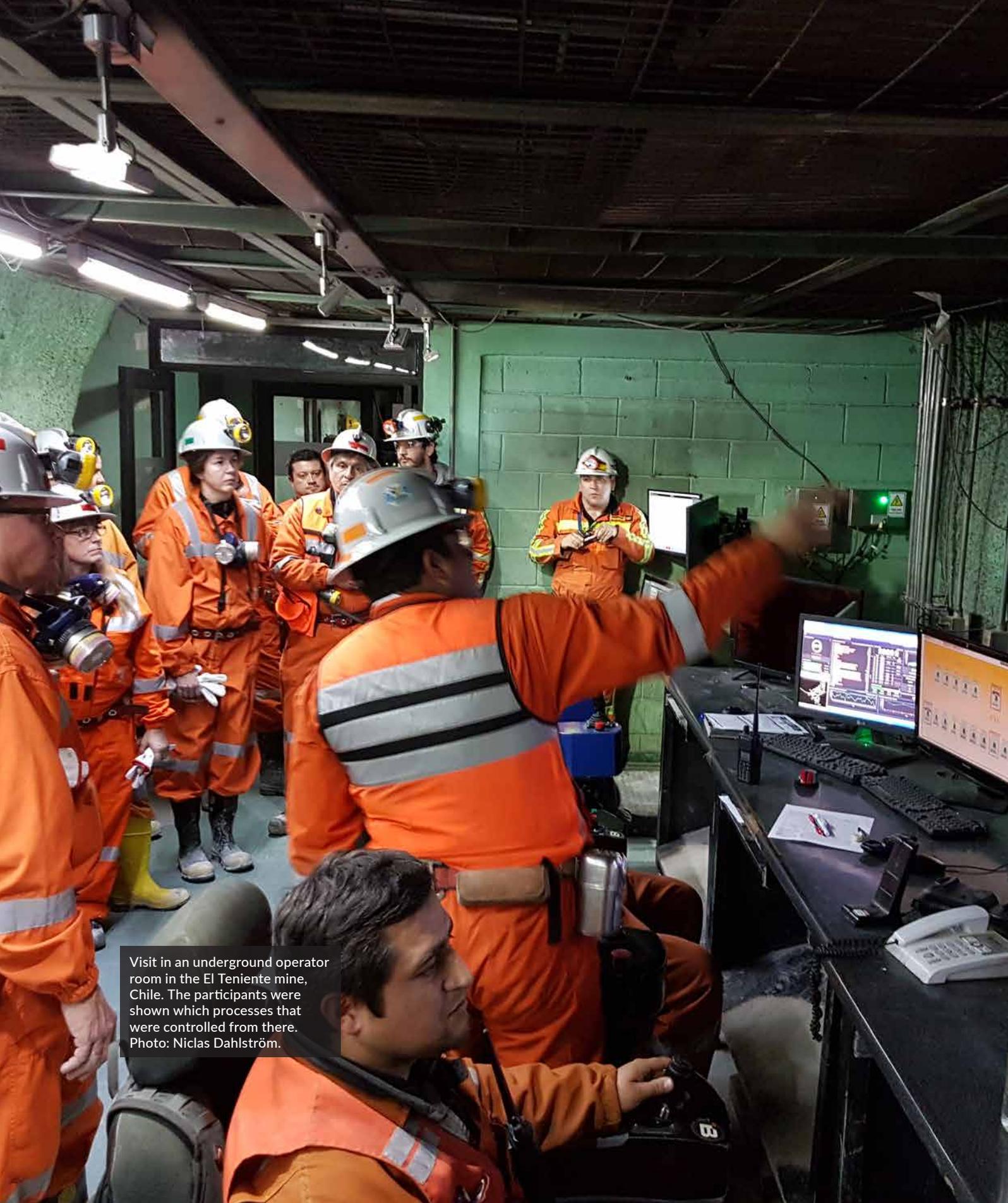
A small workshop on internationalisation and upscaling was held and activities within EIT RawMaterials were presented. In addition, all new projects were presented.

### **General Assembly, 29 November**

At the General Assembly, representatives of all supporting organisations that are active within SIP STRIM meet. At his meeting, the annual activity report for 2017 and an activity plan for the forthcoming year was approved.



Participants and audience of the Innovation idea competition of 2017.  
Photo: Peter Olofsson.



Visit in an underground operator room in the El Teniente mine, Chile. The participants were shown which processes that were controlled from there. Photo: Niclas Dahlström.

# Education

To improve access to skilled personnel in Sweden, a graduate school is planned within the auspices of STRIM. The graduate school will be open to all PhD students who are active in any of the focus areas of STRIM. For more information, contact the programme office.

During 2017 a first workshop was held at Luleå University of Technology with the purpose of developing the idea and vision of the graduate school.

# Internationalisation

STRIM works actively to create international networks, both for activities to enhance knowledge and to enable actors within STRIM to reach a wider market. STRIM also participates continuously at various international conferences, workshops etc.

During the year all STRIM projects have had the possibility to apply for funding to lever their projects. The funding has been used to plan and apply for international funding to lever a part of or an entire STRIM project.

SIP STRIM has also continued its close collaboration with EIT RawMaterials NCLC in the joint idea competition but also within the project “Method development to create more commercially successful applications and projects” where STRIM

projects were aided in leveraging their projects to EIT RawMaterials.

The programme office also works with an advocacy platform to secure future funding for mining-related research and development at the EU-level, both regarding the work programmes of Horizon 2020 and the future framework programme FP9.

The SIP STRIM programme office was present at the European Raw Materials Week in Brussels 6–10 November 2017 and at meetings of the European Innovation Partnership Raw Materials (EIP RM) and European Technology Platform on Sustainable Mineral Resources (ETP SMR) during the year.

The programme was part of “Team Sweden” at the Candian-Swedish mining initiative in Toronto.

# Programme management and organisation

The innovation programme SIP STRIM is run on a daily basis by the programme office located in Luleå. During 2017, the office expanded from three to five part-time staff. All decisions on funding of projects are taken by the Board of Directors.

## Board of Directors

STRIM is chaired by a Board of Directors whose members are appointed by the various larger organisations that collaborate within the SIP STRIM programme.

During 2017, four Board meetings were held, in February, June, September and November. At the Board meeting in June, new projects were approved following the open call that closed in May. The Board meeting in September was accompanied by a workshop during which the outcome goals of the SIP STRIM programme were updated.

### *Members of the Board in 2017:*

Kent Tano, LKAB (Chairman)  
Anders Gustafsson, Zinkgruvan Mining  
Karin Högdahl, Uppsala University  
Erik Höglund, Luleå University of Technology  
Margaret Simonson McNamee, RISE  
Staffan Sandström, Boliden  
Mikael Ramström, Atlas Copco  
Susanne Gylesjö, Vinnova (co-opted member)  
Per Ahl, Svemin (co-opted member)

## Programme office

All day-to-day activities are managed by the programme office which is hosted by Luleå University of Technology. The work has been led by the Programme Director Charlotte Andersson.

During 2017, two new part-time staff were recruited to the programme office: Matz Sandström as Programme manager with project support as special responsibility, and Jeanette Bergman Weihed as Communications Officer. Already working in the programme office were Jenny Greberg, Manager

Technology and Innovation, and Sabine Mayer, Programme Manager with outreach and EU as special responsibility.

## Executive Committee

There is an advisory body, the Executive Committee, which together with the programme office is responsible for the thematic development of STRIM's focus areas. The Executive Committee was formed in 2017 and had its first meeting in June.

### *Members of the Executive Committee during 2017*

Evalena Blomqvist, RISE  
Jonas Brandt, RISE  
Johan Eriksson, Mefos  
Anders OE Johansson, RISE  
Niklas Juhojuntti, LKAB  
Roger Karlsson, LKAB  
Åke Krukka, Atlas Copco  
Lars Malmgren, LKAB  
Hamid Manouchehri, Sandvik  
Rikard Mäki, Boliden  
Kari Niiranen, LKAB  
Anders Sand, Boliden  
Matz Sandström, RISE  
Lena Sundqvist, Mefos

## General assembly

The general assembly consist of all supporting organisations. They appoint the Board and approve the annual report.

## Public funding organisations

Half of the funding of the STRIM programme originates from public funding agencies and half of the

funding comes from the participating industry and organisations.

The public funding agencies are Vinnova (the Swedish innovation agency), Energimyndigheten (the Swedish energy agency) and Formas (a Swedish research council for sustainable development).

### Information activities

A new, more modern web site for SIP STRIM was launched at the end of October. Hopefully this will be

easier to maintain and also allow a more continuous flow of news and activities.

At the same time as the new web site was developed, the general graphic profile was modified to fit the web site. The communication plan was also updated during 2017.

A folder with a presentation of all ongoing projects was produced in May before the conference Bergforskardagarna. In addition, four newsletters were distributed to project members and other interested parts.

The STRIM programme office of 2017. From left: Matz Sandström, Sabine Mayer, Charlotte Andersson, Jeanette Bergman Weihed and Jenny Greberg.



# Facts and figures

## From the start in 2013

Number of approved projects: 83

(includes pilot projects, full-scale projects, feasibility studies, strategic projects)

Approved subsidy from STRIM: 137,2 million SEK

Granting degree: 55%

Percentage of female project leaders: 35%

Number of contributing partners: 95

## Projects approved 2017

Number of approved projects: 20

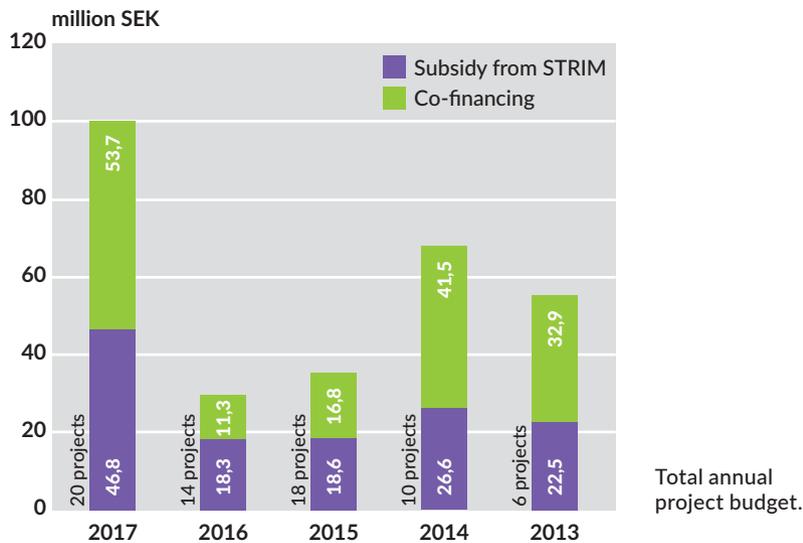
(includes pilot projects, full-scale projects, feasibility studies)

Approved subsidy from STRIM: 46,8 million SEK

Granting degree: 51%

Percentage of female project leaders: 30%

Number of contributing partners: 37



# Contributing partners

ABB AB  
Agio System och Kompetens i Skandinavien AB  
Aktiebolaget Sandvik Materials Technology  
Alecom AB  
Alfred Nobel Science Park AB  
Askersunds kommun  
Atlas Copco Craelius AB  
Atlas Copco Rock Drills AB  
Bergteamet AB  
Bioprocess Control Sweden AB  
Björka Mineral AB  
Boliden AB  
Boliden Mineral AB  
Brokk Aktiebolag  
Cameco  
Cementa AB  
Chalmers Tekniska Högskola AB  
Creamus AB  
Des Nedhe Development  
Dragon Mining (Sweden) AB  
Dräger Safety Sverige AB  
Ductus Preeye AB  
Enetjärn Natur AB  
English River First Nation  
Forcit Sweden AB  
Fracsinus Rock Stress Measurements AB  
Galvano Tia AS  
Hedemora Näringsliv AB  
Högskolan Dalarna  
IGW Europe AB  
Inkonova AB  
Innan AB  
Innovative Machine Vision Pty Ltd  
Interspiro AB  
Jernkontoret  
Kobolde & Partners AB  
Kungliga tekniska högskolan  
Kuusakoski Sverige AB  
LKAB Kimit AB  
LKAB Minerals AB  
LKAB Wassara AB  
Lovisagruvan AB  
LTU Business  
Luleå University of Technology  
Lundin Mining AB  
Luossavaara-Kiirunavaara AB  
Länsstyrelsen i Norrbottens län  
Maskinteknik i Oskarshamn AB  
Minalyze AB  
Mobilieris AB  
Mälardalen University  
Nordic Rock Tech Centre AB  
Nordkalk AB  
Northern Mining Products AB  
Northland Resources AB  
Optimation AB  
Orexplora AB  
Oskarshamns kommun  
Outotec (Sweden) AB  
PEAB Anläggning AB  
Ramböll Sverige AB  
Region Dalarna  
RISE Acreo AB  
RISE Energy Technology Center AB  
RISE Processum AB  
RISE Research Institutes of Sweden AB  
RISE Sics AB  
Rubico Consulting AB  
Ruukki Sverige AB  
SICS Swedish ICT Västerås AB  
SKB Näringslivsutveckling AB  
Skellefteå kommun  
SP Process Development AB  
SSAB Merox AB  
Stena Recycling AB  
Stena Recycling International AB  
Sustainalube AB  
Svemin AB  
Svensk Kärnbränslehantering AB  
Sveriges geologiska undersökning  
Sveriges Lantbruksuniversitet  
Swedish Geological AB  
Swerea Kimab AB  
Swerea Mefos AB  
Tailings Consultants  
Scandinavia AB  
Taoshi Energiteknik AB  
ThingWave AB  
Umeå University  
University of Northern British Columbia  
University of Saskatchewan  
Uppsala University  
Vale S.A.  
WideFind AB  
Xore AB  
Zinkgruvan Mining AB  
Örebro University

Text and layout: SIP STRIM

Cover: Atlas Copco, Certiq – a telematics solution from Atlas Copco.

Print: Printfabriken Karlskrona, 2018

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