Current trends in research on active mining and drainage quality in Sweden

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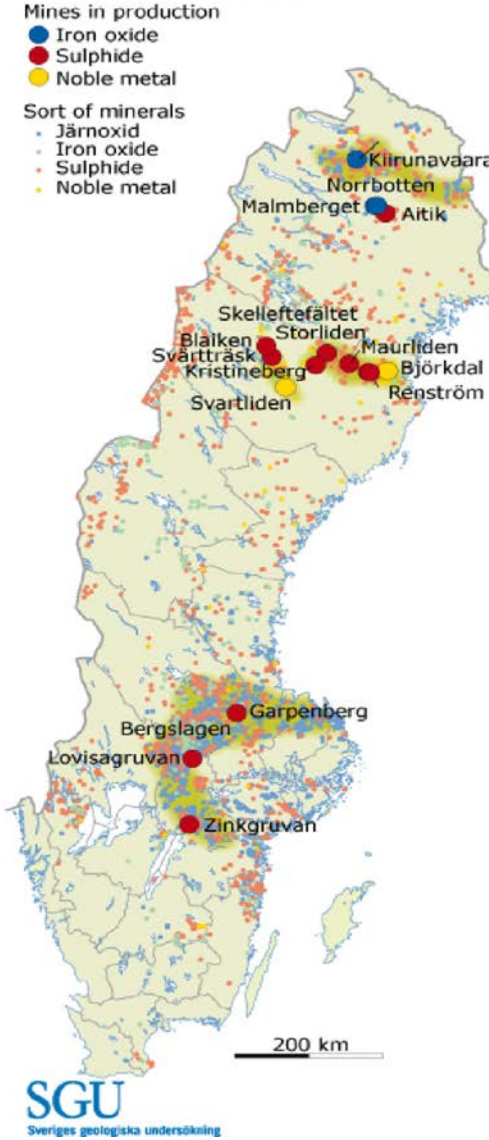
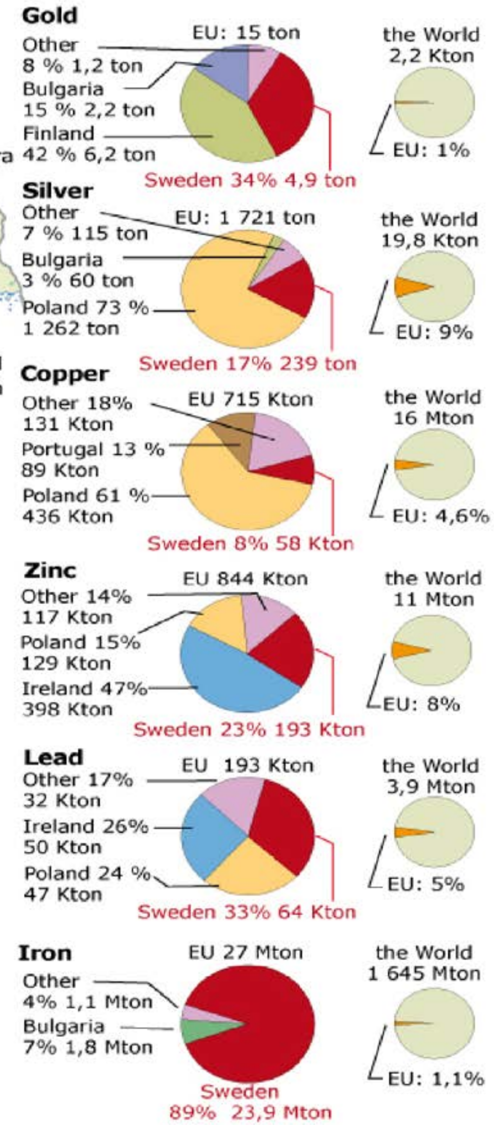
The global demand for metals and minerals is rapidly growing, powered by the growth industries of Asia and China. Europe has a huge trade deficit for metallic minerals, and needs to utilize more of its own resources to decrease this dependence.

Thus, an EU mine drainage research exchange must work together with the active mining industry, and not only focus on historical sins.

Mines and minerals of Sweden 2008



Mines production in Sweden 2008 in relation to EU27 and the World



Mining operations may have detrimental effects on soil, water and biota. The Swedish mining sector uses 1.7 % of the electric power in the country. In addition, a substantial amount of fossil fuel is used, and nitric gases are emitted from various processes. Leakage of the nutrient nitrogen from undetonated explosives and cyanide leaching for gold extraction occurs. Dust and noise problems are common at mine sites.

However, these effects occur only as long as a mine is active.

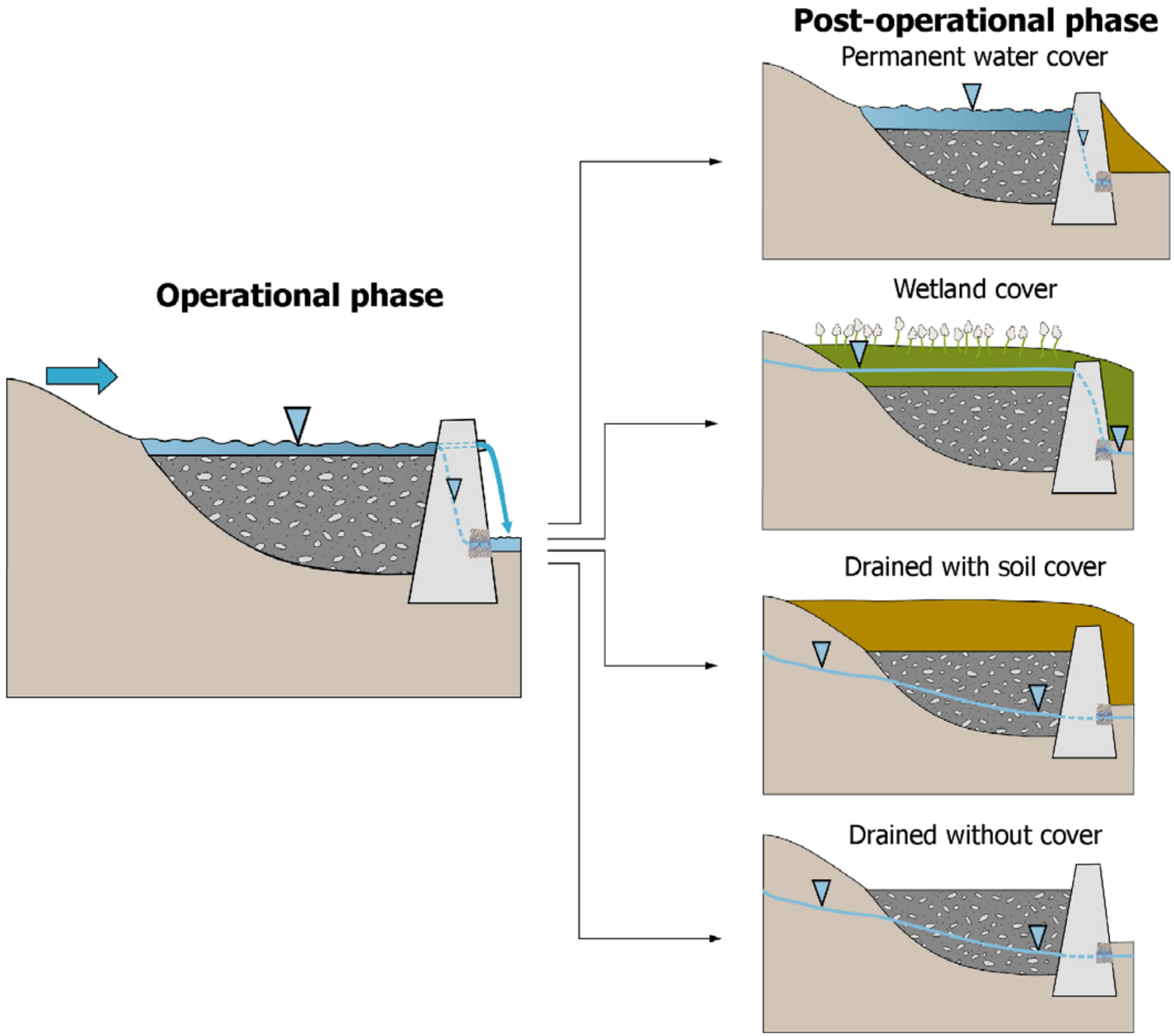
The major potential long-term environmental effect of mining is formation of acid mine drainage in sulphide-bearing mine wastes, which can last for hundreds or even thousands of years.

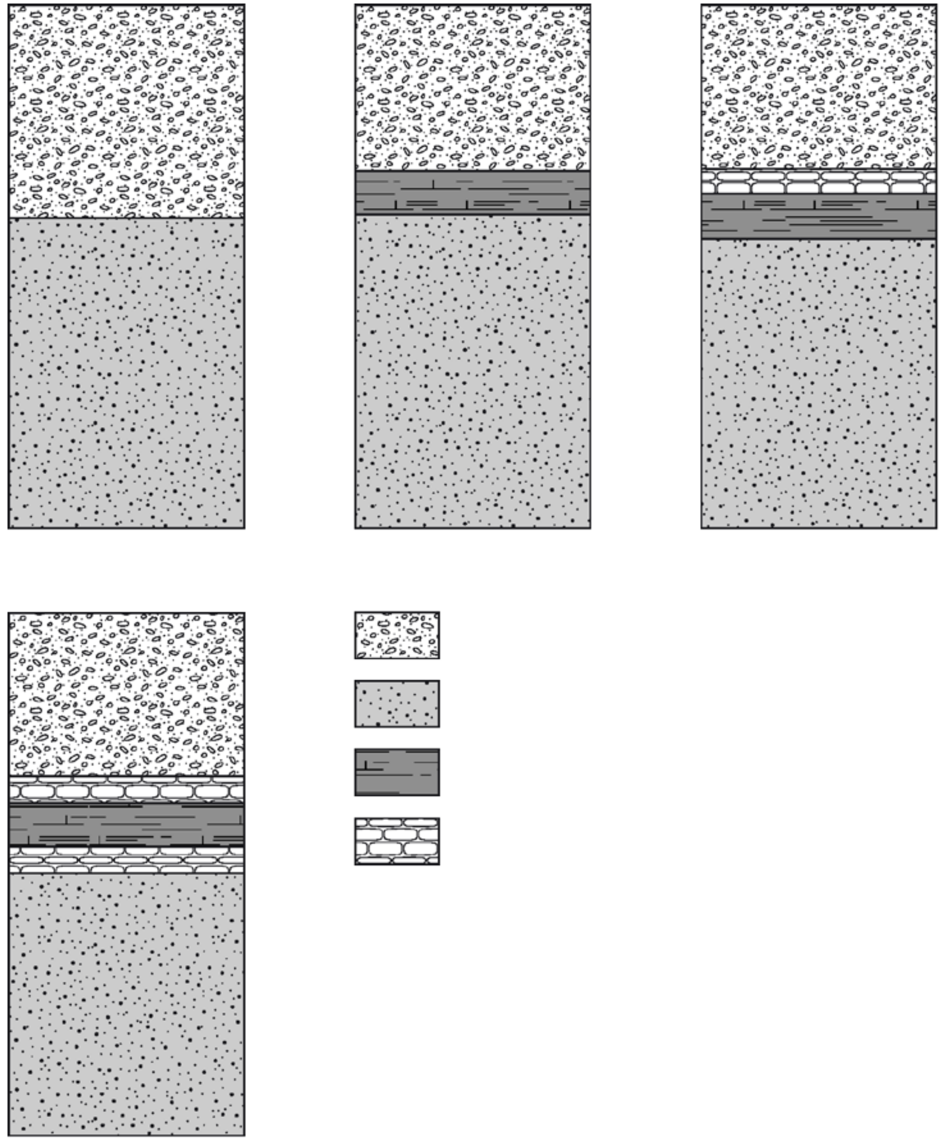
- In Sweden, management of sulphide-bearing mine waste is directed towards prevention of formation of acid mine drainage, also on a very long time perspective (next glaciation perspective).

- After closure, it should be possible to leave the remediated waste without continued maintenance.

- Treatment methods such as liming for ever or at least for a very long time is not an option.

Research on remediation of tailings has been mostly focused on soil cover and water cover

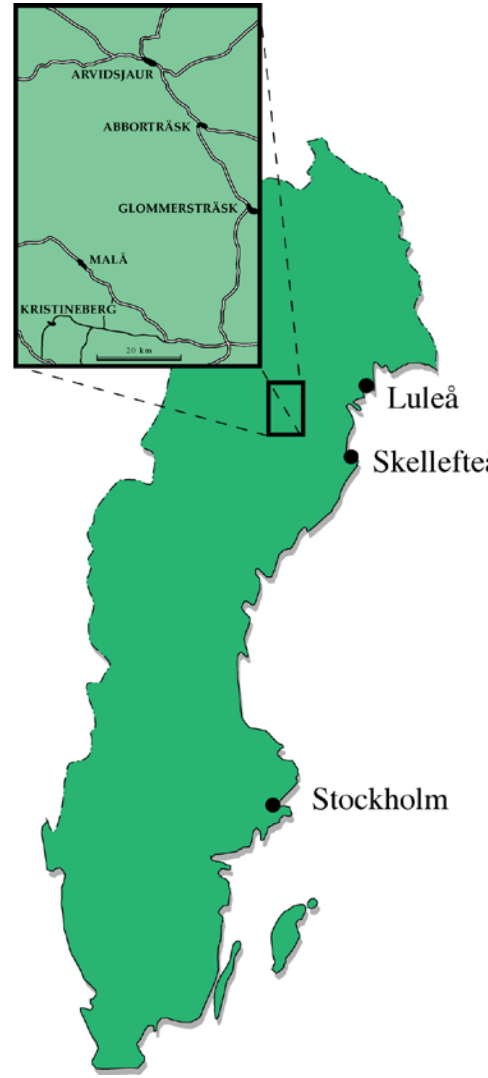

Post-operational phase
Permanent water cover
Operational phase
Wetland cover
Drained with soil cover
Drained without cover



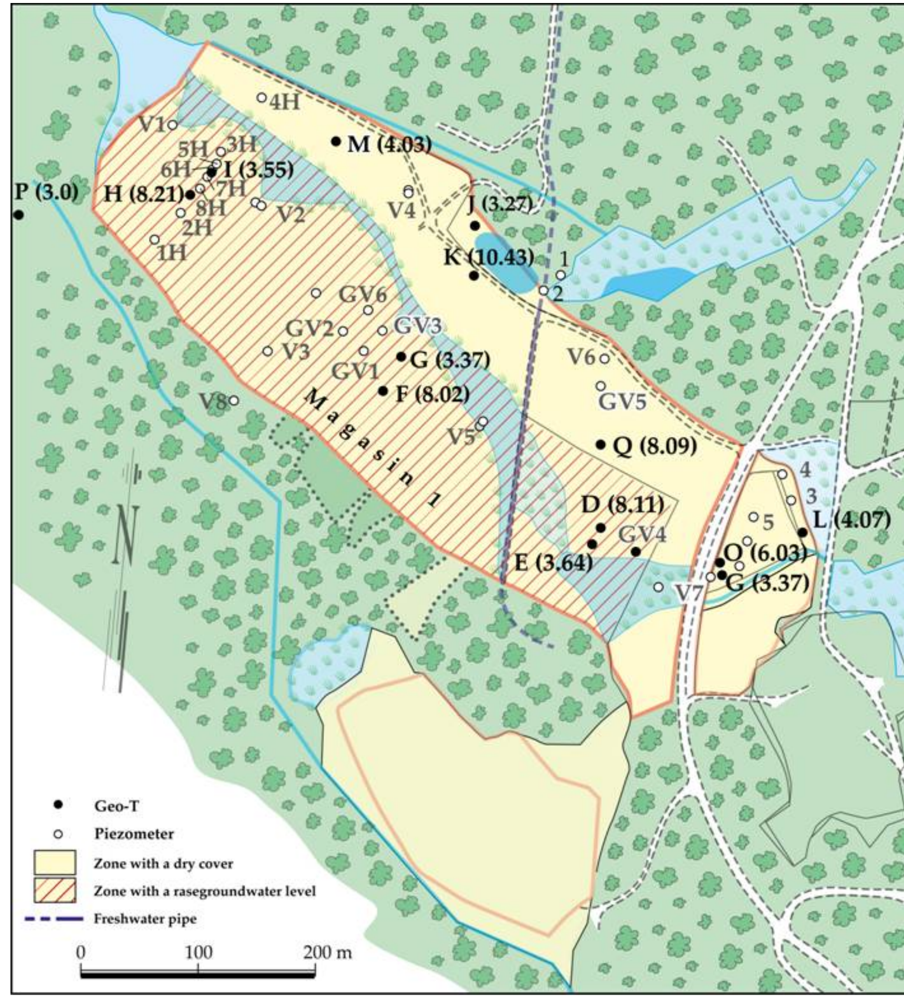
RESEARCH AREA

- MiMi
- GEORANGE

- Long term
- Pilot scale

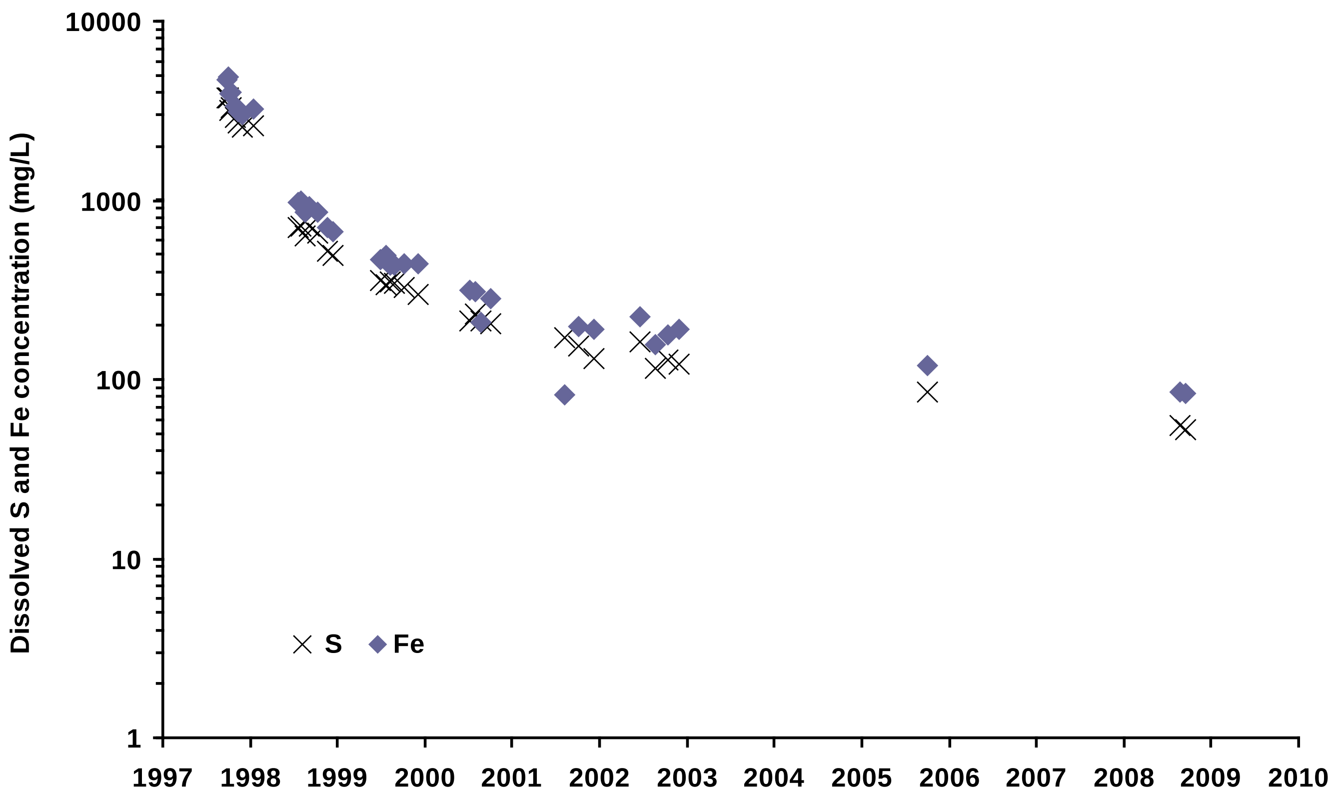


Groundwater in a remediated impoundment



Since 1998 => 2010

Iron and sulphur concentration in groundwater 1998-2009



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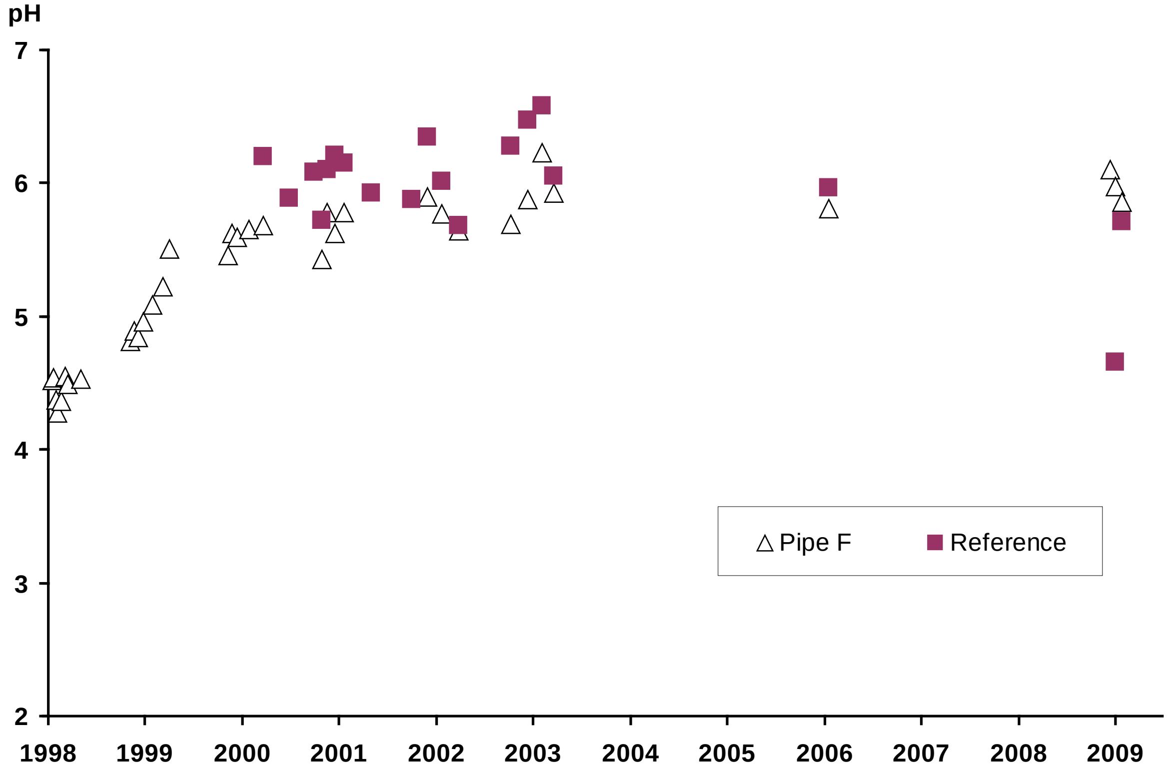
pH in groundwater 1998-2009



In the last years, there has been a trend to study the use of waste or rest products from other industries or activities for remediation of mine waste.

Examples are sewage sludge, incineration ashes and waste from the forest and paper industries (such as Green liquor dregs (GLD), alkaline rest products from the paper production).

GEORANGE ENVIRONMENTAL TEST SITE

TEST CELLS – KRISTINEBERG, 2001-

C1- PYRITE /TAILINGS

C2- CLAYEY TILL

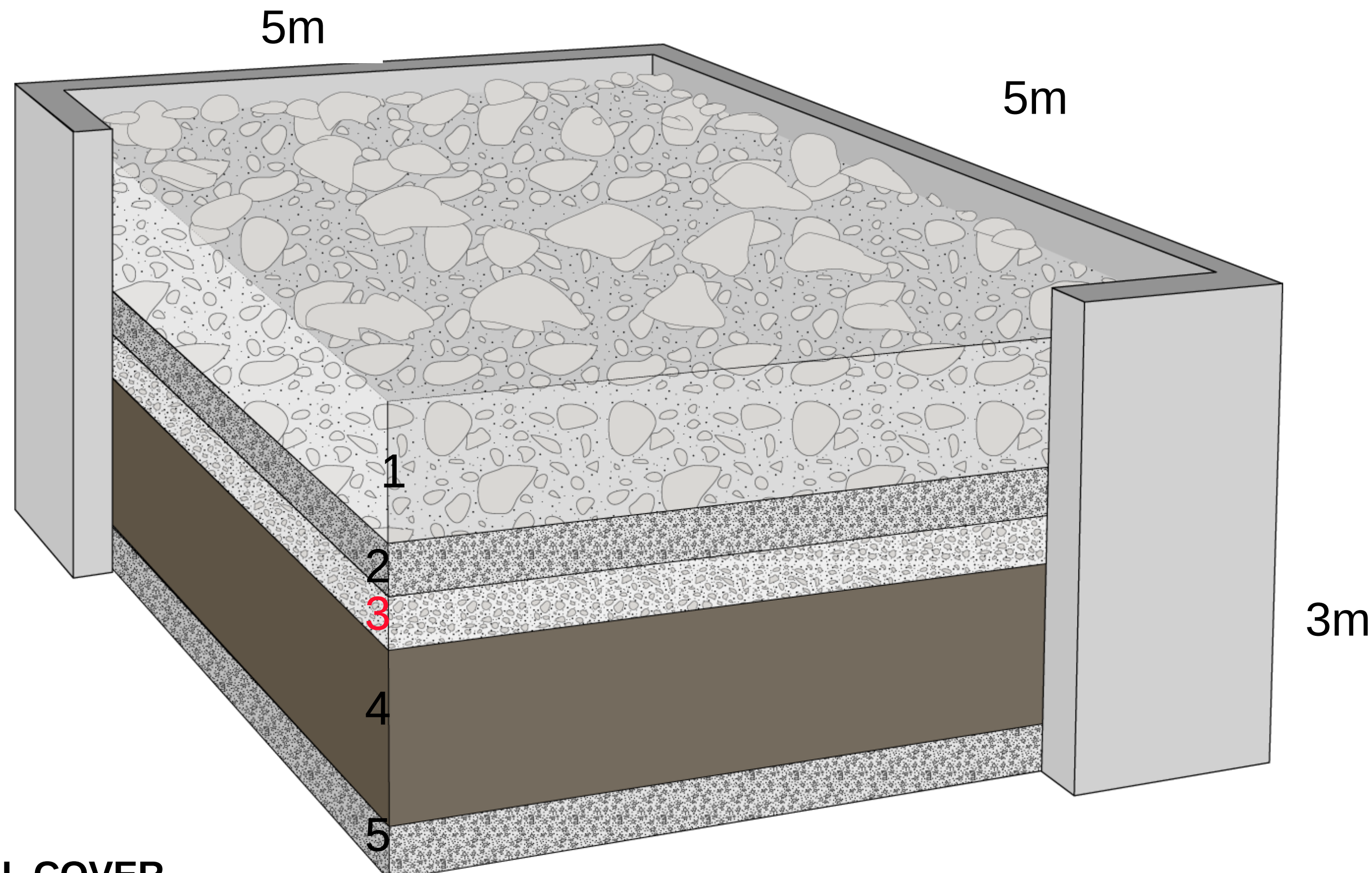
C3- SEWAGE SLUDGE

C4- APATITE

C5- OX. WASTE ROCK/UNOX. WASTE ROCK

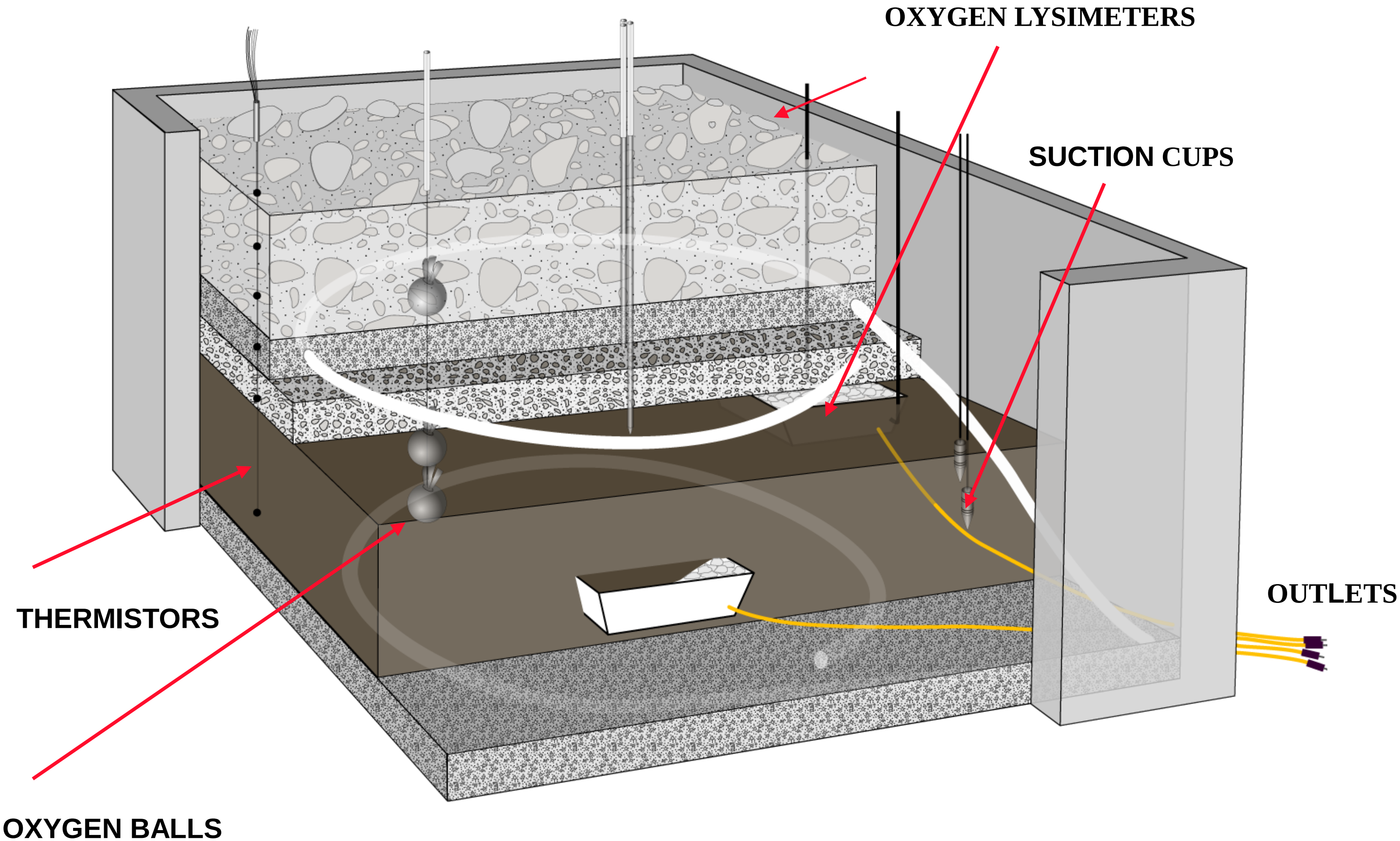
C6- UNCOVERED

General structure



1. TILL COVER
2. DRAINAGE LAYER
3. SPECIAL COVER LAYER
4. UNOXIDISED TAILINGS
5. DRAINAGE LAYER

Sampling installation



Immobilisation of metals in unoxidised tailings

Within the tailings impoundment (absence of oxygen) metals can be a) adsorbed to mineral surfaces, b) precipitated as carbonates, hydroxides etc. and c) forming secondary sulphides, e.g. CuS, “FeAsS”.

At Umeå University these geochemical processes are studied with tailings of different composition:

- Chemical analysis of tailings and pore water
- Mineralogical characterisation
- Metal binding capacity
- Structural characterisation – XRD, EXAFS
- Development of a modelling tool

Metal attenuation by secondary iron minerals

Metals may also be retained by geochemical processes outside the impoundment. The significance of secondary iron precipitates for metal immobilisation is studied:

- Sampling of precipitates of different age and geochemical composition
- Chemical analysis
- Mineralogical characterisation
- Structural characterisation – XRD, FT-IR, EXAFS

Investing in your future

EUROPEAN UNION
European Regional
Development Fund

GEORANGE

Nitrogen effluents from mine sites: Environmental effects and removal of nitrogen in recipients

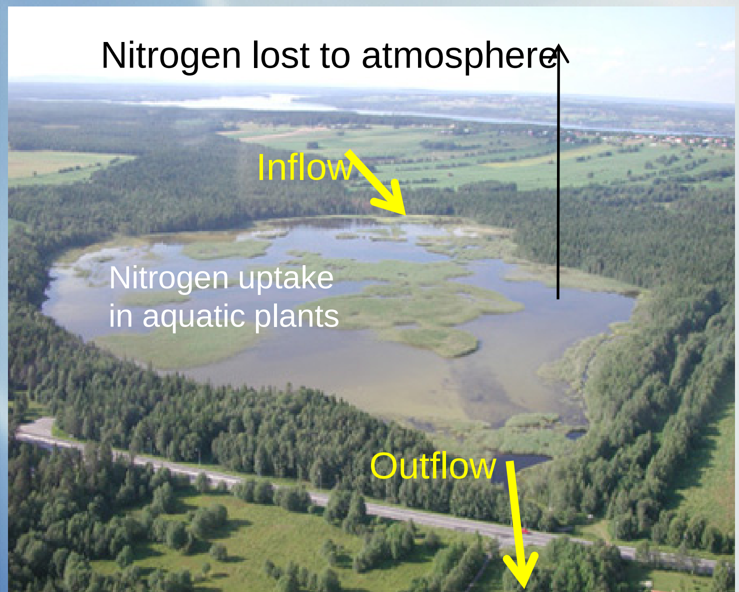
A Strategic Mining Research Programme funded by VINNOVA, LKAB, Boliden Mineral and The Adolf H Lundin Charitable Foundation

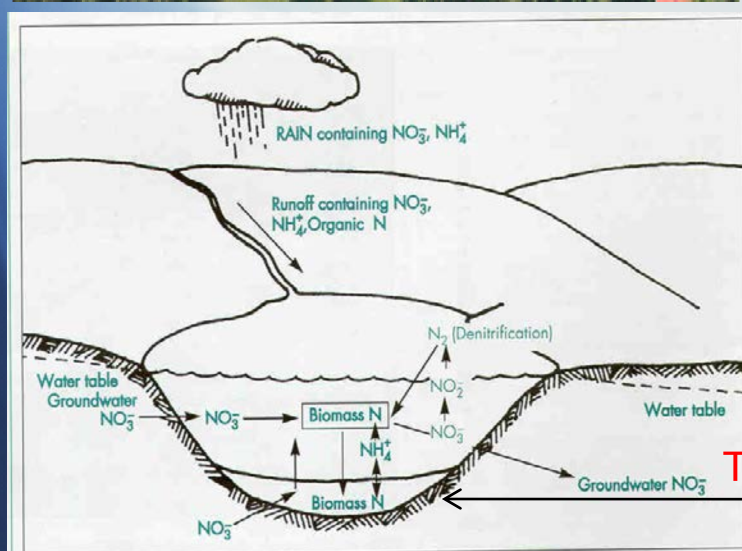
Project period: 2007–2011

Anders Widerlund[1], Sara Chlot[1], Roger Herbert[2], Björn Öhlander[1]
1Division of Geosciences, Luleå University of Technology
2Department of Earth Sciences, Uppsala University

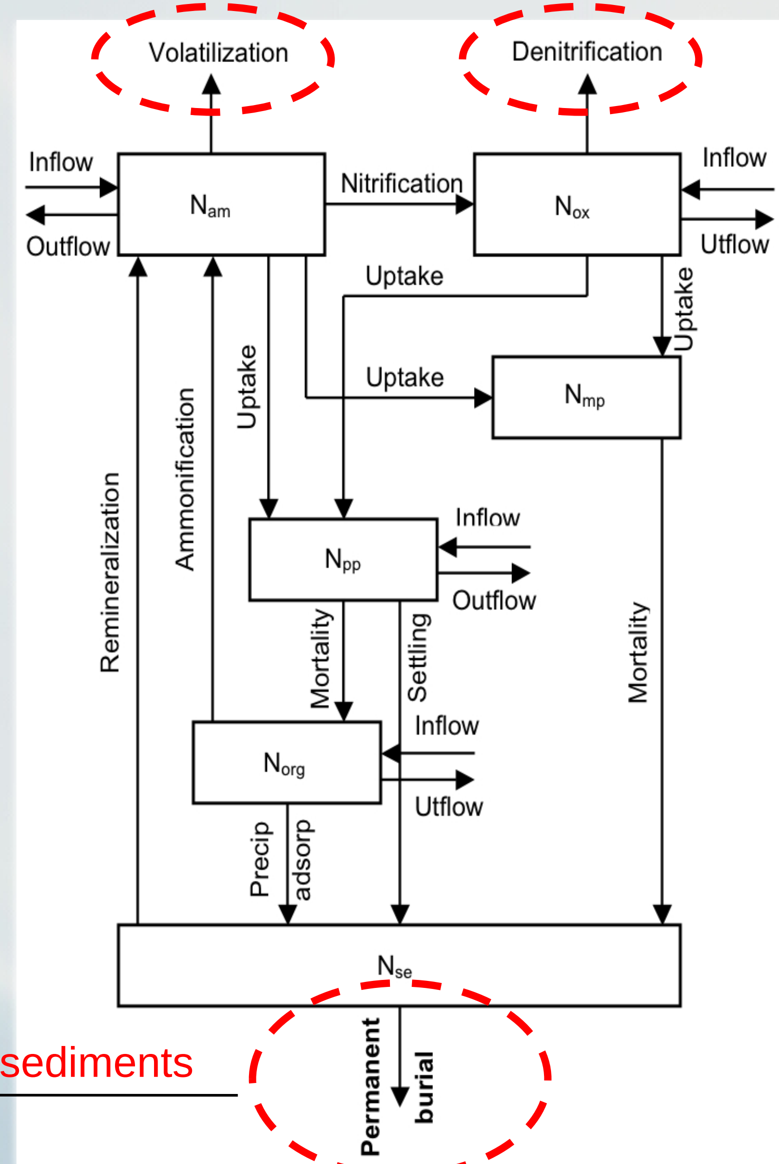
Conceptual and numerical model of nitrogen transformations in lakes

To atmosphere





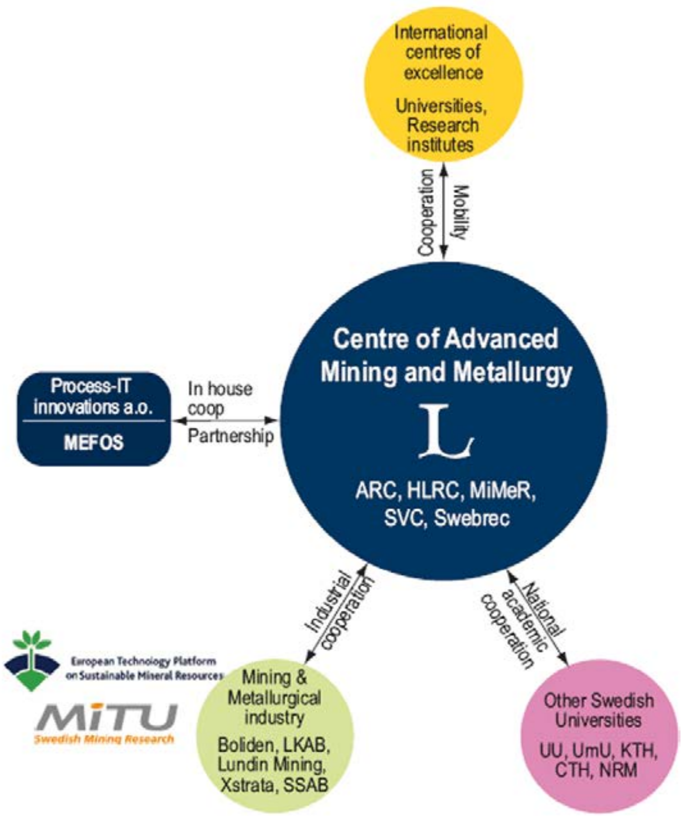
To sediments



Luleå University of Technology is the centre of mining related research and education in Sweden.

This is further strengthened from 2010, when the Centre of Advanced Mining and Metallurgy (CAMM) was established, based on strategic funds from the Swedish government.

CAMM
Centre of Advanced Mining and Metallurgy



- Geometallurgy and 4D geological modelling
- Deep mining
- Lean mining –production systems
- Particle technology
- **Green mining – reducing the environmental footprint (prof. Björn Öhlander)**
- Raw materials for future iron- and steelmaking

Coordinator: Prof. Pär Weihed

Green mining – reducing the environmental footprint

Coordinator prof. Björn Öhlander

Innovative remediation of mine waste deposits, focusing on the use of waste from other industries

Construction of mine dams

Natural weathering in mineralized areas (natural background concentrations)

To define the research needs for the period 2011-2020, and to improve the image of the mining industry, a new project was initiated in 2009

Mine of the Future

Conceptual study - Mine of the Future
March 2009 – Dec 2010

NEW BOLIDEN

KGHM POLSKA MIEDŹ S.A.

LKAB

NCC

GEORANGE

LULEÅ UNIVERSITY OF TECHNOLOGY

RTC ROCK TECH CENTRE

ABB

Atlas Copco

metso

SANDVIK

0

MITU Swedish Mining Research

VINNOVA

RTC ROCK TECH CENTRE
från teori till praktik ● moving theory into practice

Conceptual Study – Mine of the Future

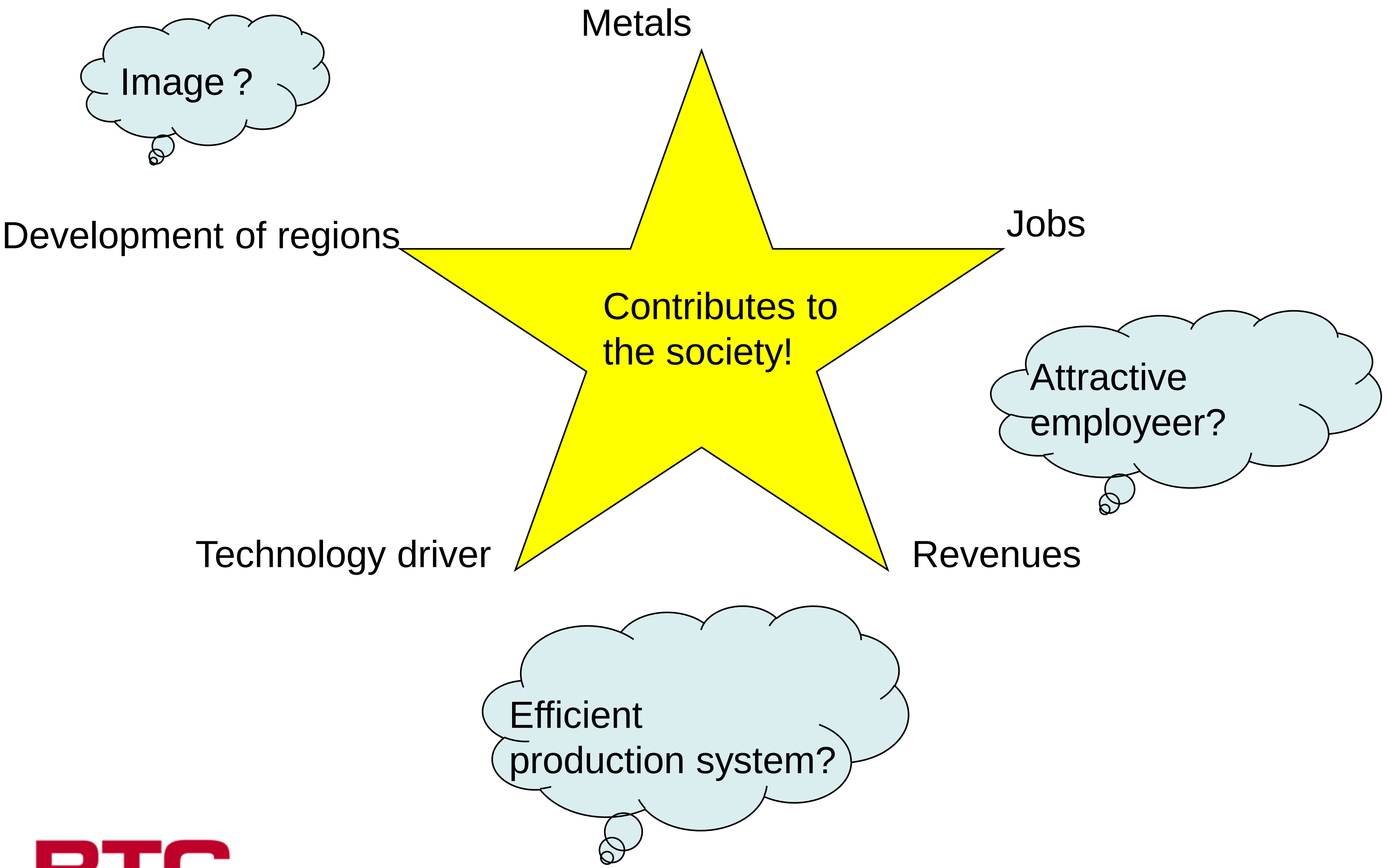
Views on mining
by 2030 and beyond

Göran Bäckblom[1,2]
[1]Programme Director Nordic Rock Tech Centre AB,
[2]CEO Swedish Mining Research Foundation MITU

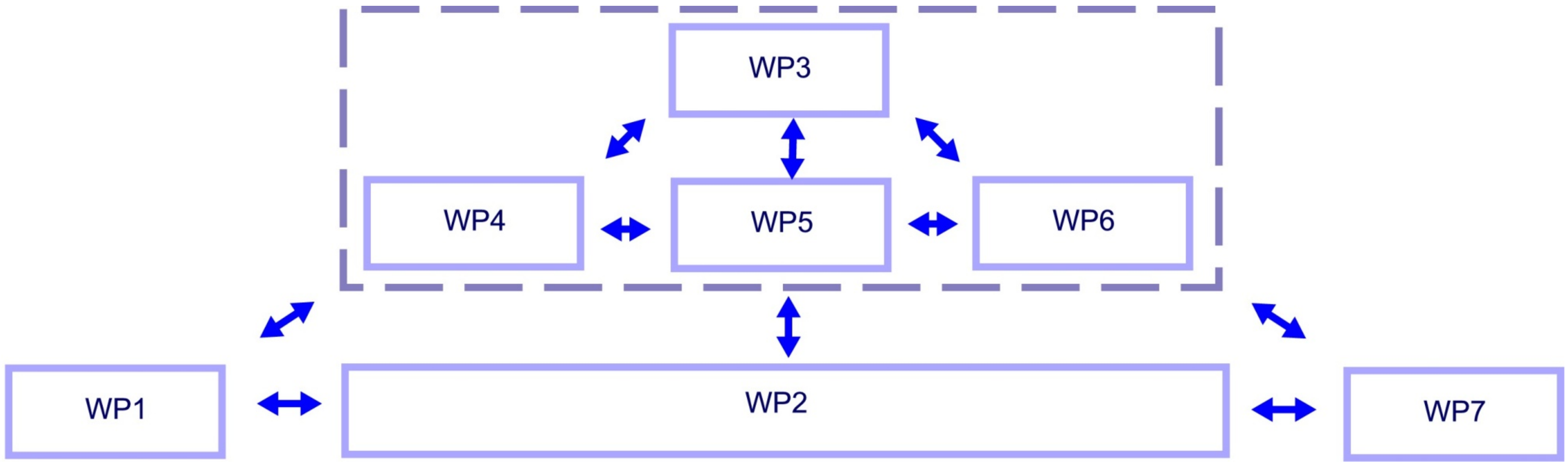
RTC
ROCK TECH CENTRE
från teori till praktik • moving theory into practice

MITU
Swedish Mining Research

Current status of the mining industry

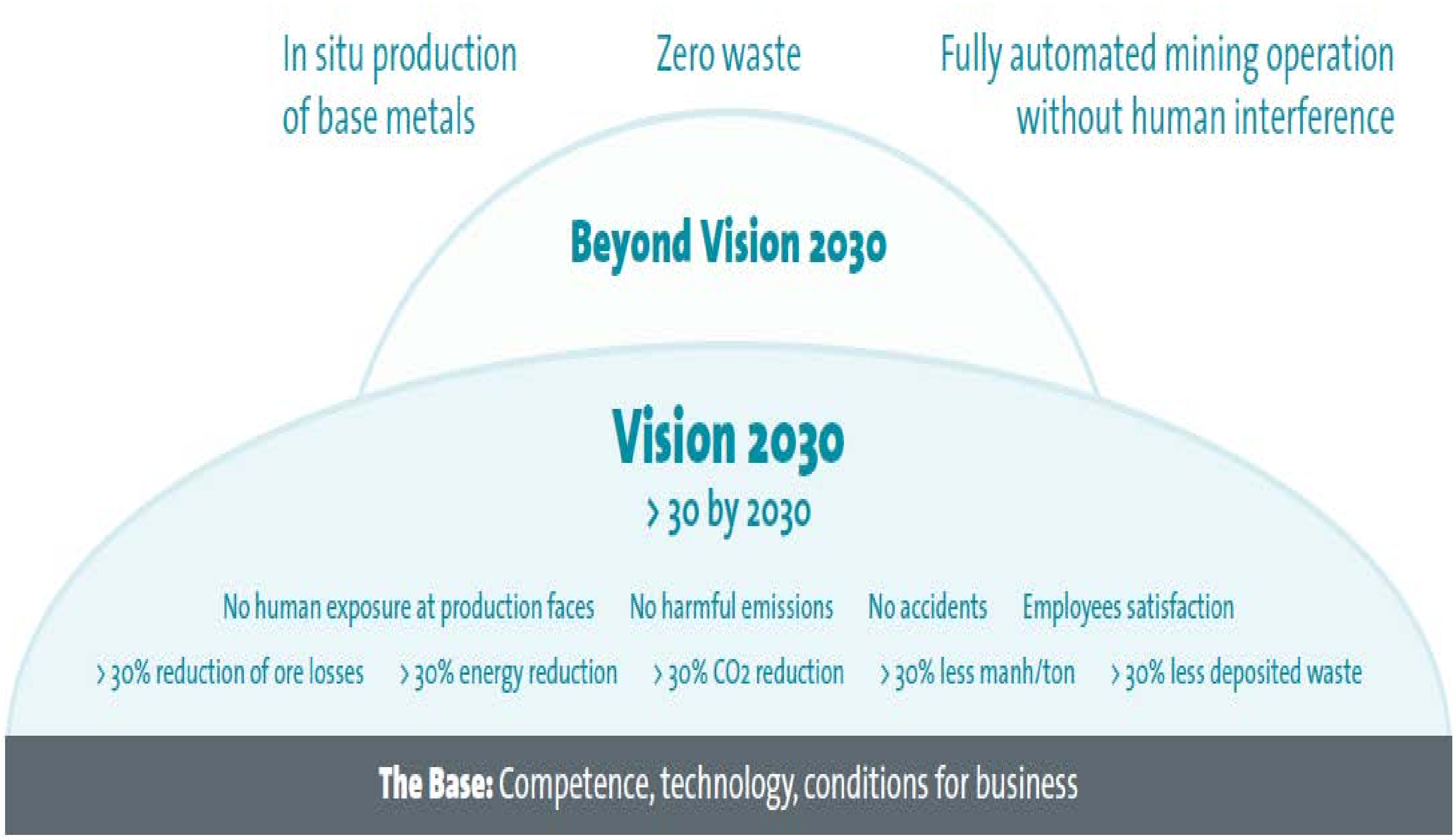


Work Packages



- WP3: The **Attractive Workplace**, Prof. Jan Johansson, LTU
- WP4: **Lean Mining**, Sunniva Haugen, Boliden
- WP5: **New Production Processes and technologies**, Torbjörn Naarttijärvi, LKAB & Prof. Eric Forssberg, LTU
- **WP6: Green mining – reduced environmental footprint, Prof. Björn Öhlander, LTU**
- WP1: **Setting the Scene**; WP2: **Conceptualise the Mine of the Future**; WP7: **Integration of results, the way forward and final deliverable**, Göran Bäckblom

Commitments (draft)



Iron sulphides such as pyrite and pyrrhotite are causing the main problem with mine waste, the acid mine drainage

Shall we continue to spread them in large waste deposits?

This is really a research challenge

Trace elements in pyrite (FeS_2)

(from Levinson, 1974)

ppm or wt. %

	max	common
Se	300	10-50
Ni	2,5 %	10-500
Cu	6 %	10-1%
Co	>2,5 %	200-5000
V	1000	10-50
Pb	5000	200-500
As	5 %	500-1000
Ti	600	200-500
Mn	1 %	10-50
Ag	200	<10
Sn	400	10-50
Zn	4.5 %	1000-5000
Tl	100	50-100
Bi	100	10-50
Sb	700	100-200

Traces of Au may occur

In addition, pyrite oxidation is an exothermic reaction, generating 7,500 kWh/ton.

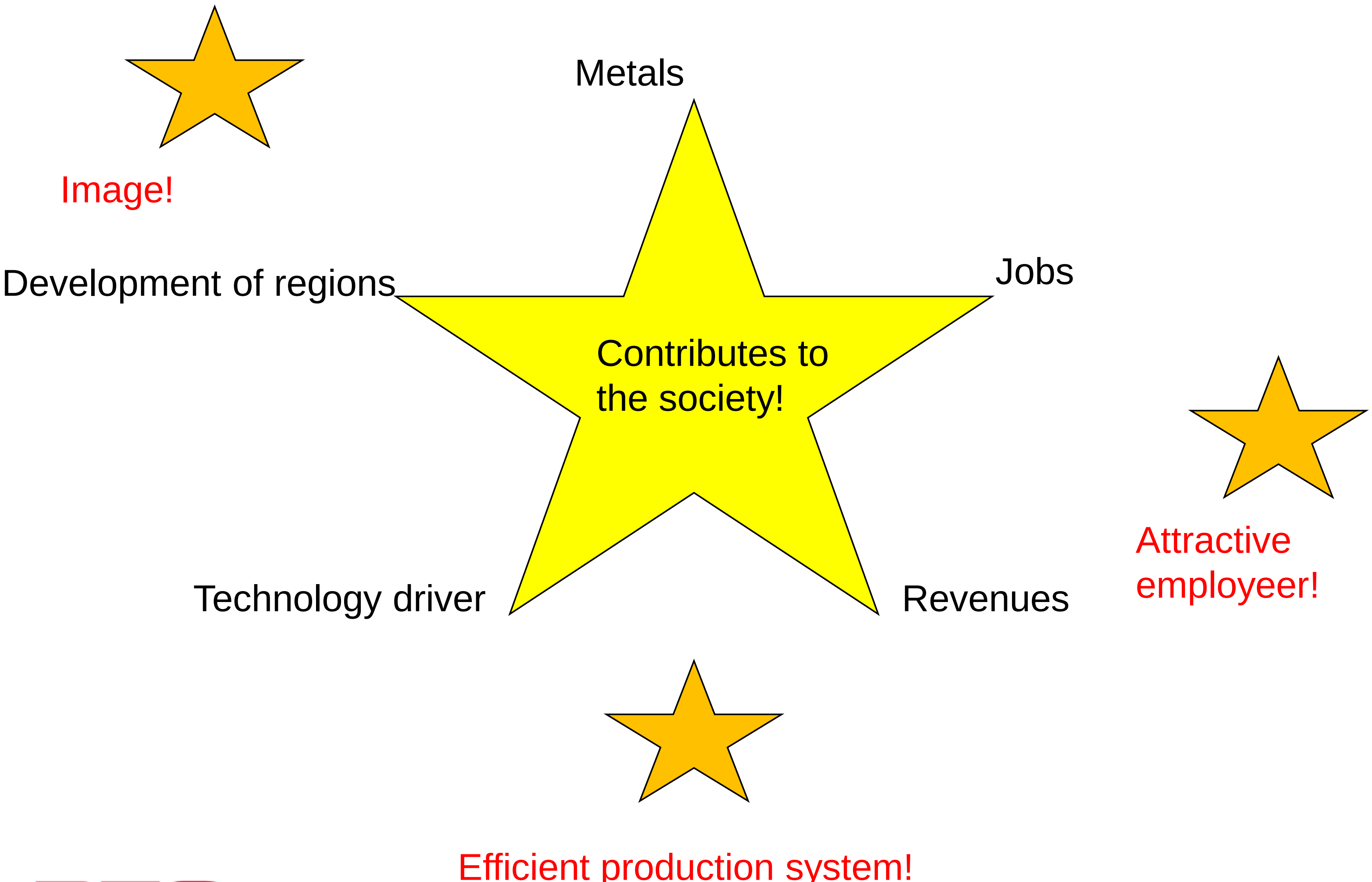
Instead of spreading the iron sulphides in large waste deposits, it could be better to concentrate them, extract metals and utilize the energy from the oxidation.

If this is impossible for some reason, the iron sulphides could be backfilled in the mine, or deposited separately.

Mine of the Future, WP 6, Green Mining, main ideas so far:

- Desulphidization.
- Use waste from other industries for remediation.
- Make products of the waste (REE from apatite, metals from pyrite, waste rock as construction material, tailings without Fe-sulphides as filler in concrete, etc.).
- Study natural background concentrations in mineralized areas, compare with mine sites. Have a comprehensive view and integrate geochemistry and ecology.
- Post-closure added values; for example tourist attractions, sculpture landscapes (by co-disposal waste rock – tailings), increased biodiversity, etc.

Future status of the mining industry



Metal mining in Europe has a good future

Environmental issues are recognized also by the industry as very important

Environmental aspects are integrated parts of mine planning as well as of mine-related research programmes