Water Conscious Mining - Wascious

Margareta Wahlström, VTT, Finland
NordMin workshop “How to go further in Nordic collaboration in the mining research and education”
Water conscious mine concept (ref. BEP 2011)

- High recycling of mine water
- Collection and treatment of mine water in a way not to pose risks for health
- Discharge of water to the environment not to cause significant contamination of downstreams waterways
- Minimised impacts from tailings and sludges from water treatment
Project: Water Consious Mining - Wascious

- Financier: NordMin and participating partners
- Budget: 7.98 Mill. DKK
- Project coordinator: Margareta Wahlström, VTT, Finland
Consortium

Research organizations:
VTT Technical Research Centre of Finland
LUT Lappeenranta University of Technology, Finland
Sintef, Norway
NTNU, Norway
Luleå University of Technology, Sweden
ÍSOR Iceland Geosurvey, Iceland

Solution providers:
Veolia, Denmark
Outotec (Finland) Oy
ÅF Consult Ltd

End-users:
FQM Kevitsa Mining Oy, Finland
Dragon Mining Ltd, Finland
LKAB Luossavaara-Kiirunavaara AB, Sweden
FinnMin - Finnish Mining Association
SveMin - Swedish Association of Mines, Mineral and Metal Producers
Overall objectives

- Development of a technology concept for water conscious mining, and safe utilisation or disposal of tailings
- Establishment of Nordic research platform on the research topic

Photo: Samrit Luoma
Project components

- **Survey of current practices**, their economic and environmental burdens and resources available for alternative practices

- **Requirements** for recycled and discharged waters, tailings quality (utilisation, disposal)

- **Identification and evaluation of key technologies** for distributed water management, process management, tailings treatment and water treatment

- **Research and development of novel technologies** for dewatering of tailings, process and effluent water treatment aiming at in-line treatment and minimum fresh water intake. Novel technologies in this project will focus mainly on electrochemical treatment methods combined in an efficient way with other existing methods (membranes, chemical precipitation, solid/liquid separation etc.

- **Development and evaluation of the concept**

- **Plan and actions for continuation**
Summary from data collection on current practices (1): Water quality and regulations

- Concentration of suspended solids (SS) are regulated at almost every site in Sweden and Finland
  - Clarification ponds
- Metal mines in Sweden have lower limit values for metal concentrations in mine effluents than Finland
  - Does not however seem critical, as the effluents seem to fulfil the current criteria
- Nitrogen appears to be more often regulated at Swedish sites
- Sulphate has been regulated at a couple of sites in Finland, but not at Swedish sites
Starting point 2: State-of-the-art technologies for removal of key contaminants from mine water

Focus on: \( \text{SO}_4^{2-}, \text{NO}_3^-, \text{NH}_4^+, \text{Cu}, \text{Ni}, \text{Zn} \)

Technologies: proved or commercial technologies

Report:
- Principle
- Advantages
- Disadvantages
- Performance characteristics
- Level of technology:
Technology development

Current practice in Nordic mines and review on available technologies

**Mine water treatment:**
Lab. tests with artificial samples and real mine water samples

**Tailings management**
Characterization, Treatment

**Water recycling:**
Modelling of water flows

SO$_4^{2-}$, NO$_3^-$, NH$_4^+$, Cu, Ni, Zn

Water impact index – Comparison of treatment method
Feasibility studies
Technologies:

- Biosorbents: VTT
- Precipitation processes: VTT, Veolia
- Crystallization and solid-liquid separation: NTNU
- Electrochemical processes and solid/liquid separation: LUT
- Membrane processes: SINTEF, Veolia
- Polymer particles and intelligent tracer technologies for waste water monitoring: SINTEF
- Biological processes: Veolia
- Sorbents: Veolia
- Process modelling: LTU, Outotec
- Tailings management: Outotec, VTT

Support: ÅF, FinnMin, SveMin,
### Studied methods for sulphate removal

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Ettringite precipitation</strong></td>
<td>- $\text{SO}_4^{2-} + \text{lime} + \text{Al}^{3+} \rightarrow$ precipitation</td>
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<tr>
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<td>- Efficient sulphate removal (&lt; 10 mg/l)</td>
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<td></td>
<td>- Generation of sludge</td>
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<td><strong>Electrocoagulation</strong></td>
<td>- Use of electric charge</td>
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<td></td>
<td>- Especially for salt concentrations</td>
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<tr>
<td></td>
<td>- No chemical addition</td>
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<tr>
<td></td>
<td>- Generation of sludge</td>
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<tr>
<td><strong>Biosorption</strong></td>
<td>- Use of fungi <em>P. chrysosporium</em></td>
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<tr>
<td></td>
<td>- Not applicable for sulphate</td>
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<tr>
<td><strong>Membrane technologies</strong></td>
<td>- Tailored polymers developed</td>
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<td></td>
<td>- Efficient sulphate removal (max.&lt;30 mg/l)</td>
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<tr>
<td><strong>Eutectic Freeze Crystall.</strong></td>
<td>- Works in low temperatures (&lt; -2 °C)</td>
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<td>- Suitable for high salt concentrations</td>
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<td></td>
<td>- Generation of pure ice</td>
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**Next step:**
Combination of processes:
- Electrocoagulation + membrane technique (done in project)
- Eutectic freeze crystallization + membrane techniques/electrocoag.
- Membrane technology + ettringite precipitation
- Link between process and rejects (sludge)
Simulation of water flows (recycling) using HSC SIM for 2 technologies at conditions in 2 mines

<table>
<thead>
<tr>
<th>Input data</th>
<th>Outcome</th>
<th>Validation</th>
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</thead>
</table>
| Description of the treatment  
  • Reaction equations | Quality of the treated water in the full water balance | Influence of 2 technologies on water quality |
| Efficiency of the treatment:  
  • Target substances | Removal of species | |
| Consumables:  
  • Material  
  • Energy  
  • Reagents…  
  Quantity of consumables  
  Price for consumable | Operational costs | |

- Reaction equations
- Quality of the treated water in the full water balance
- Removal of species
- Operational costs
- Influence of 2 technologies on water quality
Nordic Cooperation:

- Visits to 5 research organizations
- Visits to 3 mines (FIN, S) and one exploration site (Iceland)
- 2 scientist visits
- Supply of real water samples
- Characterization of samples
- Test runs at mines
- Combination of processes
- Modelling/simulation of processes (incl. data from mines for modelling)
- Comparison of techniques

Outcome:
several joint scientific articles (>5), conference papers
How has the project been influenced by being a Nordic collaborative project?

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- Information on similarities and differences in regulation (e.g. substances and levels of concern, point of compliance)
- Complementary skills across the partners. Each organization has limited resources, cooperation opens possibilities for new information in discussions
- Sharing of information has been easy, no formalities (same culture, positive attitudes). No big differences in the working culture of the Nordic countries – easy to work together and agree on things

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- Moderate budgets
- No mining company participating from Norway
Next steps:

- Cooperation with mines and technology companies will continue
- Identification of future opportunities leading to further discussion between research organization on combination of methods --- a good base for H2020 proposal in future
- Ph D thesis to be finished
- Finalization of the project report (will be available on the NordMin webpage)
- Joint article on the project findings
Thank you for your attention!

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