MIN-NOVATION
MINING AND MINERAL PROCESSING WASTE MANAGEMENT INNOVATION NETWORK

TABLE OF CONTENTS:

2 State of the Art Review
3 Mining waste re-use, industrial heritage and environmental protection: the case of Ljusnarsberg copper mine
3 Study trip in the Bergslagen mining district (5th MBN Meeting, Örebro-Åkerby Herrgård, June 18-20)
4 Bergskraft 11·13

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The MIN-NOVATION partnership has compiled background information on the state of the art both in terms of research into mining waste management technologies and existing technologies in use at mining and post-mining sites. The State of the Art Review combines a literature review of technologies and processes related to 1) prevention, 2) recovery and 3) land reclamation with a listing of best available technologies and processes.

The mining heartland of Sweden - Örebro and surrounding counties – is home to a number of exciting developments in the area of mining waste management, which are included in the State of the Art Review. Below is one sample entry, which concerns waste prevention.

**ZINKGRUVAN (LUNDIN MINING), SWEDEN**

**Type of mine and mining waste**
Underground Zn-Pb-Ag mine from 1857 and ongoing, from 2011 also Cu-mine. Several mining methods used since 1857. 1) Open cut 2) Backfilling with pull-down of backfill 3) Backfill 4) Open stopping 5) Open stopping with hydraulic backfill (sand) 6) Open stopping with cemented backfilling. Mining currently below 1 100 m depth.

**Basic description of mining process where waste is generated**
Currently, barren rocks are used for 1) building of new dams 2) roads in the mine 3) Sulphide free waste rock is sold to local contractors 4) gangue minerals separated from ore in enrichment plant are mixed with cement and used for backfilling of openings underground and construction of pillars. Enables close to 100 % recovery of ore.

**Data on waste producer**
1.1 Mt/yr of Zn-Pb-Ag ore, and from 2011 0.3 Mt Cu-ore. Between 300 kt and 750 kt coarse waste rock/yr (depending on frequency of special projects) and 900 kt/yr tailings (majority reused in cemented backfill).

**Short description of the technology of extraction in which mining waste is generated**
Traditional enrichment plant with flotation.

**Stage of technology implementation: research stage, trial stage, production stage**
Traditional technology, plant built in 1975 and constantly developed/refined. Cemented backfill since about 2000.

**Quantity of mining waste generated annually in the mine**
About 750–900 kt/yr now used as cemented backfill instead of disposed in tailings pond.

**Potential possibilities of use of technology for processing of other types of mining waste**
Cemented backfill can be used in any underground mining operation to increase the recovery of ore and to stabilise underground workings.

The final version of the State of the Art Review will be a searchable, publicly available, online resource which will complement BAT documents.
Iron oxides in mining waste from the abandoned Ljusnarsberg copper mine are recovered and used as a red colouring pigment for producing red paint by the local company Kopparbergs Pigment AB. This specific type of paint has been commonly used to cover the outside walls of houses in Sweden for centuries. The in-house developed method uses a dry process and the company has the resources and capacity to become a major supplier on the Swedish and maybe European market.

However, extraction of mining waste is not a straight forward matter, since the Ljusnarsberg copper mine and many other old mines in the area are designated Historical Heritage Sites as well as being top ranked on the county environmental hazard “black list”. The MIN-NOVATION partner organisations, the University of Örebro and the Örebro Regional Development Council, have been working with regional decision-making bodies to find the best way forward.

The same mining waste pile is also the site for the Bergskraft environmental test field where applied research has been investigating methods to prevent, control or treat the leakage of potentially hazardous substances from the mining waste.

One of the results of fieldwork done at Ljusnarsberg has been a research paper on the ability of selected alkaline materials to stabilise acid generation in mine waste. The authors, Mattias Bäckström, Lotta Sartz, Erik Larsson and Stefan Karlsson, carried out extensive pilot scale trials which revealed that certain by-products of industrial chemical processes: lime kiln dust (lime production) and green liquor dreg (paper industry) are well suited to increase pH levels and reduce trace metal concentrations in mining waste slurries. More information on this research is available by clicking on this link.

During the last MBN meeting, the MIN-NOVATION partnership visited several closed-down mine sites such as the Stollberg Fe-Mn-Zn-mine in Ludvika, as well as recultivated sites, including the former Norrtorppssjön alum shale mine (water filled pit lake) in the Närke region and the Kvantorp waste pile (Kvarntorpshögen). Kvarntorpshögen stands out as a testament to former industrial prowess (at over 157 m above sea level, it towers over the surrounding landscape) and human ingenuity (it is now used as a recreational area with art installations, café and walking paths). But it doesn’t stop there: it is estimated that the market value of the waste pile is about 1 billion Euro, primarily because of the uranium, vanadium and molybdenum concentrations, which – given the advance of technology and increasing demand for trace metals – may at one point in the future be exploited.
Mining and mining waste is a phenomenon known to all people living in the historical mining district of Bergslagen in south-central Sweden. The potential environmental hazard as well as the content of potential raw materials in the waste piles has challenged the inhabitants, companies and academia for hundreds of years. The Bergskraft organisations have been cooperating with the University of Örebro and the Örebro Regional Development Council in the Min-Novation project since 2011.

Since 2004, municipalities, counties, NGOs and companies have joined forces with the purpose of rejuvenating the mining industry in Bergslagen.

Today, a public and open economic association, Bergskraft Bergslagen Economic Association, owned by municipalities, private persons, and companies runs a series of projects in cooperation with local, public organisations and universities with some support from the European Union aiming to:

- Increase exploration and mining in the area.
- Develop new methods to handle environmental problems from historical mining.
- Develop methods or cooperation aiming to recover and/or handle mining waste.
- Increase children’s interest in science related to mining and environment.
- Create “mining issue focused” arenas and platforms for collaboration between the more than 50 municipalities and the nine counties that administrate the Bergslagen region.
- Develop long-term relationships between modern mining and mining/industrial heritage related tourism.
- Stimulate and facilitate research on issues related to economic geology and mining related environmental issues in Bergslagen.
- Increase the knowledge level related to mining at the local and regional administration level.

The background to the Bergskraft 11-13 project is that mining was for hundreds of years one of the Bergslagen area’s major sources of income, and for a long time the area was one of the world’s largest producers of metals, chiefly iron but also one or more of the elements Mn, Zn, Cu, Pb, Ag, Au, W, Co etc. Dramatic changes during the post-war period reduced mining activity and forced the closure of many mining-related businesses in Bergslagen to the point that at the end of the 20th century, there were only a few mines left out of what had once been hundreds. The entire industry had practically vanished. But things are changing, metal and mineral prices have gone up due to increasing demands on the global market and the Bergslagen area is receiving new attention.