

# ENVIMINE – developing environmental and geodynamical safety related to mine closure in the Barents region

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The Barents region has been active in terms of mining, with great potential for new discoveries and new mines. The challenges of the mine closure will arise due to environmental safety regulations for minimizing environmental impacts.

The project Envimine is carried out in 2012-2014, in cooperation between Geological Survey of Finland, Mining Institute KSC RAS, Russia, and Luleå University of Technology, Sweden. The study areas are the active chrome mine of Kemi in Northern Finland, the closed mines of Umbozero in Northwestern Russia, and Laver in Northern Sweden. The objectives are to develop methodology for safe mine closure under specific conditions in the Barents region and to assess environmental impacts.

Multilateral relations are developed between Finnish, Russian and Swedish organizations, responsible for environmental management. Results of the project will be the updated database of the study areas, recommendations of the after-care plans and information for target groups.



The study areas of the project.

Kemi mine was in operation since 1968. In 2014, estimations of ore reserves were 50.1 Mt and mineral resources 97.8 Mt. In future ore is processed ca. 2.7 Mt/a, and all gangue is used for backfilling of the underground mine. The ore consists of chromite, tremolite, chlorite, talc, carbonates and serpentinite. The average  $\text{Cr}_2\text{O}_3$  content of ore is 26.5 %. Kemi mine has a monitoring program of emissions, water quality, dust, noise, tremble, composition of tailings and waste rock. Process water is circulated.



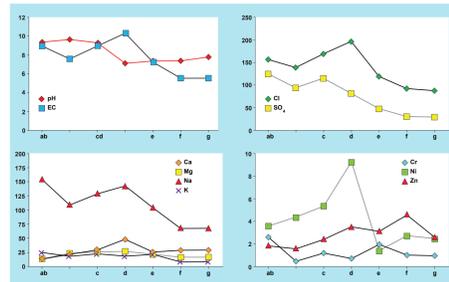
Kemi mine.



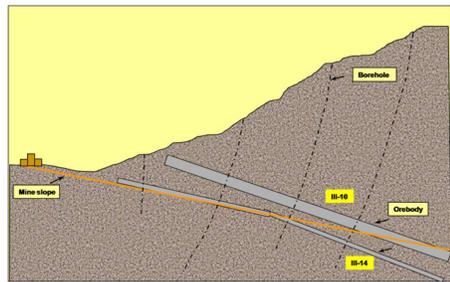
View to the Khibiny Tundra from Umbozero mine.



View over Laver mine.



Parameters of water quality at Kemi mine.

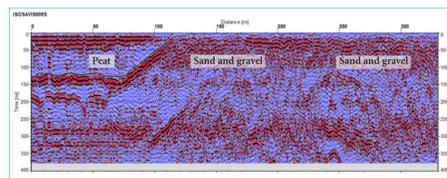


Section of the mine slope of Umbozero.

Umbozero mine is a part of Lovozero alkaline massif. The mine was in operation in 1984-2004, producing rare metal raw materials from loparite ore. The basic contaminants are fluorine, sulphates, chlorides and nitrogen. Dust of the tailings is also a problem.

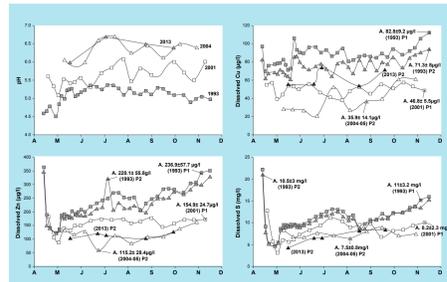


GPR measurements at the tailings, Umbozero.



Example of GPR profile at Umbozero mine site.

Laver mine with copper sulphide ore was in operation in 1936-1946. The original copper ore deposit contained ca. 1.537 Mt of ore, with an average Cu content of 1.51 %. The major sulphide minerals in the ore were pyrrhotite and chalcopyrite, with minor amounts of sphalerite, pyrite and arsenopyrite. The tailings have never been remediated except for the establishment of grass vegetation. Since then oxidation of sulphides has acidified recipient water courses and contaminated them with metals.



Changes of pH and concentrations of Cu, Zn and S with time in a brook downstream of Laver Cu-mine.



Field measurements of water samples in Umbozero.



Sampling of organic stream sediments at Kemi mine.

Geochemical studies were carried out in the study areas by analyses of groundwater and surface waters, organic stream sediments and surficial deposits. The tailings in Umbozero were also studied by GPR and XRF measurements. Geodynamical data with seismic events have been collected by monitoring of stress strained state of Lovozero massif.

Monitoring data of Kemi mine indicate diminished emissions, especially after open pit mining was finished in 2006, and low concentrations of heavy metals in waters. Some elevated concentrations of phosphorus were found in the tailings pond, due to paludified soil, which was not removed from the bottom of the pond. Nitrogen concentrations have lately increased, due to enlargement of the mine and increased use of explosives, but the concentrations were decreasing downstream of the mine. Groundwater of Umbozero mine had high pH values (max. 10.4), and high fluorine and aluminum concentrations, due to the rock type. Concentrations were decreasing downstream of the mine, also heavy metal concentrations were low. Research data is used for making recommendations for providing environmental and geodynamical safety of Umbozero.

Several geochemical studies have been conducted in Laver. Water samples have been collected downstream of the mine and compared with studies from 1993, 2001 and 2005. The dissolved concentrations of sulphide-associated elements such as Cu, S and Zn, released into the brook, have decreased over time, while pH has increased. The oxidation rate in the tailings has decreased over time, which may be due to the increased distance over which oxygen needs to diffuse to reach unoxidised sulphide grains, or their cores, in the tailings.

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