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The restoration of the close-down uranium mine in Ranstad, Sweden

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Introduction

The uranium mine in Ranstad (Fig. 1) was opened as a part of the Swedish Nuclear Power Programme. Uranium was extracted by percolation leaching with sulphuric acid from the alum shale, which has a grade of about 300 g/t. The shale also contains about 22 % of organic matter and about 15 % of pyrite. The plant was operated from 1965 to 1969 with open pit mining. During this period, 1.5 Mtons of alum shale were mined and 215 tons of uranium were produced. The total amount of the tailings is about 1 million cubic meters containing about 100 tons of uranium and $5 \cdot 10^{12}$ Bq of radium-226. The tailings cover an area of 250 000 m^2. The size of the open pit mine was in a form of a 2 000 m long, 100 - 200 m wide and 15 m deep trench. The open pit was kept dry until November 1991 when the pumping was stopped.

As the operation licence for the Ranstad plant expired in 1984 discussions about the final restoration started. At that time the leachate from the mill tailings, that were covered by a 0.5 m thick layer of moraine, was collected and purified before it was released to the recipient river Flian. The open pit mine was kept dry by pumping. The environmental consequences were not critical but the continuous pumping and treatment of leakage water was costly. Consequently, a plan for final restoration had to be prepared.

Studsvik AB was responsible for the project planning, sub-contracting, performance of the restoration as well as the environmental control. Since 1992 AB SVAFO, own by the Swedish nuclear power industry, is responsible for the restoration.

Objectives

The aim of the restoration of the Ranstad site is to make all future maintenance unnecessary. When it is fully completed it is anticipated that the area will comply with environmental legislation without any further intervention.

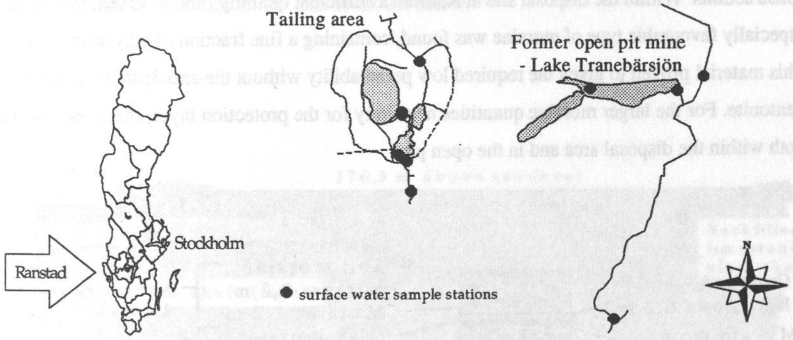

Figure 1

The Ranstad site

Restoration

Different studies were performed during the 1970's and 1980's to find effective ways for reducing the leaching processes. The aim of the investigations was to find methods for reducing the infiltration of precipitation and entrance of oxygen into the tailings. Among other things a test pile, consisting of 15 000 tons of the mill tailings, was constructed in 1972 for studying the effect of different cover systems. In 1985 the planning of the restoration started with general planning and investigations including collection of available information and completion concerning maps, geology, hydrology and water quality. A detailed plan for the restoration was submitted to the County Administration in October 1988. After reviewing the authorities granted permission for the project to be started in January 1990. The demands from the authorities were that a release and recipient control programme for the concentration of uranium and radium as well as heavy metals as e.g. cadmium, copper and nickel should be performed.

The mill tailings

The establishment of a tight cover on the leaching residues and additional mill tailings was the most complicated part of the restoration, considering the County administration's requirement of a hydraulic conductivity less than $5 \cdot 10^{-9}$ m/s. Also such factors as availability of material, the long-term stability and the experience from using the material had to be considered in the design of the covering system. The preferred solution is shown in Figure 2.

Moraine is a reliable, natural material, having been used in many Swedish hydro-power dam constructions. Within the disposal site at Ranstad a sufficient quantity (about 50 000 m^3) of an especially favourable type of moraine was found, containing a fine fraction of clay shale particles. This material proved to given the required low permeability without the anticipated mixing with bentonite. For the larger moraine quantities necessary for the protection layer, there was good supply both within the disposal area and in the open pit.

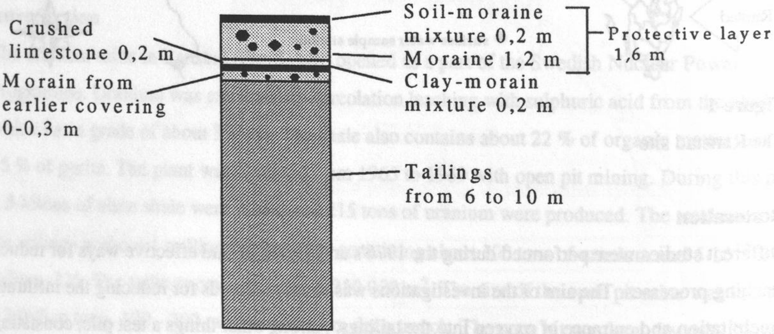

Figure 2
The cover system.

The sealing layer was strictly controlled by laboratory and field testing of such factors as moisture content, fine particle fraction and compaction. The total covered area was about 250 000 m^2. After quality acceptance the limestone layer for draining and the moraine layer for protection were successively laid out. For future monitoring of the cover system, a large number of pipes for observation of the groundwater level above the tight layer was installed. For testing of oxygen diffusion as well as for infiltration of percolating water, lysimeters have been installed underneath the tight layer.

The open pit mine

The very tight alum shale bottom has been used to create a lake with an area of 250 000 m^2, by letting the groundwater fill up the mining area to about the original level and discharge to the natural recipient. Before the water filling, waste rock along the mining front was removed to the bottom of the pit and covered by moraine.. Totally over 0.5 M m^3 of rock and earth material was moved before water filling.

The water-filling of the lake was completed by mid 1993. A new lake with a volume of 1.3 Mm^3 had been established. A section of the lake is shown below.

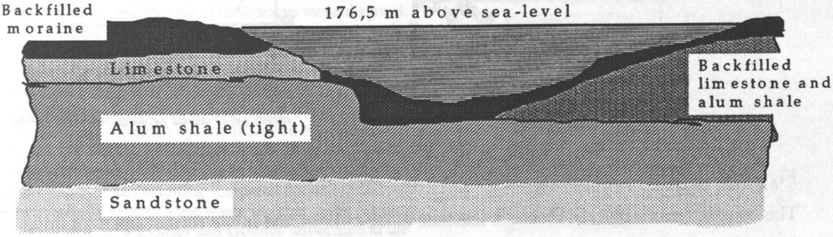

Figure 3

Schematic section of the lake.

Results

The aim of the restoration of the Ranstad site is to reduce the effects of the mining activities to levels that are acceptable compared to the background values of the surroundings. A comprehensive environmental control programme has been performed to follow the water quality within the disposal area as well as in the former open-pit area and their recipients. Standard parameters as macro constituents, pH, alkalinity, as well as heavy metals, uranium and radium are measured. Discharge measurements are also performed to be able to calculate the transport of different elements, i.e. the total load of these elements.

The primary restoration was finished in the end 1992 when the cover-system on the tailings was completed. It can be concluded, three years after the primary restoration was finished, that the concentration of pollutants in the leachate from the disposal area has decreased to about one third of initial ones, see Figure 4. Furthermore, the concentrations of uranium and heavy metals as nickel in lake Tranebärssjön, the former open-pit, have been stabilised on a relatively high level. The difference between the surface and bottom water is marked, see Figure where the concentration of nickel and uranium is shown. The stratification in the lake is very stable with anaerobic conditions below 10 meters depth.

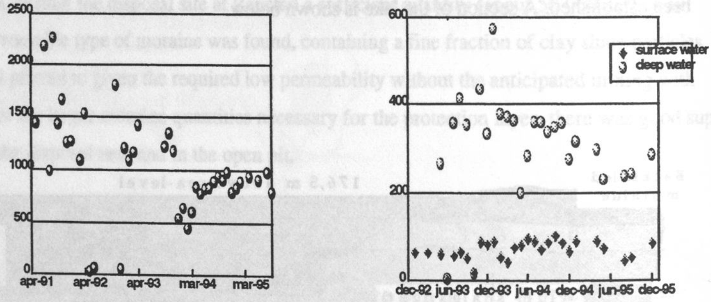

Figure 4

The concentration (μg/l) of nickel in leachate at the tailings and in the former open pit mine

Conclusions

Predictions of the environmental consequences were an important part of the investigation phase. They gave a scientific base for judgement of the restoration efforts and a possibility for authorities to evaluate the restoration plan. The technique for preparing a barrier with a low hydraulic conductivity, an appropriate quality assurance and control programme have been well tested and established.

The project is in a follow-up phase after the primary restoration. The concentration of heavy metals including uranium in the leachate from the mill tailings is decreasing three years after the application of the cover-system. However the decrease is slow and it will take at least another three year period before the metal concentrations are in accordance with acceptable levels compared to the back-ground values. In the stratified lake, the former open-pit mine, Lake Tranebärssjön, the concentrations of most metals increased initially in the bottom water. However the concentrations in the surface water are stable at a relatively high level for elements as uranium, nickel, cadmium and cobalt.

The requirement of the function of the cover-system was to minimise the infiltration of the precipitation and preventing the oxygen transport. Observations indicate that the infiltration is about 10-15 percent of the precipitation and that the content of oxygen in the tailings is less than one percent. Thus the cover-system fulfil the requirements.