OIL SHALE 1994, Vol. 11, No. 2

https://doi.org/10.3176/oil.1994.2.06

REVIEWS

SIGGE BERGH

URANIUM PRODUCTION IN SWEDEN

As was mentioned in my previous articles, the World War II led to an exploitation of the Swedish alum shale on a large scale. In the last phase of the war it also became obvious that the shale might be used for energy production of quite another kind than oil. Atomic bombs got their force from uranium, an element constituting up to 0.03 % of the richest shale horizons. In fact the Swedish alum shales represent one of the largest uranium deposits of the world.

In 1947 AB Atomenergi was founded, an enterprise with one of its purposes to extract this uranium for peaceful use: for production of nuclear energy in a country already fully using its resources of hydro-electrical power production.

During the first years the activities of the company were to be located at Kvarntorp with its big shale oil factory. During the years 1950—61 not less than 62 tons of uranium were produced here in a pilot plant. Fairly soon it was established that the enormous amounts of shale ashes from the production of oil were not suitable as a raw material for uranium production as the previous high temperature treatment of these ashes had brought the element into a stable state little accessible to chemical solution. The physical dressing of the shale such as flotation proved impossible for uranium extraction, too, the element not being clearly associated to any known mineral.

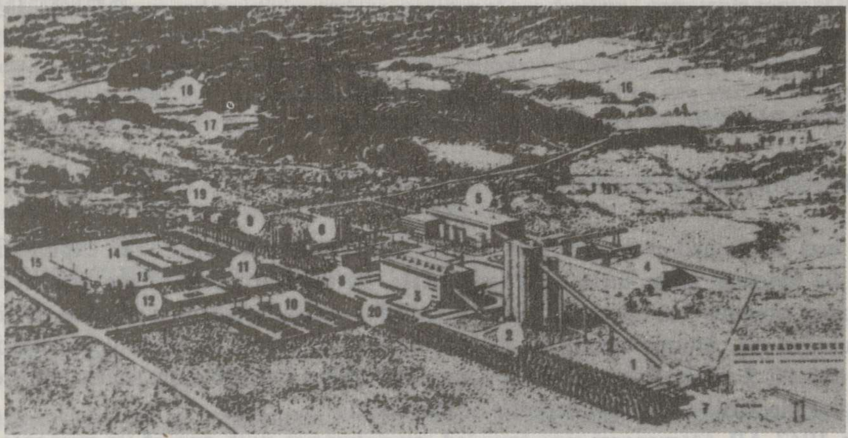
The most favourable way for uranium extraction proved to be the one already most frequently used in other countries viz. leaching with sulphuric acid. Percolation leaching at 60 °C in 15 % sulphuric acid of shale crushed to the size below 3 mm and reasonably free from dust was the treatment finally found to give optimal results.

In 1958 the decision was made to build a plant of industrial size basing on this method. Scrupulous geological investigations were undertaken in order to establish the location of shale with the highest possible uranium contents. Ranstad in Västergötland, between the towns of Skövde and Falköping, was finally chosen. A shale easily accessible to open-cast mining and by some 25 % richer in uranium than the shale at Kvarntorp was available there. Even other points such as water supply and environmental aspects were in favour of Ranstad. A plant with a yearly capacity of 120 tons of uranium, easily expandable to the double, was erected at Ranstad and ready for production by 1965 (Figure).

In general the main data characterizing the plant were as follows:

The shale consumption at full operation amounted to some 0.8 Mtons per year. It was mined by an open-cast process after removal of an overburden of 10—20 m. The shale was uncovered along a 2,000 m front. After blasting and removing of the uranium bearing shale, the overburden was dumped on the excavated side, thus allowing of minimum mining costs.

The treatment of shale started with separation of some 10 % limestone appearing as lenses and thin layers in the shale, an operation performed by a sink-and-float treatment after coarse crushing. The fine crushing is a sensible operation as strong fragmentation is required and still a minimum of dust and fines is imperative.



The Ranstad plant layout: *1* - conveyor, *2* - bunkers and screens, *3* - dressing plant, *4* - weathering pile, *5* - leaching plant, *6* - neutralization plant, *7* - transformer station, *8* - steam boiler and water supply, *9* - oil storage, *10* - main entrance and parking place, *11* - dining rooms, dressing rooms, etc., *12* - office and laboratory, *13* - workshop and storage, *14* - garage, *15* - storage area for materials, *16* - waste area, *17* - water reservoir, *18* - retain basin, *19* - sanitary effluent treatment plant, *20* - tunnel to underground crushing station

An intricate system of impact crushers and vibrating screens was used to obtain the right type of the starting material for the leaching process.

The leaching was performed as a batch-wise operation in vats holding some 2,000 tons. The shale was preheated by steam and leached counter-currently at 60 °C with sulphuric acid of successively rising concentration. Each batch needed 900 cubic metres of water and 100 cubic metres of concentrated acid, giving 750 cubic metres of pregnant solution with 0.6 g/l uranium and in addition carrying free acid and salts of iron, aluminum, magnesium, etc.

From this solution uranium was recovered by the ion exchange process using an anionic resin, Amberlite IRA 400. The uranium content of the barren solution after this treatment was 2 mg/l which means a recovery of almost 100 %. Uranium was eluated from the resin by sulphuric acid giving a solution containing 15 g/l which in turn was treated at an ELUEX solvent extraction plant where uranium was transfered into the organic phase. The final reextraction with soda gave uranyl carbonate from which sodium uranate was precipitated as the final product. After drying the uranate powder ("yellow cake") had the uranium content of 71 %.

At the time when the erection of the Ranstad plant was decided, uranium could not be freely purchased in the world market. At the start of production seven years later (1965) this situation had changed, the market being free and the price about $ 10 per 1 lb of oxide. This number corresponded fairly well with the operating costs at Ranstad, calculated for full capacity. In the years 1965—1969 the plant was operated at 3/7 capacity, producing some 50 tons per year. At that time no domestic uranium consumption was at hand. This situation was to continue till the late 1970ies.

From the start in Ranstad and for many years to come there was therefore hardly any interest in an immediate large uranium production. It was decided to use the plant for studies of its more effective exploitation in case of an expansion in the future, bearing in mind the reactor program. In the years towards 1974 these efforts were solved quite successfully above all by increasing the output of leachable shale but also by simplifying the chemical treatment thus increasing the leaching output from 68 to 79 %.

Based on these improvements a big new plant was planned with a capacity of 1275 tons per year, corresponding to the uranium need for 13 nuclear power plants to be built. In 1974 such plant was calculated to be competitive, the world market price then being $ 13 with a rising trend (in 1976 the price was some $ 40).

However, the hopeful situation did not last for long. Sweden got a new government with the majority of it being against nuclear power. Domestic uranium production was not considered to be of interest. On the top of this local authorities of the Ranstad region had strong apprehensions against a big uranium plant for environmental reasons. Finally they interposed their veto.

A very big venture in the years 1960—81 amounting to some 400 M SEK thus came to nothing, mainly because of environmental fears. In the course of time, however, also economical reasons began to speak against the project. During the 1980ies the world market price of uranium fell to very low levels, quite out of reach for a Swedish plant. Continuously new ore deposits were discovered with uranium contents a hundred times and more over those of the Swedish shale. A strong overproduction was at hand and uranium prices seemed to be to remain low. Thus the expectations on the Swedish shale came to nought for the second time. The shale seemed to have a future neither as oil nor as uranium resource.

As environmental aspects were more or less the cause to discontinue the uranium projects, it seems reasonable to give an account on the measures of precaution that were taken during the time of operation at Ranstad and also on the steps undertaken afterwards.

During the operation the greatest radiological health hazards were to be found at the final steps of production — at precipitation from the concentrated salt solutions after extraction, drying and packing of the yellow cake as well as its storing. All jobs belonging to these categories were performed under the monitoring of physical health indicating constantly very low individual dose exposions.

In all other parts of the work checks on external radiation and radon exposure were taken. Nowhere did the tests lead to protective measures to be taken. Not even immediately above the surfaces of the leaching vats radon contents higher than 150 Bq/m^3 were found, a number that should be compared with the Swedish housing standard, which lies at half this value.

The complete termination of the work on uranium production from shale occurred in 1989. Remediation of the mining and works area was then planned in cooperation with scientific institutions, contractors and local authorities. A general plan was submitted to the County Administration and approved in 1991. This plan has been in the main performed by now. The whole project amounts to some 140 Mio. SEK, half of it foreseen for contractors' work.

The aim of this work is to make all the future maintenance unnecessary. It is anticipated that when fully completed the area will comply with environmental legislation without the need for any further intervention.

The open-cast mine has been transformed into a lake harmonizing with the landscape. The straight walls of the pit have been given a softer outline with a curving shore. The embankment formed during mining has been turned into soft hills to match with the surroundings. Marshland, small islands and open beaches will promote birds' nesting.

A more difficult problem was the remediation of the vast disposal area where one million cubic metres of leaching residue and slimes had been dumped to a thickness of 6—10 metres over an area of some 50 acres. Arrangements had to be made to restrain supplies of oxygen and thus also the weathering of pyrite in the shale. Here the solution was a scrupulous covering of the area and embankments. Natural moraine found in the neighbourhood proved to be a suitable low-permeable material to be used. With the help of dump trucks, scrapers and vibrating rollers this material was laid out to form a leaktight barrier about one foot thick. Over the tight cap layers of crushed limestone, moraine and so on were put, altogether some two yards of thickness. Various performance controls will be going on for several years. So far expectations have been confirmed. All water from the disposal area is collected and treated in a water cleaning plant until the comprehensive monitoring program indicates a water quality the authorities can accept to be discharged without further treatment.

Usable buildings have been leased to small enterprises by the present private plant owner and a harmless industrialization of a formerly agricultural region has thus been accomplished.

REFERENCES

1. *Hultgren Å., Olsson G.* Uranium recovery in Sweden, history and perspective: A study produced for AB SVAFO. Draft august 1993.
2. *Strandell E.* Ranstad, 35 års utveckling av processer för utvinning av uran ur mellansvenska skiffrar (35 years development of processes for the recovery of uranium from shales of Middle Sweden) (To be published).
3. *Linder P., Sundblad B.* Remediation of closed-down uranium mine in Sweden. Proc. of the 1993 Int. Conf. on Nucl. Waste, Management & Environmental Remediation, Prague, Czech. Republ. Sept. 5—11, 1993.

Hällekis, Sweden Received December 28, 1993