The Forgotten Uranium Mine of Paukkajanvaara, North Karelia, Finland

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Abstract: The cold war era was a time with huge demand for uranium. Also in Finland exploration showed the presence of uranium in the bedrock of North Karelia. A small mine operated from 1959 to 1961 near Paukkajanvaara in the municipality of Eno. The mine produced some 30 tons of uranium concentrate. After the main ore body was exhausted the mine was abandoned, due to the low demand for uranium after 1960, the mine has never been reopened. The area was without attention for nearly three decades. During the 1990's the area was rehabilitated, covered with clay and till and replanted with pine. After the land rehabilitation project radiation in the mining site was reduced to the normal Finnish background level. The site is an interesting field laboratory to study the release of radioactive elements from uranium mining into the environment. Knowledge from this site could prove to be important, seen in the light of the renewed interest in uranium exploration in Finland.

The Paukkajanvaara uranium deposits

Uranium is an element found in very small quantities in the earths crust. Under some special geological conditions uranium can be enriched thousand fold into ore deposits and concentrations may be sufficient to start mining operations. Uranium became an important commodity after the Second World War when both the United States and the Soviet Union started to build up their nuclear arsenals. This and the need of uranium for nuclear power plants created a huge demand for uranium. Exploration for uranium resources became a lucrative business and many part-time prospectors invested money in simple Geiger counter equipment.

In 1957 two brothers, Eino and Martti Justander from Eno, North Karelia bought a Geiger counter and started exploring the area around their home near lake Herajärvi (Fig. 1). Soon they found a radioactive metabasite outcrop from which they sent samples to Atomienergia Oy, the Finnish firm responsible for atom energy in Finland at the time. Further field investigations by the geologist Piirainen revealed radioactive erratic boulders. Samples from these proved to contain 1.5 % uranium and this led to intensive exploration in the area (Piirainen 1968). The average concentration of uranium in the earth's crust is far less, about two to three mg/kg, which is 10.000 times less than the samples from Eno. The

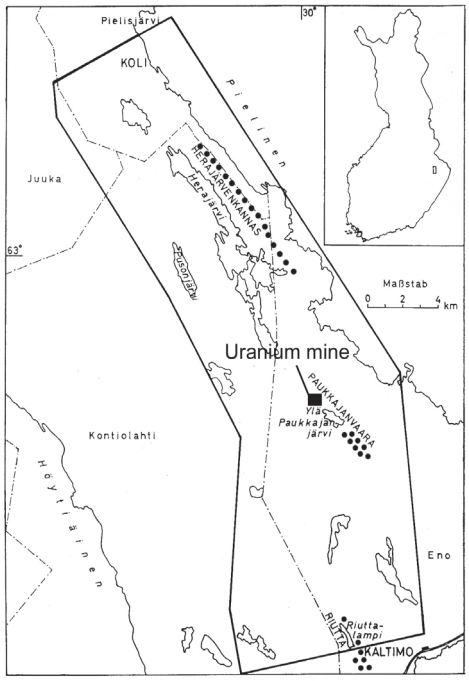

Figure 1. Location of the boulders containing uranium ore (black dots) and the uranium mine (from Piirainen 1968, modified by the author).

explorations were carried out swiftly and led soon to a mining claim. During 1957 – 1958 numerous radioactive erratic boulders were found in the Herajärvi – Riutta area. During the 1960's the area has been intensively explored and various small uranium deposits have been identified.

The radioactive boulders were deposited in a string-like fashion in NW-SE direction, as they have been plucked from the bedrock and transported during the last glaciation. The uranium is deposited in small local metadiabase dykes and metamorphic-sedimentary contacts with these intrusions (Fig. 2).

From exploration to mining

In 1959 a small mining operation was started at the northern shore of lake Ylä-Paukkajanjärvi, called the Paukkajanvaara mining site (Fig. 3). The mine was basically a test facility to assess the feasibility of large scale uranium mining. The site consisted of the Mårtenson quarry, which was soon transferred into an underground mine and close to this a second, smaller quarry. The ore was milled and enriched at the mining site. Several tens of workers were employed at the mine. No special protective gear was used but workers were however obliged to carry dosimeters (Tauno Piirainen, pers. comm.). Radiation caused by radon gas has been a major problem in many mines due to insufficient ventilation. At present dust and other normal mining hazards are probably more important health issues. Although radiation is higher near uranium bearing rock the dose is still low, for the Paukkajanvaara site it is in the range of 1 – 9 μS/h, the Finnish average being about 0.1 μS/h (Mustonen & al. 1989). From the Paukkajanvaara mining site there have been no reports of negative effects on the health of workers, which would of course be difficult to prove due to the limited number of personnel and short production period.

Between 1959 and 1961 about 30 700 tons of uranium ore was extracted from the mine, 21 400 from underground and 9 400 tons from the open pit mine. The uranium content was between 0.075 (quarry) and 0.143 % (Mårtenson mine) (Sillanpää & al. 1989). About 27 tons of uranium ore concentrate (20 – 30 % purity) was produced from the crude ore. The purified uranium ore was sold to Sweden. The Mårtenson

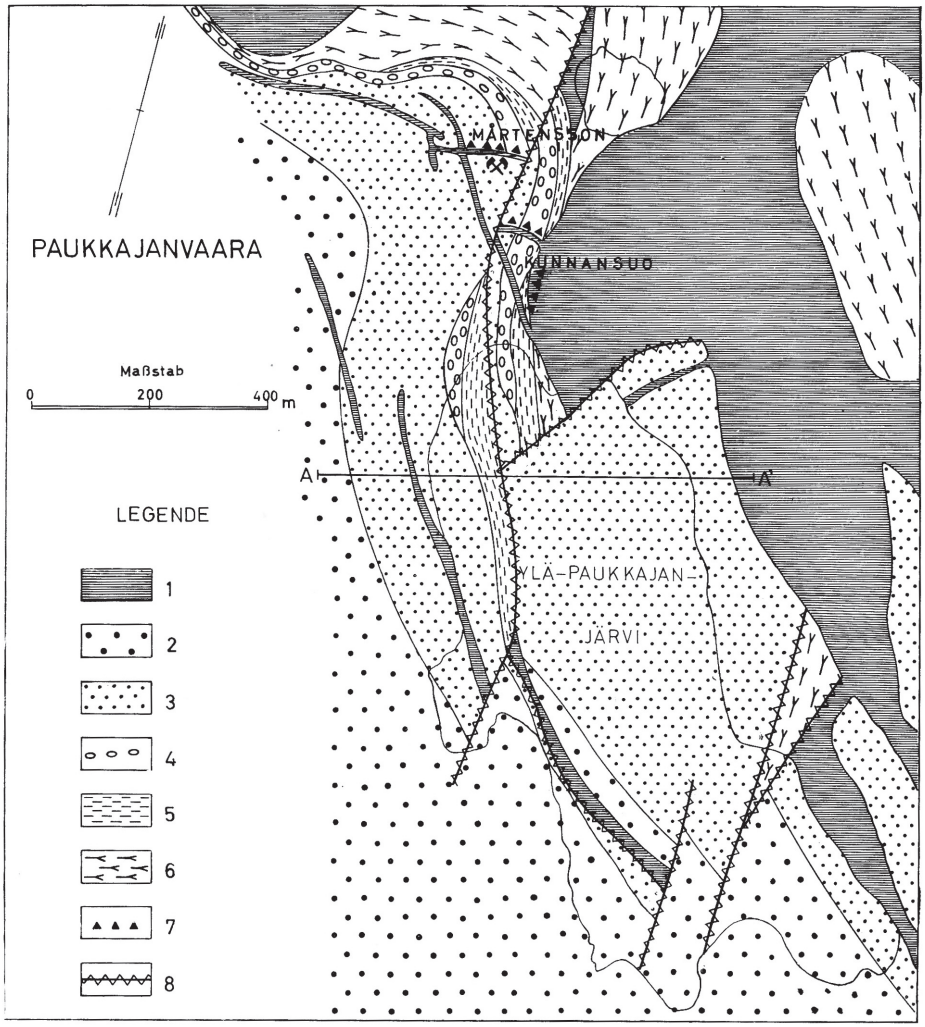

Figure 2. Geology of the Paukkajanvaara area (Piirainen 1968).1 = metadiabase, 2 = arkosic quartzite, 3 = ortho quartzite, 4 = conglomerate, 5 = sericite quartzite, 6 = granite, gneiss 7 = uranium ore, 8 = fault (Piirainen 1968, published with permission from the author).

uranium ore was exhausted already in 1961 and mining of the Kunnansuo deposit was not economically profitable. After the operations stopped in 1961 the site was abandoned. In 1974 the last purified uranium ore, about 2 300 kg which was left in a storage building was removed and transported to the facilities of Outokumpu Oy in Pori. The production buildings were demolished between 1976 and 1980, the entrance of the mining shaft was covered with a concrete slab, the rest of the area, tailings, waste-water ponds etc. were left as they were. In 1985 some earth moving was done to uncover

Figure 3. The Mårtenson uranium mine in 1960. Photo: Ilkka Laitakari, Geological Survey of Finland.

mica containing rock strata and a new 200 hectares mining claim was made containing the old uranium mining site. The site remained dormant and no production was ever resumed.

Uranium and radiation in the environment

After the closure of the mine, it was forgotten by all but the local residents and media. In 1962 the local water authorities made an inquiry about the safety of fish in the area, the response of the local authorities was short and clear, no contaminated materials could be released into the downstream area (Letter to the... 10.11.1962). The Finnish Centre for Radiation and Nuclear Safety started a major study, monitoring air, water and soil in and around the site. The area had been untouched for nearly 30 year and was therefore an ideal study site for dispersal of radioactive material into the environment. Previously measurements had been made in 1974 and 1979, but in 1984 systematic sampling of the area and a geologically similar undisturbed reference area (Riutta) started. The project ended in 1989. The radiation at the mining site was estimated to have been increased 0.5 μS/h as a direct result of the mining operations. Radon levels were exceptionally high in the air above the mining site, this was mainly caused by the tailings consisting of fine grained material from the milling and leaching process. About 12 000 m^3 of fine grained material and about 7 300 m^3 of waste rock were present in the

tailings. On top of the tailings measured values were 150 – 300 Bq/m^3, for the whole site a value of 100 Bq/m^3 was assumed (Sillanpää & al. 1989). The Finnish maximum level for indoor values has been set to 400 Bq/m^3 (STUK 2006).

Contamination of surface water occurred as a small ditch was flowing through the mining site transporting sediments towards the Iso-Hiisilampi pond (about 200 meter downstream) from where it flowed into the stream draining into lake Pielinen. Radiation levels in the surface water were considerably higher than in the Riutta reference area, 0.2 – 0.4 Bq/l compared to 0.002 – 0.003 Bq/l (Sillanpää & al. 1989). Radiation level of the surface water was normal about two kilometer downstream were it flows through a small lake (Saarilampi) and becomes more diluted. The amount of dissolved uranium in the surface water downstream from the mine was about 20 to 25 µg/l, values decreased slowly reaching normal levels when entering lake Pielinen. Values for the Riutta reference area were much lower, 0.2 to 0.5 µg/l (Sillanpää & al. 1989).

Radiation values from uranium for bottom sediment were much higher, 10 000 to 30 000 Bq/kg (dry mass) for the bottom of the pond just downstream of the mining site, reducing sharply to 1 000 Bq/kg and becoming normal some two kilometers downstream in the Saarilampi lake, for the reference area values were 100 – 400 Bq/kg.

Plants and mushrooms had only slightly higher uranium contents, and this only in those plants growing directly on the mining site. Fish, however, had 20 to 30 fold uranium levels as compared to the Riutta reference area. The activity was highest in fish for the direct downstream area but also fish form the Saarilampi lake had relatively high amounts of radioactive isotopes (Mustonen & al. 1989).

The conclusions by Mustonen & al. (1989) are that rehabilitation was needed if the radiation levels of the mining site were to be ameliorated to the original levels. They also conclude that the radiological effects of the uranium mining activity could be traced all the way downstream to lake Pielinen.

Rehabilitation of the mine

In 1991 planning of the rehabilitation of the mining area started (Imatran Voima 13. 12.1991). The total cost of removing the contaminated sediments and veering of the drainage were estimated to be 680 000 Finnish marks (about 113 000 €). The project started in 1992 and was finished in 1994. Most of the planned actions were implemented, but the small ponds and stream sediments were not removed. The Mårtenson mine shaft and pit were demolished with dynamite. The whole area including tailings was covered with 30 centimeter of clay on top of which 1.2 meter of till. The resulting area was landscaped into a gently sloping grade and finally pine trees were planted.

The final inspection of the area was done 23.08.1994 and the area was proclaimed to be without restrictions for outdoor use. The building of houses and cottages however remained prohibited. Measurements by the Finnish Centre for Radiation and Nuclear Safety were made and showed only near the previous enrichment station slightly above average values, all other parts of the

Figure 4. Old sign at the entrance gate with the text “Radioactivity, access prohibited”. Photo: Alfred Colpaert 18.8.2004.

area were at the normal Finnish average (Bonvesta 23.8.1994).

When we visited the area in 2005 there were only few signs left of the former mining area, only a rusted sign at the gate (Fig. 4) reminds us of the former history. The rehabilitated area itself looks like any planted pine forest (Fig. 5), some quarry areas can still be distinguished. The area is still drained by a small ditch running through the middle of the area. We did some radiation measurements with a DGM meter from Kata Oy, and did not find signs of radiation above the normal base level (0.08 μS/h on our device). Only in the gravel near the entrance of the area slightly higher values were found 1.32 μS/h (Fig. 6).

Renewed interest in uranium exploration

Uranium exploration and mining was not very profitable during the last decades of the previous century due to environmental issues related to atomic energy. Countries like Sweden and Germany were de facto stopping production of atomic energy, and in many countries plans for new reactors were put on hold. Also the availability of weapons grade nuclear material which was diluted and sold for peaceful energy

Figure 5. The rehabilitated mining area. Photo: Alfred Colpaert 18.8.2004.

Figure 6. Radioactivity measured at the former gate, 1.32 µS/h. Photo: Alfred Colpaert 18.8.2004.

production pushed prices of uranium down.

The present environmental concern about global warming and greenhouse gasses has renewed the interest in nuclear power production. Trading in carbon dioxide has made nuclear energy more profitable and former stock piles of decommissioned nuclear weapons are exhausted. Also the rise in price of fossil fuels, like oil and gas and the dependence on these has led many countries to review their stand on nuclear energy.

As uranium is commonly found in areas like Russia, Canada and Australia, areas with old Archean age bedrock with granite intrusions and contact areas, exploration in Finland has been intense during the last years. The whole eastern region along the Russian – Finnish border from Porvoo in the south to Inari in the very north is under investigation. Some claims have already been made, near Porvoo and Eno by the French mining company Cogena, and by the Finnish company Namura in Kuusamo (KTM 2006).

Conclusions

The former uranium mine Paukkajanvaara near Eno was by any standards a very small operation. It operated effectively only for three years and produced a limited amount of waste rock. It was easy to rehabilitate and presently there is no measurable radiation at the site, only the bottom sediments of the nearby pond and stream could possibly contain some traces of uranium. In respect to possible large scale uranium mining in Finland the site could prove to be a valuable study object. For example the fact that a small stream was allowed to flow through the mining site was a mistake not taken into account during the 1960's. At the time it was believed that due to its large specific weight uranium would not leave the site by air or water. Although uranium content of rock and ore is very low and direct radiation is relatively small, the mining, milling and tailings produce radon gasses which can be a health problem.

The lesson from the Paukkajanvaara mine is that direct and short-term effects of uranium mining are not very great, the main problem is the long lasting effects of waste material leaching and water and sediment contamination.

Well managed and maintained, under strict environmental and radiological control uranium mining could be safe. It must however be considered as special and the highest caution and safety standards for both workers and the environment are needed. Rehabilitation should take place directly after ending of production, and mines should not be allowed to lay dormant. When a mine lies unattended for several decades the protection measures around tailings and other facilities tend to become unstable and leaching by rain water creates a possibility for ground- and stream water contamination.

Acknowledgements

I would like to thank emeritus professor Dr. Tauno Piirainen, former mine geologist Dr. Matti Tyni for their valuable information and comments and Dr. Heikki Vesajoki, who accompanied me on the mining site, for his assistance and comments.

References

Karhu, E. (2006). Uraani kiinnostaa kannattajia ja kiihottaa vastustajia. *Metallitekniikka* 2006: 6, 30-33.

Mustonen, R., T. K. Ikäheimonen, L. Salonen & T. Sillanpää (1989). Uraanin louhinnan ja rikastuksen radiologiset ympäristövaikutukset Enon Paukkajanvaarassa. *STUK-B-VALO* 61. Finnish Centre for Radiation and Nuclear Safety.

Piirainen, T. (1968). Die Petrologie und die Uranlagerstätten des Koli-Kaltimogebiets im Finnischen Nordkarelien. *Bull. Comm. Geol. Finlande* 237. Geological Survey of Finland, Helsinki.

Sillanpää, T., T. K. Ikäheimonen, L. Salonen, T. Taipale & R. Mustonen (1989). Paukkajanvaaran vanhan uraanikaivos- ja rikastamoalueen ja sen ympäristön radioaktiivisuustutkimukset. *STUK-B-VALO* 56. Finnish Centre for Radiation and Nuclear Safety.

WWW-material

KTM (2006). Ministry of Trade and Industry. *http://www.ktm.fi/index.phtml?s=1585*

STUK (2006). Finnish Centre for Radiation and Nuclear Safety *http://www.stuk.fi/sateilytietoa/sateily_ymparistossa/radon/fi_FI/radon/_files/71375051672125691/default/onko_ kodissasi_radonia.pdf*

Archive material

Letter to the local water authorities in the Paukkajanvaara area (10.11.1962). Archive of the Environmental Centre of North Karelia, Joensuu.

Imatran Voima (13.12.1991). Plan and cost calculation for rehabilitation of the Paukkajanvaaran mining area. Archive of the Environmental Centre of North Karelia, Joensuu

Bonvesta (23.08.1994). Minutes of the final inspection of the Paukkajanvaaran rehabilitation. Archive of the Environmental Centre of North Karelia, Joensuu.