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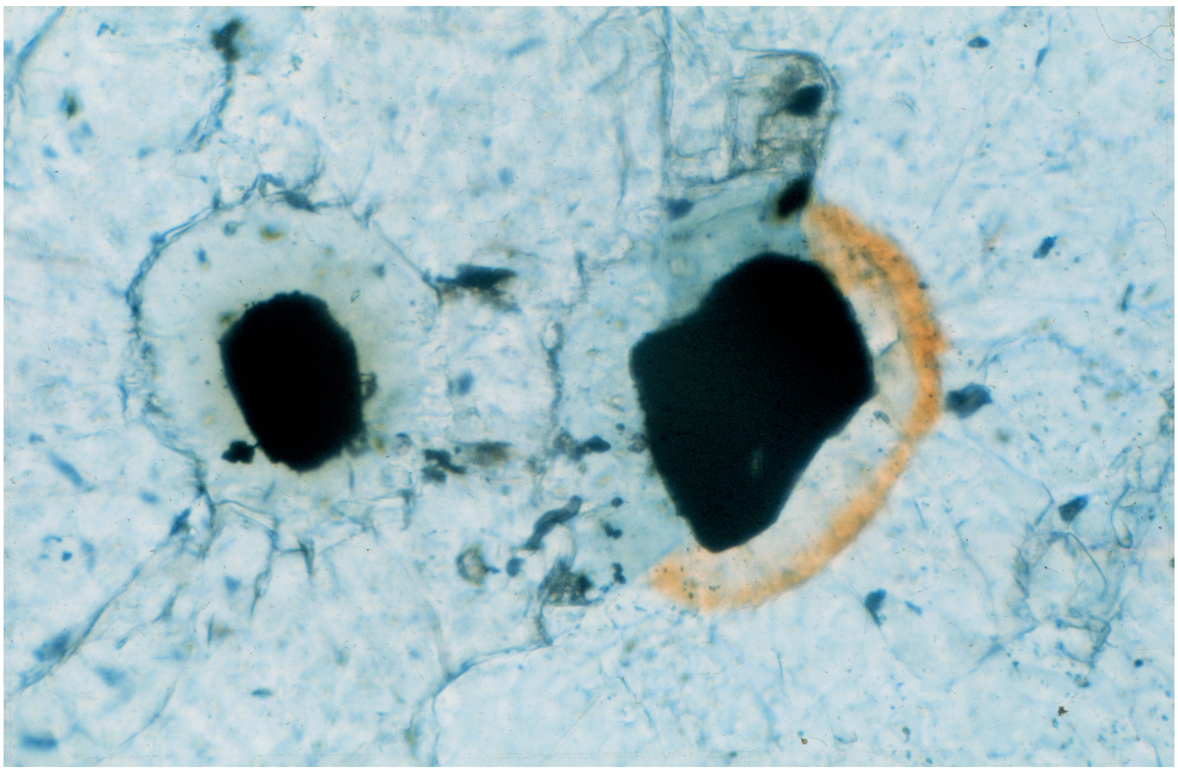
FinU - a database on uranium deposits in Finland



GTK

GEOLOGICAL SURVEY OF FINLAND **DOCUMENTATION PAGE**

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Title of report
***FinU* – a database on uranium deposits in Finland**

Abstract
The report reviews uranium exploration in Finland from the mid-1950s to the late 1980s, and describes essential background information sources available for uranium exploration, with emphasis on the GTK databases on the Internet.
The Finnish uranium deposits are briefly described according to the geological-geographical national classification as well as applying the uranium deposits classification of the International Atomic Energy Agency. As requested by the purchaser, three major deposits models are more thoroughly considered in relation to Finland: the unconformity-related, the Francevillian-type, and the Olympic Dam –type deposits.
The contract included a one-week field trip in northern and eastern Finland; information of the route and the targets are attached to this report.
Essential part of the work was done collecting detailed data of 60 uranium and thorium deposits and occurrences of Finland. The information derived from public sources, especially from the various databases of GTK. The uranium deposits database "*FinU*" was built to comply with the structure and style of *FINGOLD* and *FINZINC*, the gold deposits and zinc deposits (under preparation) databases of GTK. As described and listed in the appendices of this report, the first version of *FinU* does not include maps or photographs of the deposits.
According to the contract, this report is accompanied with a CD-ROM disk, comprising the report in MS Word format and the *FinU* database as a MS Access file.

Keywords
Uranium deposits, thorium deposits

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Map sheet

Other information
The English of the report and the database has not been checked.

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Raportin nimi
***FinU*- a database on uranium deposits in Finland**

Tiivistelmä
Raportissa luodaan katsaus Suomen uraaninetsinnän vaiheisiin 1950-luvun puolivälistä 1980-luvun lopulle ja esitetään oleellisimmat käytettävissä olevat tietolähteet uraaninetsinnän pohjaksi Internetin kautta saatavissa olevaa materiaalia painottaen. Uraaniesiintymiin sovelletaan sekä Suomessa käytettyä geologis-maantieteellistä luokittelua että Kansainvälisen atomienergiajärjestön (IAEA) kehittämää uraaniesiintymien luokittelua. Tilaajan pyynnöstä työssä on pohdittu kolmen esiintymämallin – ”Unconformity-related”, ”Francevillian-type” ja ”Olympic Dam –type” – soveltamista Suomen kallioperään ja sen uraaniesiintymiin.
Toimeksiantoon liittyi viikon mittainen ekskursio Pohjois- ja Itä-Suomen uraaniesiintymille; retken reitti ja kohteet on kirjattu raportin liitteeseen.
Työhön liittyy yksityiskohtaisemman aineiston kokoaminen 60 uraani- ja toriumesiintymästä. Tiedot on kerätty julkisista lähteistä, joista keskeisen osan muodostavat GTK:n eri tietokannat. Tiedot on koottu tietokannaksi (”FinU”), jonka rakenne ja esitystapa mukailevat GTK:ssa aikaisemmin toteutettua kultaesiintymien tietokantaa ja tekeillä olevaa sinkkiesiintymien tietokantaa. Raportin liitteinä esitettyjen kuvausten ja listauksen mukaisesti tähän Suomen uraaniesiintymien tietokannan ensimmäiseen versioon ei ole sisällytetty kartta- ja kuvamateriaalia.
Tilaajalle on toimitettu raportin lisäksi CD-ROM-levyke, joka sisältää itse raportin MS Word –muodossa sekä tietokannan MS Access –tiedostona.

Asiasanat (kohde, menetelmät jne.)
Uraaniesiintymät, toriumesiintymät

Maantieteellinen alue (maa, lääni, kunta, kylä, esiintymä)
Suomi

Karttalehdet

Muut tiedot
Raportin ja tietokannan englanninkieltä ei ole tarkastettu

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Cover: Microphoto of an inclusion and an intergranular grain of uraninite (<0.1 mm in diameter) with their typical radiation halos in diopside (left) and apatite (right) from a phosphatic calc-silicate rock, drill core OKVI-1575, 92.50 m, Outokumpu Oy Vihanti Mine (see Rehtijärvi et al. 1979). Plane polarized transmitted light, photo by O. Äikäs.

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Introduction

In spite of many years of uranium exploration in Finland, from the late 1950s to the mid-1980s, economically feasible uranium deposits are still waiting to be discovered. A total of 4400 tonnes of uranium (*in situ*) has been reported in more than six deposits, and of these resources only 2500 tonnes can be considered minable, although not economic at present (Äikäs & Puustinen 1997). The exploration and research on uranium has been dormant in Finland for more than ten years, and during this time the mining legislation has been renewed, domestic companies in the exploration and mining business have reoriented their strategies, and the atmosphere has opened up allowing and encouraging international operators to carry out exploration and mining projects in the country.

Commissioned by COGEMA, France, this report and the attached first version of uranium deposits database "*FinU*" aim at presenting basic information for the evaluation of uranium potential in Finland. Thorium deposits have beed included in the database because of the close relationship of these two metals both in geology and in exploration. The data were collected by Mr O. Äikäs during the summer 2000; Ms N. Ahtonen assisted in designing the MS Access database. A draft report and database were submitted to COGEMA in the beginning of September. As a part of the contract, a one-week field trip was carried out from Lapland to eastern Finland in late September; Mr A. Pakonen as a field technician and Mr E. Vanhanen as a guiding geologist assisted the field trip in northern Finland. Mr K. Pääkkönen, Dr K. Puustinen, Mr H. Seppänen and Mr B. Saltikoff have reviewed the draft report and database or parts of them.

The text of this report contains references to the Internet pages of the Geological Survey of Finland (GTK); in the MS Word file of the report these are meant to act as links to respective GTK pages on the Internet. In all versions of the report and database, the English of the texts has not been corrected.

1 Uranium exploration in Finland

1.1 Historical review

Wiikite, a REE-bearing niobate was the only uranium mineral known in Finland until the 1950s. The earliest studies on radioactivity were related to the identification of radioactive pegmatite minerals and to investigation of radioactive springs (e.g., Aartovaara 1912; Äikäs 1989a).

Exploration for uranium ore deposits started in 1955 as a response to the UN Geneva Conference on the Peaceful Uses of Atomic Energy (Vaasjoki 1956). The first discoveries of 1955-57 triggered off a uranium rush that resulted in a number of claimed prospects in southern and eastern Finland. In 1958-61 Atomienergia Oy developed its property at Paukkajanvaara, eastern Finland, to a stage of mining and ore dressing on a pilot plant scale. During this time a total of 40 000 tons of ore was hoisted, grading 0,1-0,2 % U. The end of the operations at Paukkajanvaara also marked the end of the rush.

From the 1950s to the early 1970s uranium exploration was carried out by several organisations. Radioactive areas were delineated using ground radiometric methods, together with detailed geochemical and soil gas methods, trenching and diamond drilling. Guided by the Atomic Energy Commission and funded by the Ministry of Trade and Industry, development of low-altitude airborne gamma-ray spectrometry and regional geochemical surveying was started in the early 1970s. The regional programmes were soon assigned to the Geological Survey of Finland (http://www.gsf.fi/). Since 1972, the average annual coverage is 10000 to 15000 km^2 by airborne geophysics including spectrometry. Completed in the early 1990s, the annual coverage of regional geochemical mapping was up to 20000 km^2. By the end of the 1970s responsibility for all uranium exploration in Finland was transferred to the Geological Survey (Anon. 1996).

During the worldwide peak in uranium exploration in the late 1970s, the Geological Survey launched a special project to intensify exploration for domestic uranium resources. In 1979-1980 Finland's uranium resources were evaluated by the IUREP Mission of the OECD (1981, 1982). In the 1980s the Geological Survey found and evaluated the Palmottu deposit in southern Finland. In the Kuusamo area, northeastern Finland, uranium exploration of the Geological Survey led to the discovery of a cluster of small Au-Co-U deposits. In the course of the uranium exploration projects of GTK and other organisations, occurrences and non-economic deposits of thorium were also discovered.

In terms of the OECD/IAEA classification scheme (OECD 2000), Finland has Reasonably Assured Resources of 1 500 tonnes U in the cost category 80-130 US$/kg U, and 2 900 tonnes in the category 130-260 US$/kg U. These resources are reported to occur in deposits of vein type, sandstone type, intrusive type, and phosphorite type ores.

From mid-1980s to 1990 uranium exploration activities in Finland decreased essentially, being limited to minor follow-up of aeroradiometric survey. However, research related to uranium mineralogy and uranium ore geology has been going on through the 1990s at the Palmottu deposit by the international Palmottu Natural Analogue Project, hosted by the GTK (e.g., Ruskeeniemi *et al.* 2000). Presently there are no uranium exploration projects going on in Finland.

1.2 Organisations

In addition to the *GTK*, - a government research and survey institute under the Ministry of Trade and Industry - many private and government-owned companies took part in uranium exploration since the mid-1950s. In the early 1970s the companies were encouraged to explore for uranium with partial funding by the Ministry of Trade and Industry for this purpose.

Atomienergia Oy was founded by five major companies in forest industry in 1955 to look after the interests of private industry in the sprouting uranium business. The company carried out uranium exploration throughout the country, concentrating its efforts to operate the Paukkajanvaara pilot mine and concentration plant in eastern Finland. The company gave up its activities in 1962, transferring its uranium exploration files to Outokumpu Oy.

Imatran Voima Oy, a power company presently part of the *Fortum Power and Heat Oy*, found a glacial erratic boulder with 30 % U in southern Finland, north of Porvoo in 1956. Subsequent exploration resulted in a couple of small uranium deposits at Askola, where the company also built a pilot concentration plant for beneficiation tests. The operations of this company related to uranium exploration were restricted to the late1950s.

Oy Perno AB was established to utilize the findings of a private prospector, A. Viento, at Käldö, east of Porvoo, also in the 1950s. The company quarried some ore in one of the small pockets discovered at Käldö and dressed it at the Askola pilot plant of Imatran Voima Oy.

Exploration department of *Outokumpu Oy*, presently *Outokumpu Mining Oy*, commenced uranium exploration in the 1950s, continuing it systematically until 1975. The company carried on Atomienergia's work in the Koli area (Paukkajanvaara), and found a number of uranium occurrences all over the country, Nuottijärvi, Kesänkitunturi, and Pahtavuoma-U being the best of those. Uranium mineralisations were also found in some of the sulphide mines of Outokumpu, at Vihanti and Korsnäs.

Rautaruukki Oy, another government-owned mining company also carried out uranium exploration especially in northern Finland where it had a subsidiary, *Lapin Malmi Oy*. The exploration activities of Rautaruukki ceased in the 1980s, its uranium files were transferred to Outokumpu and Lapin Malmi became a subsidiary of Outokumpu.

Several other companies have funded uranium exploration in minor operations for short periods, for instance *Neste Oy, Kemi Oy, Lemminkäinen Oy, and Kajaani Oy*.

In the 1970s the *Technical Research Centre of Finland* (http://www.vtt.fi/indexe.htm) developed methods for determination of uranium and thorium in geological samples, based on nuclear activation analyses (Rosenberg *et al.* 1977).

STUK, the *Radiation and Nuclear Safety Authority* (http://www.stuk.fi/english/) has monitored the radiation safety in Finland since 1958. GTK and STUK are cooperating in the radioelement determinations of ground water survey in Finland. The responsibility of STUK is to supervise the restoration of uranium mining areas, for instance Paukkajanvaara (Sillanpää *et al.* 1989).

1.3 Data available

In order to cover one of the main duties of the GTK – to promote mineral exploration and mining in Finland – the information on GTK's Internet pages serves the same purpose as the respective chapters in the IUREP reports twenty years ago (OECD 1981, 1982). Two changes are essential to the past two decades: the opening of the country for internationally operating exploration companies, and the enormous progress in information technology allowing data manipulation and transfer in digital format.

Up-to-date information about mineral legislation (Kortman *et al.* 1996) and infrastructure relevant to exploration in Finland can be found on the Internet Exploration Home Page of the GTK (http://www.gsf.fi/explor/gtk_exploration_directory.htm).

GTK Active Map Explorer (http://maps.gsf.fi/gtk/eexpert.asp) provides information of land tenure, drilling sites, deposits and mines of metallic ores and industrial minerals, indications of metallic ores (boulders/showings), selected till geochemical data (Ni, Zn, and Cu), and ages of igneous rocks, all plotted on geographical, bedrock or Quaternary geological or aeromagnetic maps.

The lithological outlines of Finland are shown in Fig. 1. A brief description of Finland's location and geology on the Precambrian Fennoscandian Shield is given at the Internet address http://www.gsf.fi/explor/gtk_exploration_eco_overwiew.htm. A geological map of the Fennoscandian Shield is included at this address.

The Gold Page (http://www.gsf.fi/explor/gold/gtk_gold_map.htm) offers information about gold deposits, some of which contain potential by-product uranium. In the northern Finland, gold and uranium occurrences are spatially related; hence, the mineralisation history of gold described at this site can be used in evaluating that of uranium.

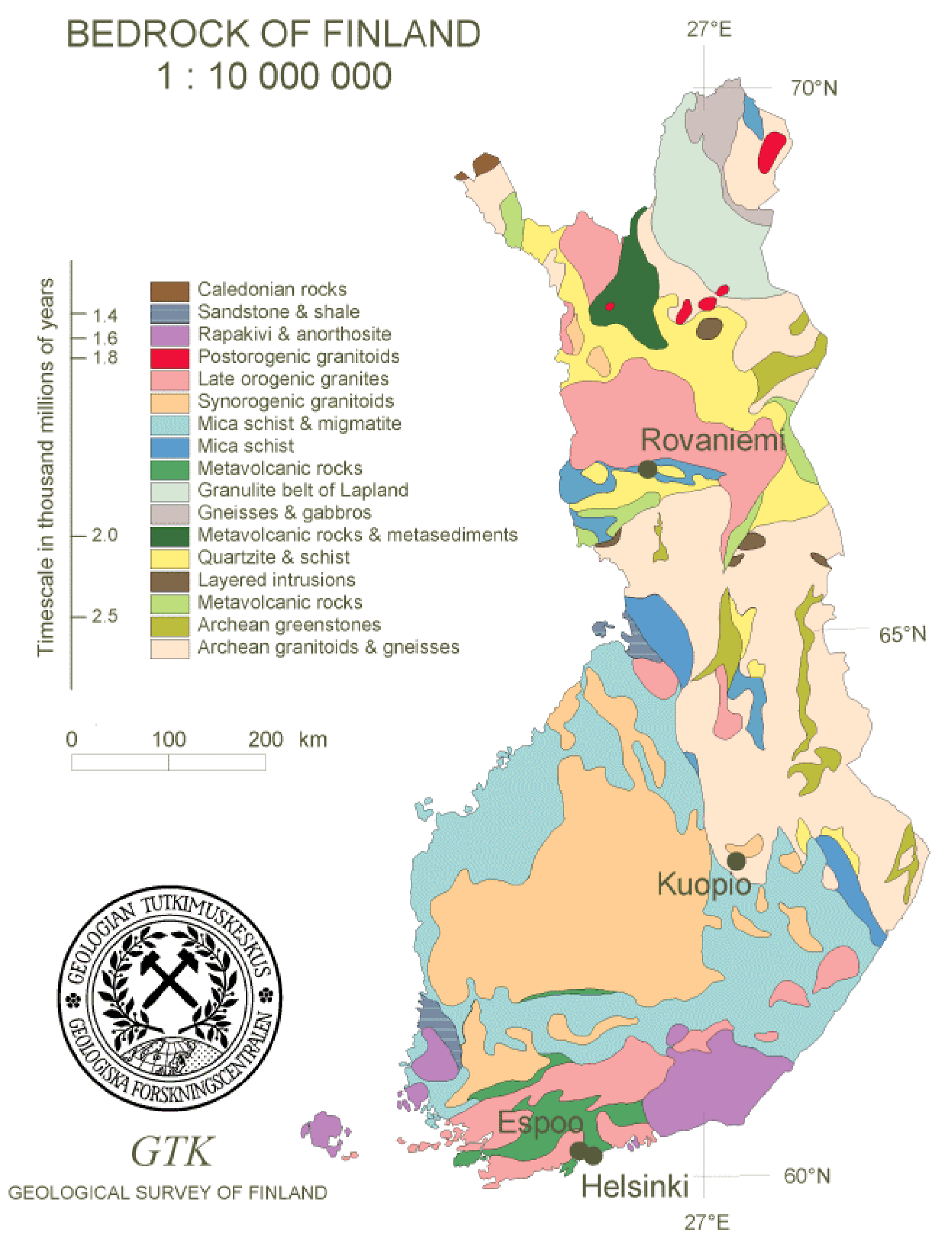

***Fig. 1**. Geological overview of the bedrock of Finland (from http://www.gsf.fi/domestic/paikkati/pk_eng2.gif).*

Among the digital databases MALMIKANTA (Ore Deposits Database) and LOHKAKANTA (Mineral Indications Database) offer detailed information of the deposits and indications at a fee of 150 FIM and 6 FIM/record, respectively. These databases contain information also from the uranium exploration summary files of Outokumpu Oy, rendered to the GTK in 1975, as well as other data from ore deposits and showings gathered by the GTK in cooperation with the mining and exploration companies.

Other useful GTK databases – free of charge through the Internet – are, for instance (Kortman 1997):

LOPPI (http://info.gsf.fi/info/loppi/loppi_eng.html) the national drill core register;

VALTRAP (http://info.gsf.fi/info/valrap/valtrap_eng.html) database on Reports of Claim Areas;

FINGEO (http://info.gsf.fi/fingeo/fingeo_eng.html) bibliographic database on Finnish geological literature;

RAPGEO (http://info.gsf.fi/rapgeo/), database of the unpublished reports of GTK.

GTK provides maps and data of regional geochemical and geophysical surveys also in digital format (Fig. 2). The index maps (including a brief description of the Finnish cartographic grid with related links), prices and contact details can be found at the Internet (http://www.gsf.fi/explor/inxmaps.htm and http://www.gsf.fi/gfyskem.htm). The results of the Survey's geochemical mapping have been compiled in the three volumes of the Geochemical Atlas of Finland (Lahermo *et al.* 1990, 1996; Koljonen 1992). Maps of the distribution of uranium in lake sediments are available from eastern Finland (Tenhola 1988). The aeroradiometric maps included in the airborne geophysical survey are printed as contour maps for total count, uranium, and thorium channels and as a combined equivalent concentration map of potassium, uranium, and thorium in the scale 1 : 20 000 for each 10 km by 10 km map sheet. The crystal volume and the number of counting channels of the airborne spectrometer have been increased through the survey from 27.3 litres/36 channels in 1973 to the present 41 litres/256 channels (see http://www.gsf.fi/aerogeo/eng0.htm).

Based on the systematic mapping and thematic research of GTK, overall (Fig. 1) and thematic geological maps of Finland including some with areas of neighbouring countries have been published in the series of Miscellaneous maps of the GTK, e.g. (all in scale 1 : 1000000):

Black shale formations and aeromagnetic anomalies (Arkimaa *et al.* 2000),
Metallogeny of the Raahe-Ladoga Zone (Ekdahl & Philippov 1999),
Geochronological map of southern Finland (Hämäläinen & Vaasjoki 1991),
Precambrian basement of the Gulf of Finland and surrounding area (Koistinen 1994),
Structural-lithology of the Raahe-Ladoga Zone (Koistinen & Saltykova 1999),
Metamorphism of the Raahe-Ladoga Zone (Korsman & Glebovitsky 1999),
Bedrock map of Finland (Korsman *et al.* 1997),
Quaternary deposits of Finland and northwestern part of Russian federation and their resources (Niemelä *et al.* 1993a, 1993b),
Metallic mineral deposits map of Finland (Puustinen *et al.* 2000).

Nordic cooperation projects have produced geological, geophysical, and geochemical data from northern and central areas of Finland and Scandinavia (Nordkalott and Mid-Norden Projects; http://www.gsf.fi/midnord/; and http://info.gsf.fi/info/gtkkartat/karttaluettelo3.html).

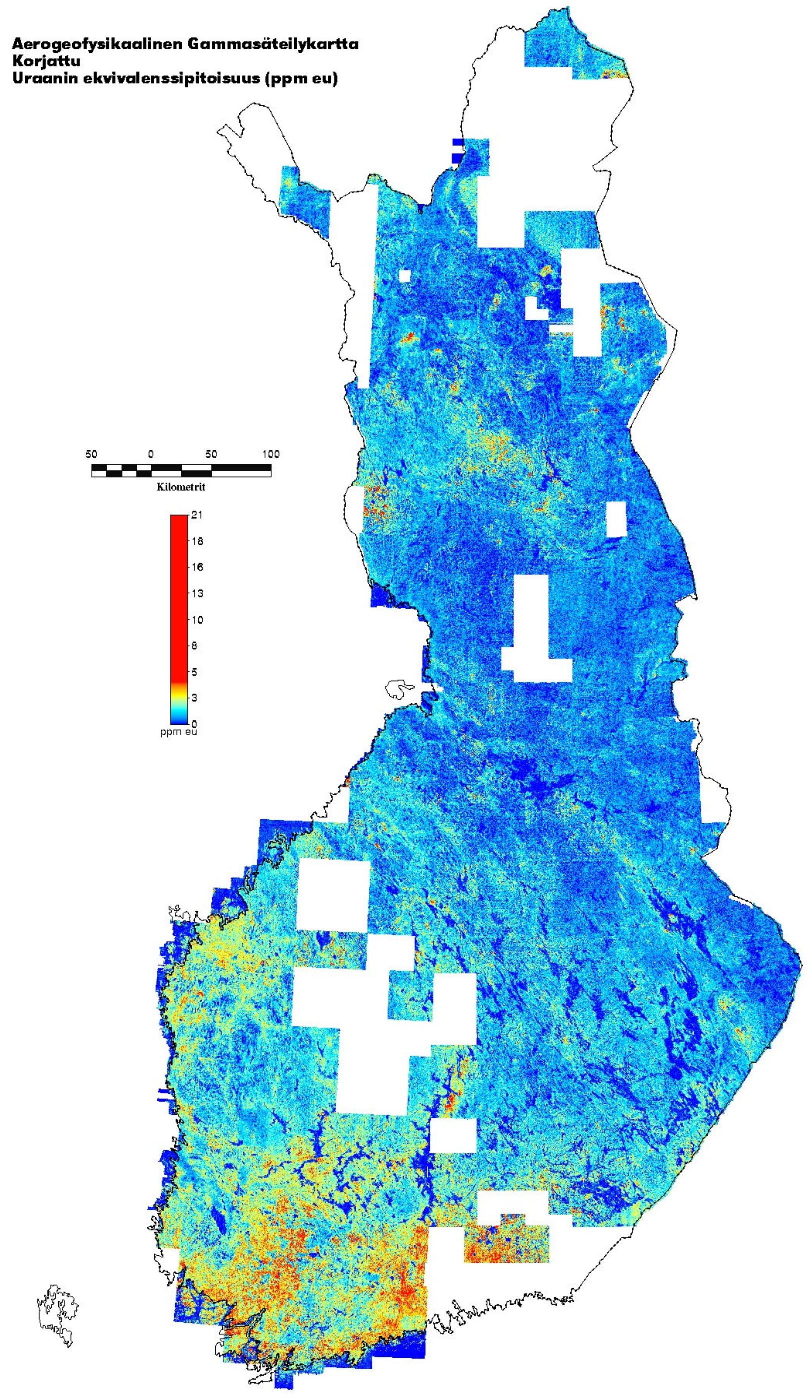

***Fig. 2**. Low-altitude aeroradiometric uranium equivalent concentration (eU in ppm) map of Finland, compiled by J. Lerssi from the digital aeroradiometric data of GTK.*

2 Classification of Finnish uranium deposits

Deposits, occurrences and indications of uranium in the bedrock of Finland discovered so far are mainly situated in the metamorphosed and migmatized Palaeoproterozoic supracrustal rocks of the Karelian and Svecofennian Domains (Fig. 9). Very little is known of the occurrence of uranium in the northernmost Lapland Granulite Belt and the Inari Complex. In the Archaean bedrock of the Karelian Domain, minor uranium and thorium occurrences are associated with granitoids and quartzose neosomes of migmatites; in many cases there are indications of Palaeoproterozoic age for these occurrences.

2.1 Uranium provinces in Finland

Uranium occurrences of Finland have previously been described and classified by Sarikkola (1974), Piirainen (1979), Äikäs (1980), OECD (1981, 1982) and Räisänen (1983). Sarikkola (1974) worked out a scheme modified by the other authors; the classifications have been summarized in the latest volumes of the Red Book (Anon. 2000). The uranium occurrences form regional clusters which can be called uranium provinces (Fig. 3). With descriptions of the host lithology, grades (% U) and tonnages (*in situ*) of the deposits, these are:

The Kolari-Kittilä province in western Lapland, including the sandstone-type deposit of Kesänkitunturi (0.06 %; 950 t U) and the vein deposit of Pahtavuoma-U (0.19 %; 500 t U) in Palaeoproterozoic quartzite and greenstone-associated graphitic schists, respectively.

The Kuusamo province in northeastern Finland, with metasomatite uranium occurrences associated with mineralizations of Au and Co in a sequence of Palaeoproterozoic quartzites and mafic volcanics. The Juomasuo deposit (http://www.gsf.fi/explor/gold/kuusamo.htm) has been developed to a pilot plant stage.

The historical ***Koli province*** in eastern Finland, with several small sandstone-type (Ipatti, Martinmonttu and Ruunaniemi: 0.08 - 0.14 %; 250 t U) and epigenetic uranium deposits (the former Paukkajanvaara mine) and occurrences of U & Th-bearing quartz-pebble conglomerate in Palaeoproterozoic quartzites, with an additional prospect of unconformity-related type in a Palaeoproterozoic regolith.

The Uusimaa province of intrusive-type uranium occurrences in Palaeoproterozoic granitic migmatites of southern Finland, represented by the Palmottu deposit (0.1 %; 1000 t U) and historical pits at Askola.

Additional occurrences with various geological settings include:

- uraniferous phosphorites associated with sedimentary carbonates of the Palaeoproterozoic sequences: e.g., the Vihanti-U and Nuottijärvi deposits (0.03 %; 700 t U and 0.04 %; 1 000 t U)
- uranium mineralisations in Palaeoproterozoic albitites and albite diabase dykes, mostly in northern Finland;
- U & Th-bearing dykes and veins of Palaeoproterozoic pegmatite granites;
- surficial concentrations of young uranium in recent peat.

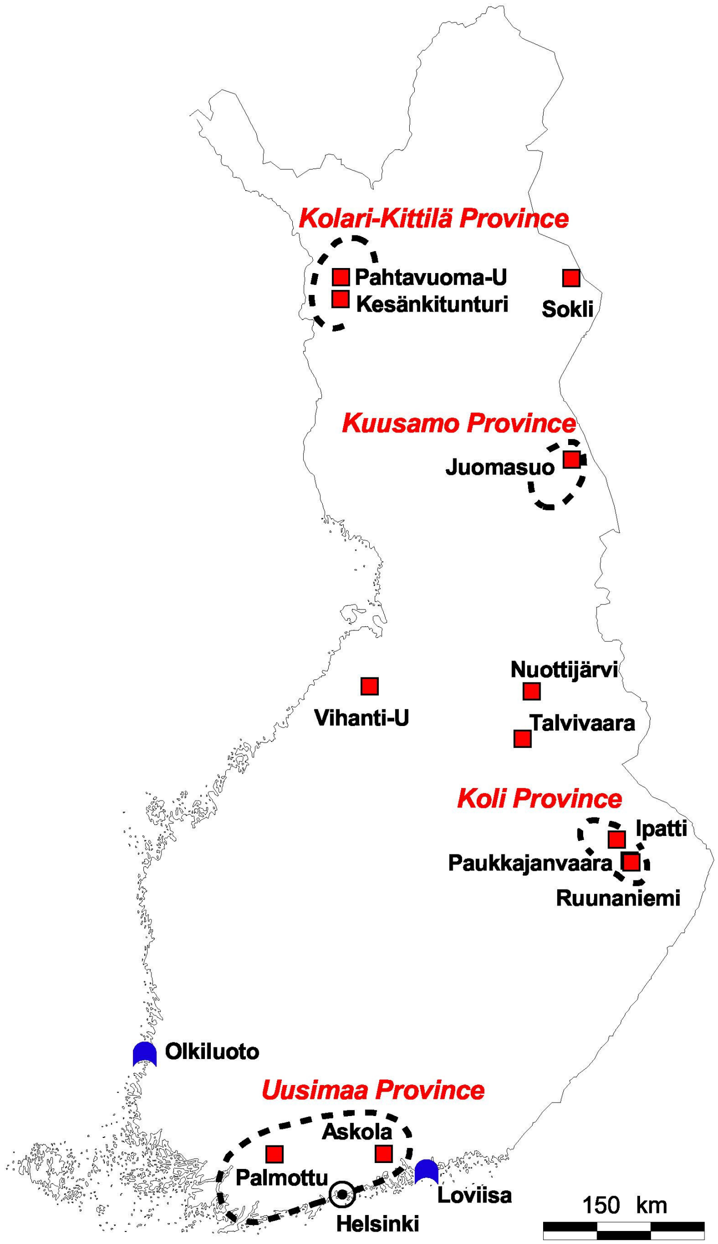

Fig. 3. *Uranium deposits and occurrences in Finland (modified from Anon. 2000). The geographically delineated uranium provinces are depicted with dashed lines. The locations of the nuclear power plants at Loviisa and Olkiluoto are included.*

Possible by-product uranium occurs in the low-grade Ni-Cu-Zn deposit of Talvivaara (0.001 - 0.004 % U), hosted by Palaeoproterozoic black schist, in central Finland, and in pyrochlore of the Palaeozoic Sokli carbonatite (0.01 % U) in eastern Lapland.

2.2 The OECD NEA/IAEA Red Book classification

In the joint Red Book volumes of the OECD Nuclear Energy Agency and the IAEA the uranium resources of the world have been grouped on the basis of their geological setting into fourteen major categories (OECD 2000). The Finnish uranium occurrences can be placed into eight to ten of these categories. Some of the Finnish occurrences show features suitable for more than one of the groups. The deposits types not discussed in this chapter include breccia complex deposits, collapse breccia pipe deposits, volcanic deposits, and lignite.

2.2.1 Unconformity-related deposits

Deposits of the unconformity-related type occur spatially close to major unconformities. Such deposits most commonly developed in intracratonic basins during the period about 1800-800 million years ago, but also during Phanerozoic time.

Finland: The pre-Jotnian (pre-Riphean) unconformity corresponds to the pre-Athabasca and pre-Kombolgie unconformities in Canada and Australia. No uranium occurrences in Finland are known to be associated with this unconformity.

There is a very long Palaeoproterozoic/Archaean unconformity zone in eastern and northern Finland, and many of the known uranium occurrences are situated at or near this unconformity. Minor unconformities occur higher in the Palaeoproterozoic sequence, e.g. the pre-Kumpu unconformity in Lapland. The Riutta deposit in the Koli area and the Pahtavuoma-U deposit in the Kolari-Kittilä area have been assigned to this class (Piirainen 1979), as well as the Mårtensson orebody at Paukkajanvaara, Koli area (OECD 1981, 1982).

2.2.2 Sandstone deposits

The deposits of this type are mostly contained in rocks that were deposited under fluvial or marginal marine conditions. The host rocks are almost always medium to coarse-grained poorly sorted sandstones containing pyrite and organic matter of plant origin. In addition to the deposits in Phanerozoic host rocks, the deposits in Precambrian marginal marine sandstones in Gabon have also been classified as sandstone deposits.

Finland: Several of the uranium occurrences hosted by Palaeoproterozoic quartzites in Finland have been included into this class: the stratabound U±V occurrences of the Koli area, the primary mineralisation of Kouvervaara-U in the Kuusamo area, and, at a higher stratigraphic level, Kesänkitunturi deposit in the Kolari-Kittilä area (Piirainen 1979, Vanhanen 1989).

2.2.3 Quartz-pebble conglomerate deposits

Restricted to a specific period of geologic time, known quartz-pebble conglomerate ores occur in basal Palaeoproterozoic beds unconformably situated above Archaean basement rocks.

Finland: Palaeoproterozoic uraniferous quartz-pebble conglomerates occur in the quartzite units in the Koli area but these occurrences are not assigned to the quartz-pebble conglomerate type (Piirainen 1979, Äikäs & Sarikkola 1987). However, minor occurrences of hematised, uranium- and thorium-bearing quartz-pebble conglomerates in the lowermost, discontinuous Vesivaara Formation (Kohonen & Marmo 1992) overlying the pre-Jatulian palaeosol belong to this class of deposits in the Koli area.

Further south in what is known as the North Karelia schist belt similar (U)-Th-bearing conglomerate interbeds occur in quartzite at Sääperi, Värtsilä and higher in the sequence at Viistola, Kiihtelysvaara (Pekkarinen 1979).

2.2.4 Vein deposits

The vein deposits of uranium are those in which uranium minerals fill cavities such as cracks, fissures, pore spaces, breccias and stockworks.

Finland: The Pahtavuoma-U deposit includes three orebodies, in which uranium minerals occur in postorogenic veins; same types of veins constitute the Laavivuoma deposit west of Pahtavuoma (Pääkkönen 1988). Minor occurrences of uraninite or pitchblende veins have been reported in mafic dyke rocks and in the Archaean basement close to the unconformity (Kunnansuo vein, Koli area; occurrences associated with albite diabases in the Kuusamo area; Puutosmäki occurrence near Kuopio (Piirainen 1979, OECD 1981, 1982).

2.2.5 Intrusive deposits

Deposits included in this type are those associated with intrusive or anatectic rocks of different chemical composition (alaskite, granite, monzonite, peralkaline syenite, carbonatite and pegmatite).

Finland: Uranium and/or thorium occurrences of this group occur all over the country in granitic intrusive rocks and pegmatitic granite bodies, both in the Proterozoic and in the Archaean lithologies. The occurrences in the neosome material of migmatitic rocks are included as well. Type occurrences are the Palmottu deposit in southern Finland (Räisänen 1989), Lemmetty and Puokio occurrences in middle Finland, and Orajärvi Th occurrence in northern Finland (Appendix 5). The Palaeozoic Sokli carbonatite with its possible by-product uranium resources in pyrochlore also belongs to this group (OECD 1981, 1982).

2.2.6 Phosphorite deposits

Sedimentary phosphorites contain low concentrations of uranium in fine-grained apatite. Uranium of this type is considered an unconventional resource.

Finland: Over 20 occurrences of uraniferous phosphorite and phosphatic rocks are known in Finland, varying from a mere cluster of erratic boulders to a small deposit (Nuottijärvi) containing 1000 tonnes of uranium. This type of uranium mineralisation is stratabound, mostly occurring in calcareous metasediments both in the Svecofennian and Karelian domain supracrustals of Palaeoproterozoic age. As a local key horizon, these deposits can be regionally used to delineate phosphatic basins within the subareas of the major domains (Äikäs 1989b). With their average ratio P_2O_5/U varying 100-300, the Palaeoproterozoic deposits of Finland differ from the younger phosphorites in their higher amount of uranium in respect to their phosphorus content.

2.2.7 Surficial deposits

Uraniferous surficial deposits may be broadly defined as uraniferous sediments, usually of Tertiary to Recent age, which have not been subjected to deep burial and may or may not have been calcified to some degree. The uranium deposits associated with calcrete are included in this type. Additional environments for uranium deposition include peat and bog, karst caverns as well as pedogenic and structural fills.

Finland: Radioactive ground water in wells and springs, hydromorphic anomalies in till and uraniferous peat bogs show that the process of leaching and transporting uranium from bedrock and mineral soil to be deposited in recent sediments has been going on in Finland for 10 000 years, since the termination of the last glaciation. Minor deposits of young uranium (uranium in secular disequilibrium) have been located although there has been no systematic exploration for this type of deposits.

Preglacial phosphatic regolith on top of the Palaeozoic Sokli carbonatite (Vartiainen 1989) contains uranium in its secondary apatite and residual magnetite, and uranium and thorium in its residual pyrochlore and in a mass of fine-grained limonite (Rehtijärvi & Lindqvist 1978).

2.2.8 Metasomatite deposits

Included in this grouping are uranium deposits in alkali metasomatites (albitites, aegirinites, alkali-amphibole rocks) commonly intruded by microcline granite. The rocks are structurally deformed and altered by metasomatic processes; there is an association with the introduction of sodium, potassium or calcium into the host rocks (Lambert *et al.* 1996).

Finland: Uranium occurrences in albite diabases and albitites have been found in northern Finland, especially in the Kuusamo area (Pankka & Vanhanen 1992), from where these occurrences continue towards NW to the Palkiskuru deposit at Enontekiö.

2.2.9 Metamorphic deposits

Uranium deposits belonging to this class occur in metasediments and/or metavolcanics generally without direct evidence of post-metamorphic mineralisation.

Finland: Occurrences of this type have not been reported in Finland. On the other hand, many of the uranium occurrences in Finland could be assigned to metamorphic deposits, for instance the uraniferous phosphorites.

2.2.10 Black shale deposits

Low concentrations of uranium occur in carbonaceous marine shales. These resources are considered unconventional resources.

Finland: Palaeoproterozoic Ni-Cu-Zn anomalous black schists deposits at Talvivaara, Sotkamo (Loukola-Ruskeeniemi & Heino 1996) contain 0.001-0.004 % U and have been reported as unconventional by-product resources of uranium (OECD 1981, 1982, 2000).

3 Application of three uranium deposit models

Based on discussions with Mr Claude Caillat from COGEMA, applications of three major types of uranium deposits are considered in the following.

3.1 Model 1 - Unconformity-related deposits

3.1.1 The model

Geological and geochemical changes that occur close to main unconformities are the prerequisites for the generation of unconformity-related uranium deposits. Below the unconformity, metasedimentary rocks of the basement are usually faulted, sheared or brecciated: the younger Proterozoic clastics on top of the unconformity are usually undeformed (Lambert *et al.*1996). Similarities of the deposits and criteria for the exploration model have been summarized for instance by Raffensberger & Garven (1995) and Mernagh *et al.* (1998). The main deposits of this type occur in the uranium fields of the Athabasca basin of northern Saskatchewan, Canada, and Alligator Rivers area, Northern Territory, Australia. The deposits in the Athabasca Basin are rich, grading 0.3-14 % U_3O_8, and occur below, across and above the unconformity (Fig. 4) where subvertical unconformity-crossing (or unconformity-reaching) faults coincide with certain strata (calcareous, graphitic) within the Palaeoproterozoic basement. In the Alligator Rivers field, the deposits are of lower grade (0.4-2 % U_3O_8) and occur below the unconformity; the exploration in this field, however, has been limited to the marginal areas of the Mesoproterozoic Kombolgie Formation sandstone (representing the basal McArthur basin sediments).

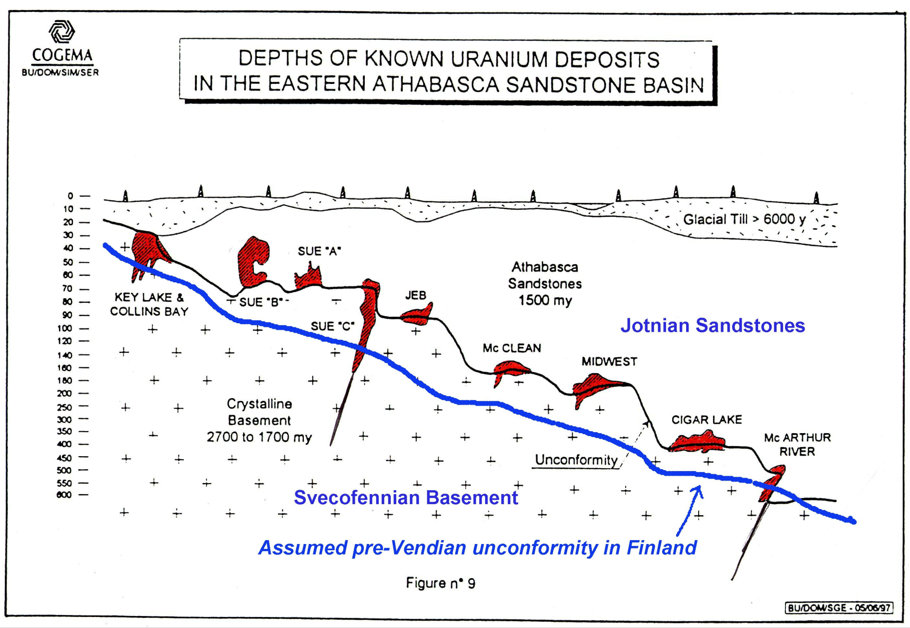

***Fig. 4**. Occurrence of uranium deposits in relation to the unconformity in the eastern Athabasca basin (from Blaise 1997). Adaptation to the Finnish bedrock indicates poor preservation of possible ores in post-Jotnian times, before the deposition of the Vendian sediments.*

3.1.2 Potential for unconformity-related deposits in Finland

3.1.2.1 Mesoproterozoic deposits

The Jotnian sediments of Mesoproterozoic (Riphean) age form the counterpart of the Athabasca basin and McArthur basin sandstones in the Fennoscandian Shield. Already in 1979, in a meeting focused on uranium geology and exploration (Parkkinen 1979), recommendations were made to start straightforward exploration for uranium at the pre-Jotnian unconformities of the Satakunta and Muhos sediments that cover small areas in NW-SE trending grabens (Figs. 1, 4 and 9).

There are no observations of anomalous uranium contents in the Jotnian sediments of Satakunta and Muhos. Samples from the Satakunta sandstone (seven specimens from outcrops and drill core sections) have been determined to contain less than 0.001 % U and up to 0.006 % Th (Appelqvist 1987). Surface follow-up of aeroradiometric gamma anomalies in the Pori flight area (map sheets 1141 and 1143) produced ten minor uraniferous targets on both sides of the Jotnian sandstone graben-fill, mostly in the granitic rocks of the Svecofennian basement, with uranium contents up to 0.065 % eU (Appelqvist & Seppänen 1988). The targets SW of the graben are Th-free, those on the NE side contain up to 0.022 % Th.

Jotnian sediments occur in more than ten localities in the Fennoscandian Shield (Kohonen *et al.* 1993, Koistinen 1994), deposited on Archaean and Palaeoproterozoic basement rocks in basins that are structurally classified as marginal pericratonic, aulacogen and graben-syncline types (Amantov *et al.* 1996).

In the southeastern part of the shield, the Jotnian sediments deposited on gneisses and granitoids of the Svecofennian domain, most of which were formed 1850–1900 Ma ago. The basement rocks underwent rapid development from uplift to erosion; in a period of about 200 Ma before the emplacement of the anorogenic rapakivi plutons, about 10 km of rock were eroded (Vaasjoki *et al.* 1994).

The bimodal rapakivi granite magmatism took place in three age groups in the Shield, producing plutons and stocks in the upper crust: Vyborg-Estonia cluster 1620-1650 Ma, Åland–Riga cluster 1540-1580 Ma, and the Salmi cluster 1540-1560 Ma (Laitakari *et al.* 1996). Contemporaneous crustal extension and the gravitational uplift and emplacement of rapakivi plutons induced depressions that were partly controlled by existing major shear zones and developed into intracratonic grabens. While sinking, the grabens were filled with coarse-clastic fluvial sediments, derived from the weathered Palaeoproterozoic basement (Kohonen *et al.* 1993). The thickness of the Jotnian sediments in the graben-fills preserved is approximated to be over 2000 m in the Ladoga-Pasha graben-syncline, in Russia, and possibly 1300 m in the Satakunta graben (Amantov *et al.* 1996). The filling of grabens and sedimentation in adjacent land areas possibly lasted for hundreds of millions of years.

At the Satakunta graben, the sediments were already cemented as sandstone, when they were intruded – 1258-1265 Ma ago - by extensive sills and dykes of (post-Jotnian) diabase of continental tholeiitic character, probably also covered by associated volcanics.

Continental erosion continued until a Svecofennian–Subjotnian–Jotnian peneplain was formed before the deposition of the Neoproterozoic (Vendian) sediments trangressively from the east; it is probable that Vendian sediments once covered the present southern Finland. Subsequent marine deposits temporarily covered the peneplain until to another period of erosion, possibly starting at the late Cenozoic time (Puura *et al.* 1996).

The Vendian sandstone at Lauhanvuori, 100 km north of Satakunta sandstone is poorly exposed, the radioactivity of the two known outcrops is very low. Observations from erratic boulders around Lauhanvuori revealed radioactive conglomerate interbeds in the sandstone, with pebbles of quartzite and vein quartz, and a heavy mineral fraction containing magnetite, monazite and zircon. Five samples analysed contained up to 0.002 % U and 0.027 % Th (Appelqvist 1973).

The Neoproterozoic erosion leading to the prominent pre-Vendian peneplain is estimated to have removed a pile of Jotnian and post-Jotnian rocks in places 500 to 2000 m thick. Also regoliths developed on the Svecofennian basement before or during the Jotnian sedimentation would have been - at least partly - scavenged by this erosion. The Jotnian sediments have been preserved in the two grabens and as larger areas in basins presently at the bottom of the sea between Finland and Sweden. A few occurrences e.g. in meteorite craters suggest that the pre-Jotnian unconformity extended over the southern and southwestern part of Finland. Scattered occurrences of Cambrian sandstone in southwestern Finland and in western parts of Central Finland indicate that the bedrock had nearly reached its present level of erosion already 550 Ma ago; hence, the present erosion surface is mostly at or below the pre-Jotnian surface of unconformity. The distance to the level of this ancient surface may not be large, possibly only few tens of metres.

The discovery of an unconformity-related uranium deposit called Karhu (Boitsov & Nikolsky 1997) on the northeastern shore of Lake Ladoga in the village of Karkku at Salmi (pre-World War II Finnish territory) shows that the same mechanism of uranium enrichment as in Canada and Australia has been active at approximately the same time in the Fennoscandian Shield. In respect to the primarily varied thickness of the Jotnian sediments and to the erosion of the Jotnian sediments and their basement leading to the pre-Vendian peneplain, the model from the Athabasca basin implies that the targets for exploration of this class of deposits in Finland might belong to that subtype which is located wholly in the basement, with or without graphite conductors, blind or outcropping but probably covered by Quaternary overburden (see table 6.5. and Fig. 6.31 in Saracoglu *et al.* 1983).

3.1.2.2 Palaeoproterozoic deposits

The Palaeoproterozoic/Archaean unconformity zone extending from eastern to northern Finland hosts many uranium occurrences. Indicating deep weathering there are in places two successive palaeosurfaces between the Jatulian quartzite and the Archaean basement. As a major unconformity the pre-Jatulian palaeosol exhibits a vast marker horizon in the Fennoscandian Shield. Minor unconformities occur also higher in the Palaeoproterozoic sequences, e.g. the pre-Kumpu unconformity in Lapland. The Riutta occurrence in the Koli area and the Pahtavuoma-U deposit in the Kolari-Kittilä area have been assigned to this class (Piirainen 1979), as well as the Mårtensson orebody at Paukkajanvaara, Koli area (OECD 1981, 1982). The placement of these deposits into the group of unconformity-related deposits means widening of the concept; however, given that the mineralisation processes took place after the global oxyatmoversion, as is the case with the deposition of the Jatulian and younger clastics covering the Archaean craton, similar chemical contrasts between the ore-bearing fluids and the host environment as during the Mesoproterozoic mineralisation might have prevailed much earlier.

3.2 Model 2 - Francevillian type of uranium deposits

3.2.1 The model

The uranium deposits in the Francevillian basin of Palaeoproterozoic age in Gabon have been classified as a special case of the sandstone type deposits, which commonly are of low to medium grade, containing 0.05-0.4 % U_3O_8. The sediments of the Franceville basin lie unconformably on Archaean crystalline rocks. The sedimentary sequence is divided into five units, formations FA to FE from the base to the top, respectively. With its thickness varying from 100 m to more than 1000 m, the FA formation of conglomerates and sandstones hosts the uranium deposits in its upper parts. The overlying FB formation is mainly composed of black shales varying from 400 m to over 1000 m in thickness. The upper three formations are mainly composed of volcano-sedimentary rocks. The rocks of the Franceville basin are practically non-metamorphic. Various isotopic methods give age estimates for the FB formation close to the range of 2000-2200 Ma within the error limits. Younger thermal events have been recorded, e.g. around 1000 Ma by the intrusion of a dolerite dyke (Gauthier-Lafaye & Weber 1989, Gauthier-Lafaye *et al.* 1996).

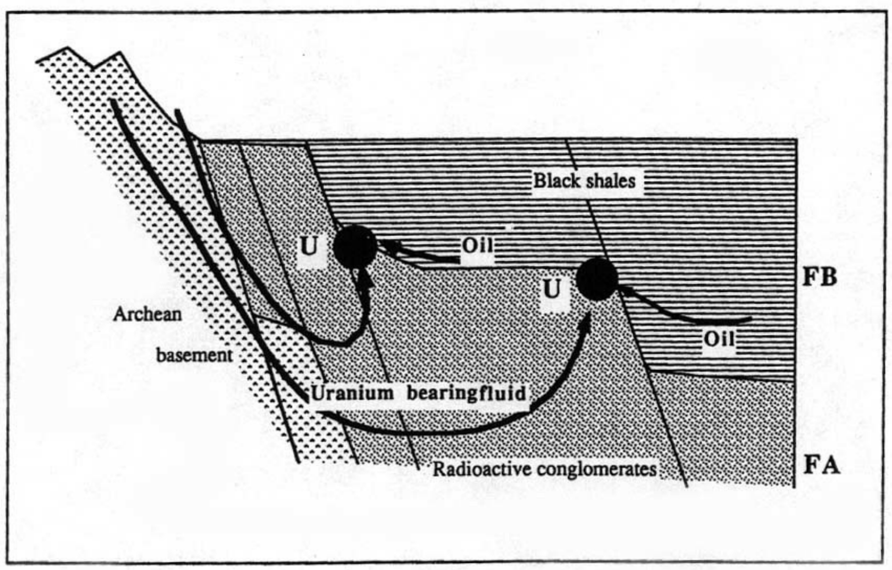

Fig. 5. *Pathways of the fluids carrying hydrocarbons from the FB formation and uraniferous oxidized fluids through the FA formation to the entrapments of mineralisation (from Gauthier-Lafaye & Weber 1989).*

Of the three types of sandstone deposits – rollfront, tabular, and tecto/lithologic – the Francevillian deposits belong to the tecto/lithologic type, in which the uranium carried in oxidized fluids through the FA formation sandstones was precipitated by reduction of these fluids by hydrocarbons. The hydrocarbons derived from the FB formation black shales and migrated to the FA formation sandstone where they remained in tectonic entrapments. In this "common ore" the uranium contents range from 0.1 to 10 % (Gauthier-Lafaye *et al.* 1996).

Criticality demanded to start nuclear reactions was achieved in small pockets where uranium contents reached 10-20 % (2000 Ma ago the relative abundance of the fissile isotope ^{235}U was five times greater than at present), and the heat from the reactors generated hydrothermal cells that accelerated uranium mineralisation and caused alteration of the wall rocks. The nuclear reactions started about 1950 Ma ago. From the six economic deposits of the Franceville basin, two (Oklo and Bangombé) contain natural reactors (Gauthier-Lafaye *et al.* 1996). The natural reactors of Gabon are unique, and their preservation is due to the non-metamorphic state of their Palaeproterozoic host rocks. The contents of uranium in the cores of the reactors range 20-80 %. The dimensions of these platy bodies are small, usually <1 m by 10+ m by 20+ m. These rich ores constituted the basis for the economically viable deposits, from which over 27 000 tonnes of uranium have been produced from 1961 to 1998. All mining was terminated in Gabon in March 1999 (OECD 2000).

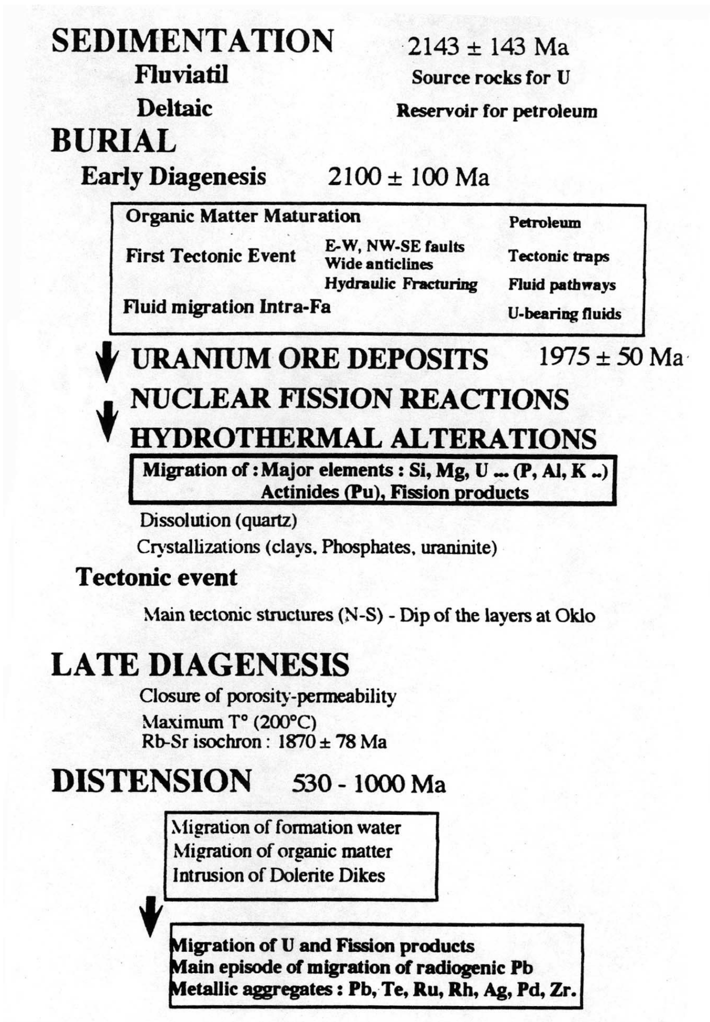

Fig. 6. *Evolution of the Franceville basin uranium deposits: deposition of the host rocks, mineralisation of uranium, operation of the nuclear reactors, and migration of fission products (from Gauthier-Lafaye 1995).*

3.2.2 Potential for Francevillian type deposits in Finland

The Palaeoproterozoic metasediments of the Karelian domain in Finland show temporally and lithologically similar features with the metasediments of the Franceville basin in Gabon. The major difference, however, is the higher degree of metamorphism and deformation in the Finnish bedrock.

Occurrences in the Koli area, the Kouvervaara-U deposit at Kuusamo, and the Kesänkitunturi deposit at Kolari show that enrichment of sandstone type uranium deposition took place in the Palaeoproterozoic of Finland; that is, oxidized solutions capable of carrying uranium were present, and deposition happened where these fluids met reductants within the clastic sequence.

Black schists – graphitic sands, shales, and mudstones – are widely spread in the country, and their distribution is well known (Arkimaa *et al.* 1999, 2000). Application of this model demands delineation of those areas, in which stratigraphic and tectonic conditions could have produced reductants from the black schists to suitable traps in the quartzites or at the interface of these units. The generally medium to high grade of metamorphism probably has destroyed the hydrocarbons. Traces of the presence of hydrocarbons are suggested for instance by uranium thucolites and uraninite-graphite spherules found in many of the Finnish uranium occurrences, in gold deposits and in some black schists. Also, the grey to blue, sometimes disconformably truncating colouration typical of the upper quartzites of the Palaeoproterozoic Kainuu schist belt might be caused by primary interstitial hydrocarbons, now a graphite pigmentation in these quartzites (A. Kontinen, oral communication 2000).

The western part of the Francevillian basin in Gabon, the Ogooué mobile zone comprises a metamorphosed series of Francevillian sediments and their Archaean basement (Gauthier-Lafaye & Weber 1989). This mobile zone could be the closest counterpart of the Finnish bedrock to that of Gabon. There is the possibility to think over an applied version of this model looking for uranium driven from higher degree metamorphic rocks towards reductant bodies and traps in lower degree rocks. The problems in metamorphic rocks, however, arise from the lack of pore spaces for fertile fluids as well as from the existence of these fluids.

Possibilities to find ancient reactors or traces of reactors are speculative. Excluding age determinations, isotopic analyses of uranium have not been made of the Finnish uranium occurrences. Metamorphism and deformation probably have destroyed or transformed possible reactor bodies, the size of which presumably was as small as those of the Franceville basin primarily. There are some unexplained findings of rich boulders as far back as from the late 1950s; these should be tested against recent models, the Francevillian type included.

3.3 Model 3 - Olympic Dam -type or Proterozoic iron oxide (Cu-U-Au-LREE) deposits

3.3.1 The model

The uranium deposit class “Breccia complex deposits” (OECD 2000) has been widened to a polymetallic concept called “Proterozoic iron oxide (Cu-U-Au-LREE)” or “Olympic Dam-type” deposits (Hitzman *et al.* 1992, Oreskes & Hitzman 1993). The Olympic Dam Cu-U-Au-Ag deposit in Australia is the result of combination of mechanical brecciation and hydrothermal replacement of wall-rock granite, with a zonal development of granite to brecciated granite to heterolithic breccia to hematite breccia (Oreskes & Einaudi 1990). The details of the origin of this deposit are somewhat uncertain; the principal mechanisms of brecciation are suggested to be hydraulic fracturing, tectonic faulting, chemical corrosion, and gravity collapse, much of which took place in near-surface environment (Lambert *et al.* 1996). The concept of Proterozoic iron oxide (Cu-U-Au-LREE) deposits includes mineral deposits e.g. of the Kiruna district in Sweden. This group of deposits is suggested to show alteration and mineralisation zoning according to depth (sodic/potassic/sericitic alteration; magnetite/hematite mineralisation; Fig. 7). On the basis of their regional tectonic setting, breccia-hosted and tabular-concordant types of mineralisation have been presented (Oreskes & Hitzman 1993; Fig. 8).

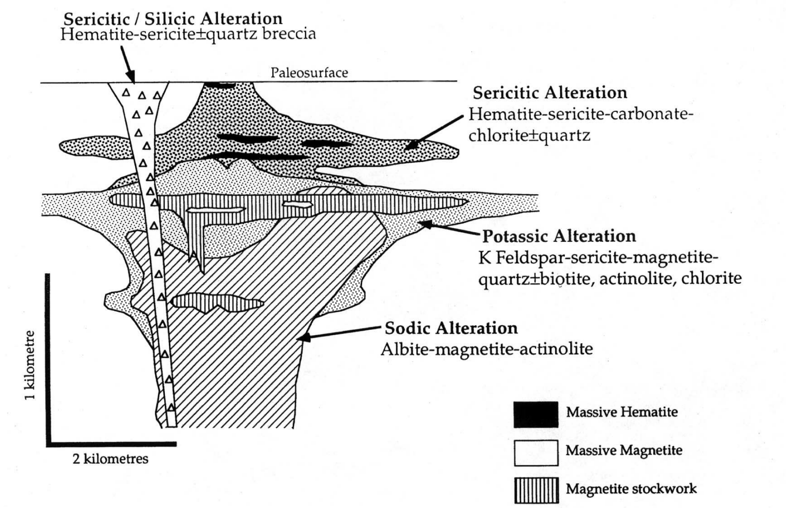

***Fig. 7**. Schematic section of the alteration and iron oxide mineralisation zoning in the iron oxide (Cu-U-LREE-Au) deposit model (from Hitzman et al. 1992).*

3.3.2 Potential for Olympic Dam-type deposits in Finland

SHRIMP U/Pb zircon data show that the polymetallic mineralisation was contemporaneous with brecciation and alteration at Olympic Dam, shortly following the cooling of the wall-rock granite (Roxby Downs granite) about 1590 Ma ago (Johnson & Cross 1995; Oreskes & Einaudi 1993). This granite is an emplacement in upper crust showing rapakivi textures (Oreskes & Einaudi 1990); however, the source of ore fluids may not be the granite, which was rapidly unroofed and eroded prior to mineralisation (Oreskes & Einaudi 1993).

As if by coincidence, the age of the Roxby Downs granite fits the age range of anorogenic rapakivi granites in Finland and in the Fennoscandian Shield. The Subjotnian rapakivi magmatism produced also extrusive or subvolcanic members, exposed on the island Suursaari (Hogland; present Russian territory) between Finland and Estonia. Hence, there may have been a possibility of diatreme-originated high-level breccias. No extensive hematisation or brecciation related to rapakivi plutons are reported, which excludes the presence of exact copies of the Olympic Dam deposit. However, uranium occurrences west of the Viipuri (Vyborg) rapakivi pluton around Porvoo generally show hematisation in varying degrees and are mostly related to zones of shearing and fracturing.

Another target for the application of breccia-hosted Olympic Dam-type deposit is the Korsnäs district in western Finland, described here on the basis of Björklund (1966) and Papunen (1986). A lead mine was operated at Korsnäs by Outokumpu from 1964 to 1972.

The lead orebody was 3-20 m thick and 400 m long extending N-S with a dip of 32-50 degrees to the east. The wall rocks are Svecofennian mica schists with interbeds of amphibolite and cherty quartzite, all broken by a network of pegmatite veins. Sphene from the ore is dated 1825 Ma. The orebody was situated in a fracture zone, hosted by carbonate rock with a number of various minerals, mainly diopside and aggregates of hornblende, sphene, garnet, epidote, scapolite, barite, apatite, fluorite, and allanite. In addition to galena, the ore contained sphalerite, chalcopyrite, pyrite, and pyrrhotite. The REE contents of apatite averaged 6 % (mainly Ce, Nd, La; contained in monazite inclusions in apatite), and apatite concentrate was a co-product of the mine. Large cavities, either open or filled by a mass of montmorillonite clay were found in the orebody. Graphite and lumps of poorly crystalline, thucolitic carbonaceous matter were common in the ore. Radioactive veins were met in the mine, reaching 10 % U, <10 ppm Th with a thickness of 0,5 cm (Rehtijärvi & Lindqvist 1978). Radioactive minerals reported are uraninite/pitchblende, monazite, huttonite, coffinite, allanite, zircon, and thucolite; the carbonaceous lumps were highly radioactive. The origin of the ore is unclear: it is suggested to be late magmatic, pegmatitic or carbonatitic deposit. The carbonate rock host, cut by pegmatite, is interpreted as a carbonatite dyke emplaced in a fracture zone; the clayey portions and cavities indicate late hydrothermal alteration. Similar mineralized fracture zones were intersected by drilling 500 m to the east and 800 m to the west of the orebody; the mineralised fracture system can be seen as linear lows on the gravimetric map. Uraniferous erratic boulders occur southeast and north of the deposit; the source of the boulders has not been found. As a whole, the deposit and its surroundings are poorly known. The Korsnäs case differs from the Olympic Dam-type model in its lack of iron oxides; on the other hand, the presence of an extensive fracture system and mineralisation of uranium, REE, and phosphate are in accordance with the model.

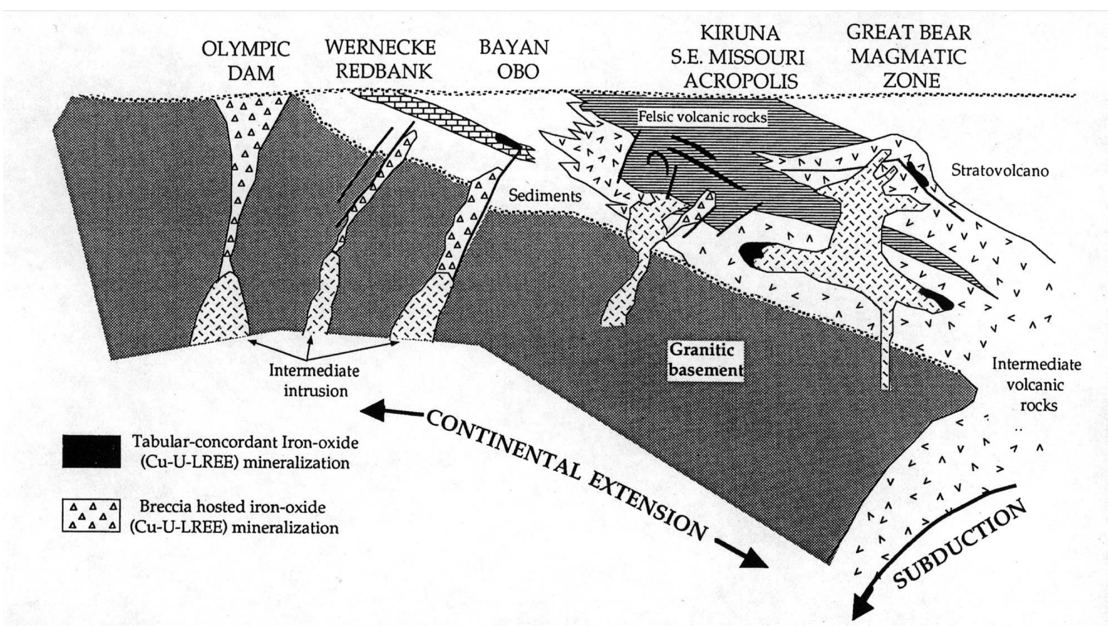

Fig. 8*. Schematic representation of the tectonic setting of the two types of iron oxide (Cu-U-LREE-Au) deposits (from Hitzman et al. 1992).*

The tabular-concordant subtype represented by the deposits of the Kiruna district should be examined in western Lapland. For instance, the Latvavuoma hematite deposits within the Latvajärvi formation volcanics of the Lainio Group show features and age analogous with the Kiruna ores (Puustinen *et al.* 1980, Lehtonen et al. 1998). Spatially the Latvavuoma deposits overlap the Kolari-Kittilä uranium province (Fig. 3). To the west of Latvavuoma, the Kolari iron ore region close to the Swedish border might partly be comparable with the Kiruna ores and Latvavuoma as well (Papunen 1986). No uranium occurrences are known in this area.

There are other deposits and occurrences that should be studied as possible members of this wide group of classification. With brecciation and prominent alteration of their host rocks, the uranium occurrences of the Kuusamo area can be included into this class (E. Vanhanen, pers. comm. 2000). In the southwestern part of the Kainuu schist belt, follow-up of aeroradiometric gamma-anomalies revealed boulders of rich (up to 10 % Th) thorite-hematite ore associated with a gneissose alkaline granite, as well as clusters of boulders of REE and Nb-bearing, radioactive metasedimentary rocks, the source of which was later located with diamond drillings by Rautaruukki Oy (Äikäs 1990). As vein-like bodies in Archaean(?) metasediments, these LREE-Nb-Y-Zr (-Th-U) enriched occurrences are related to this alkaline granite 1970 Ma in age and are located less than 5 km west of the Otanmäki Fe-Ti-V iron ore deposits in gabbroic bodies (about 2030 Ma). Intruded by red uraniferous granite ("Kajaani granite") of the age group 1800 Ma, the alkaline granite extends several tens of kilometers to the east and further northeast, largely along the Archaean/Palaeoproterozoic margin (Havola 1997, Korsman *et al.* 1997).

3.4 Discussion

The three models overlap in many of their basic requirements: uranium must be transported to the deposition site by oxidized fluids, and reductants in a suitable trap are needed to precipitate uranium, possibly with further alteration mechanisms adding to the enrichment. Spatially the models imply a geological structure or discontinuity, where changes in physical and chemical conditions are possible. Post-depositional protective agent is needed against erosion or destruction by metamorphism and deformation.

As recently suggested by Hecht & Cuney (2000), uranium leached by hydrothermal alteration of accessory monazite in the basement granitoids may represent the major uranium source in the Athabasca Basin. Leaching of uranium from monazite altered during siliceous diagenesis is suggested as a uranium source in the Franceville Basin (Cuney & Mathieu 2000). Monazite is a common accessory mineral in the Finnish bedrock and in many cases an essential mineral in the U-Th occurrences. The Palmottu uraninite, dated about 1700 Ma, is reported to have altered hydrothermally by coffinitisation, resulting in release of uranium (Kaija *et al.* 2000). The regional geophysical and geochemical surveying of GTK indicates that especially in southern Finland the bedrock contains a large amount of uranium widely dispersed in various granitoids (e.g. Fig. 2). An exploration model aimed at finding major orebodies involves knowledge of the mobilisation and mineralisation mechanisms combined with discovering suitable traps.

Numerous showings and occurrences of uranium in the Palaeoproterozoic quartzites of the Karelian Domain indicate that oxidized solutions carrying uranium were available within the ancient sandstone sequence covering the Archaean craton. Theoretically, enrichments of the unconformity-related type, general tecto-lithologic sandstone type, and Francevillian type should exist within these sequences in the Karelian domain. The Francevillian model shows, that rich uranium ores did develop already in the Palaeoproterozoic time but their dimensions probably were small, only some tens of metres. The difficulties for exploration arise from the preservation of the possible ores and their alteration halos that could help in the identification of potential targets.

Some of the unconformity-related deposits in Canada and Australia occur within the basement, below the Mesoproterozoic unconformity. If the concept of unconformity-related ores can be widened to the Palaeoproterozoic unconformities, would it not be possible to find uranium in the Archaean basement as well, at least close to the unconformities? Furthermore, within the Archaean complex of eastern Finland there are zones of intensive Palaeoproterozoic deformation and metasomatic alteration related to a thermal peak at about 1850 Ma, reflecting the thermal activity at that time in the Svecofennian area in the west and interpreted to be a result of magmatic underplating (Pajunen & Poutiainen 1999). Phosphorus and REE mobilisation is part of the alteration, and a U, Th prospect related to a Palaeoproterozoic metadiabase dyke has been found in one of these zones.

Mesoproterozoic uranium deposition at the pre-Jotnian unconformity is proven in the Karkku village at Salmi (the Karhu deposit) on the northeastern shore of Lake Ladoga in the Russian part of the Fennoscandian Shield. Subjotnian rapakivi granite plutons and related volcanics may be potential region for the exploration for Olympic Dam-type deposits, and their distribution in southern Finland (Fig. 9) coincides with the distribution of Jotnian sediments that partly covered at least the southern and probably also the western Finland. The southern Finland, and at the same time the southeastern part of the Fennoscandian Shield possibly show overlapping of these two models of major uranium deposit types. The patterns of anomalous distribution of uranium in this area can be clearly seen in gamma radiation (Fig. 2) and geochemical uranium and radon (Lahermo *et al.* 1996) data. On the basis of isotopic data, uranium mineralisation has occurred in southern Finland recurrently from the Svecofennian deposition and orogeny to the Palaeozoic mobilisation (Vaasjoki 1977).

The possibilities to find economic Mesoproterozoic uranium ore in southern Finland culminate in the demand of preservation of the deposits. The Svecofennian orogeny was followed by rapid uplift and significant erosion, which took place in low latitudes on the basis of palaeomagnetic studies. The erosion continued through the subsurface emplacement of rapakivi plutons, producing material for the Jotnian sedimentation in graben-like basins. After the intrusions and extrusions of post-Jotnian diabase magma and related volcanics, considerable amount of the supracrustal pile was eroded during the evolution of a vast peneplain before the deposition of Vendian sediments. This peneplain was conserved below younger sediments, and the present erosion surface of the bedrock in southern Finland is close to this ancient pre-Vendian peneplain. Hence, the key question is, whether the erosion between post-Jotnian magmatism and Vendian sedimentation consumed all of the possible Subjotnian-Jotnian uranium deposits or, at least in their deepest parts, left some of those untouched (see Fig. 4).

Are there uranium mineralisation models in the Fennoscandian Shield that do not fit the fourteen groups of the IAEA classification? Overlapping of mineralisation types is remarkable in such areas as the Kolari-Kittilä province (see Fig. A1/4). Showings and indications of uranium occur in pegmatite bodies and albite diabase dykes, there are stratabound uranium occurrences in quartzites and conglomerates, pebbles of older uraniferous schist in conglomerate, stratabound occurrences in biotite schist, and rich uraniferous veins in graphite and sulphide-bearing schists. In the same area there are volcanogenic sulphide ores, hydrothermal gold ores, and various types of iron oxide ores.

The Russians claim Padma and other uranium deposits of the Onega basin (200 km northeast of Salmi) unique in their complexity in mineral and elemental composition, calling these as the “Onezhky-type” deposits. These deposits are associated with shungite and controlled by tectonic fracture zones, containing vanadium, uranium, gold, palladium, platinum, and some molybdenum, copper, lead, and zinc (Bilibina *et al.* 1991). In the Finnish part of the Fennoscandian Shield similar occurrences are not known.

4 Description of the database

Various databases of GTK were used to gather information and references on uranium occurrences and deposits: MALMIKANTA, LOHKAKANTA, FINGOLD, LOPPI, VALTRAP, RAPGEO, and FINGEO turned out to be the most important sources. The data fed in the records derives from publications and, for a substantial part, from unpublished GTK, university and company reports and papers. In a few cases unreported data has been included, mostly from the material of the occurrences studied by the author of this report. One of the tools used for handling the data was a GIS based computer program (ArcView), with access to the digital survey and base map databases of GTK. The names of the geological domains and their subareas used in the database and in this report are shown in Fig. 9.

The published articles and unpublished reports on the occurrence of uranium in Finland reflect the three periods of grass-roots uranium prospecting in Finland (Äikäs 1989a) and the quite abrupt decrease in uranium exploration in the mid-1980s. Many of these papers are technical reports and descriptions of case histories without deeper research into the geology of the deposits. The shift in the priorities of GTK’s exploration strategy in the 1980s left quite many research projects on geology and mineralogy of uranium unfinished or unstarted. The gold exploration in the Kuusamo area, initiated by the uranium discoveries, and the studies related to nuclear waste management at Palmottu have, however, produced significant recent contributions on the occurrence of uranium in these deposits (e.g. Pankka 1997; Ruskeeniemi et al. 2000). Since the termination of uranium exploration, many fruitful projects have been carried out in order to construct the geological evolution of the Finnish Precambrian as well as to study the economic geology, especially gold ores. In its part, this database attempts to update the information where uranium occurrences and deposits of other ores are spatially related or where fresh results can otherwise be used to supply the former data.

According to the usage of the OECD/IAEA Red Book (OECD 2000), a uranium occurrence is a naturally occurring anomalous concentration of uranium. A uranium deposit is a mass of naturally occurring mineral material from which uranium could be exploited at present or in the future. In the FinU database, the usages of MALMIKANTA and FINGOLD databases are adjusted to rank the status of the occurrences as ‘Mapped prospect’, ‘Drilled prospect’, ‘Deposit’, and ‘Mine, closed’.

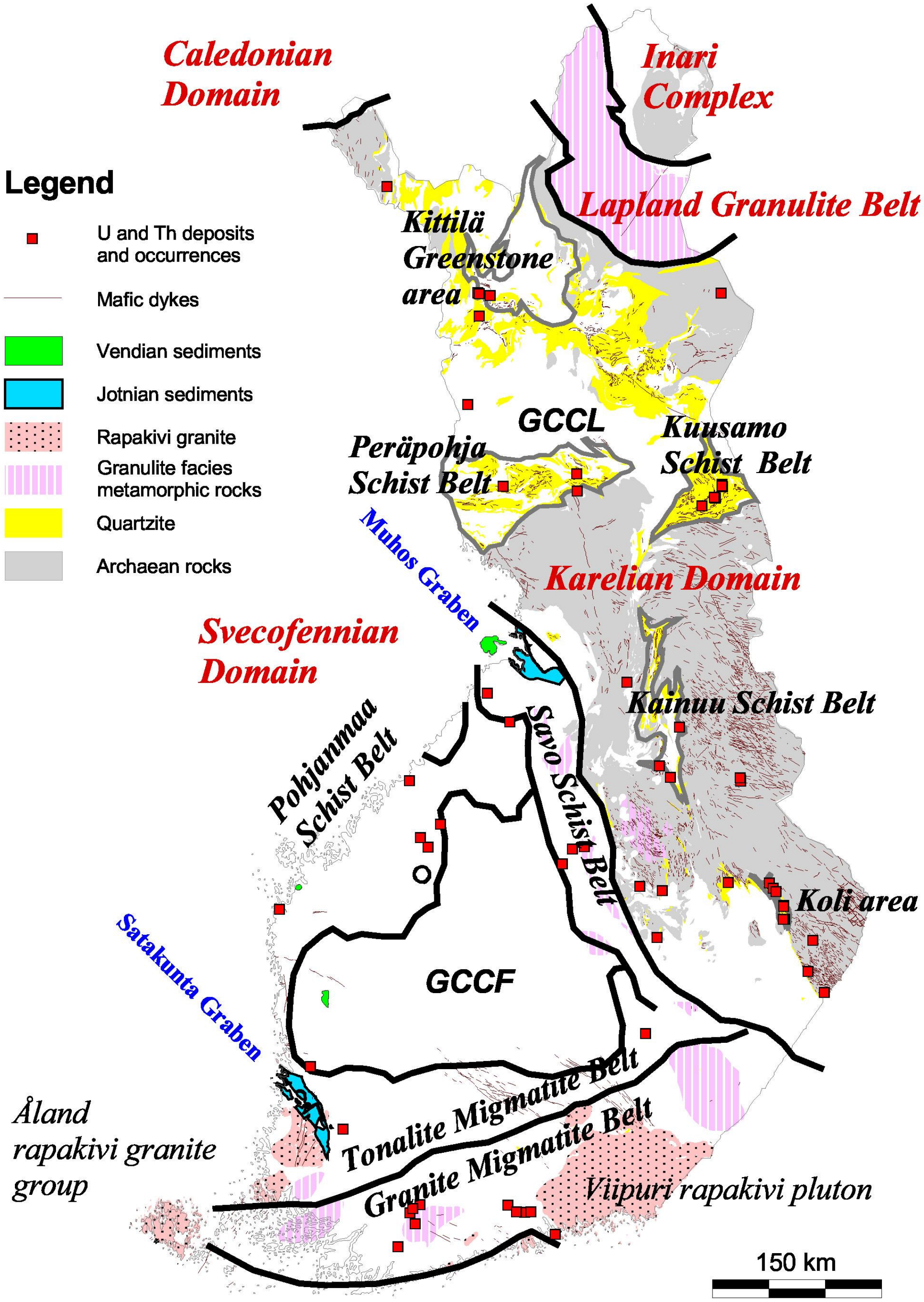

***Fig.9**. Deposits of the FinU database plotted on selected lithologies and units of the Finnish bedrock, modified from GTK data files based on Korsman et al. (1997). The names of domains, belts and other subareas used in this report and the FinU database (Appendix 5) have been added. GCCF: Granite Complex of Central Finland; GCCL: Granite Complex of Central Lapland.*

The FinU database has been compiled to follow the idea and largely also the structure of the FINGOLD database as it is given in the report by Eilu (1999). In addition to uranium, occurrences of thorium have been included, because there is a close relationship between the geology, mineralogy, and exploration methods of these two metals. Modifications to the structure and contents of the database have been made, for instance, in relation to radioactivity. Also the database on zinc deposits presently in preparation by Eilu (2000) has been used as the basis to this work.

The FinU database has been compiled as an MS Access file, in which the data is arranged in nine mutually related tables (Appendices 2-5):

Deposits. FinU identification code, codes for other databases, location, infrastructure, land tenure (past and present)

Exploration. Commodity, status, discovery, case history, geologists, diamond drilling, drill core availability, elements analysed

Resources. Best sections, extent, lodes, evaluations, resources, grade, Red Book resource class, byproducts, when mined, production

Ore. Ore minerals, minor opaques, gangue, composition, texture, and fabrics of ore minerals, composition of ore, U/Th ratio, enriched elements, stable isotopes, Pb isotopes, genesis, timing, Red Book setting, tentative model for FinU

Geology. Geological domain and province, geological setting, host lithology, intrusive rocks, metamorphism, deformation, alteration of rocks, alteration of radioactive minerals

GeophysGeochem. Response on radiometric, magnetic, electromagnetic, and other geophysical surveys, glacigenic dispersion, geochemical dispersion

Environment. Distance from population centres, protection areas, watersheds. Possible radioactive or geochemical hazards, restoration of exploration and mine workings

Literature. Supplementary table for combining the references with the deposits

Reference. List of references related to the occurrence of uranium in Finland or to the geology of the deposits in the database

As stated in the contract, this report and the first version of the FinU database (Appendix 5) form a hardcopy report as is Eilu (1999); figures and maps have been omitted in the database because of limited resources in compiling the data. On the accompanying CD Rom disk the MS Word file of this report and the MS Access file include WWW links to the “Gold Page” of GTK (the Internet version of the FINGOLD database) for those gold deposits, in which uranium is a potential by-product.

The meaning of the database sub-entry “Tentative model for FinU” is to enable development of the classification of the Finnish uranium deposits by updating the database according to the ideas that are starting to originate from the GTK/COGEMA co-operation. Although mainly being a delayed compilation of data from the work until the late 1980s, this report and the first version of the database can be seen as a step towards understanding the geology of uranium in Finland.

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Appendix 1 - GTK/COGEMA field trip, September 2000: geological field targets

Starting at Rovaniemi and ending at Joensuu, the field trip related to the contract between GTK and COGEMA took place from Monday, 25th September to Sunday, 1st October. The aim of this excursion was at visiting the most important uranium areas in northern and eastern Finland: the Kolari-Kittilä area, the Kuusamo area and the Koli area (Fig. A1/1). GTK field base at Kittilä and hotels at Kuusamo, Sotkamo, Koli, and Joensuu were used for accommodation, and a GTK car was used for travelling. Field assistant Antti Pakonen and geologist Erkki Vanhanen from the GTK Rovaniemi office served as local guides, Pakonen in the Kittilä area 25-27th September and Vanhanen in the Kuusamo area 28th September. Mr Claude Caillat from COGEMA and Mr Olli Äikäs from GTK were the participants of the entire field trip, Äikäs being responsible for the organisation and general guidance of the trip.

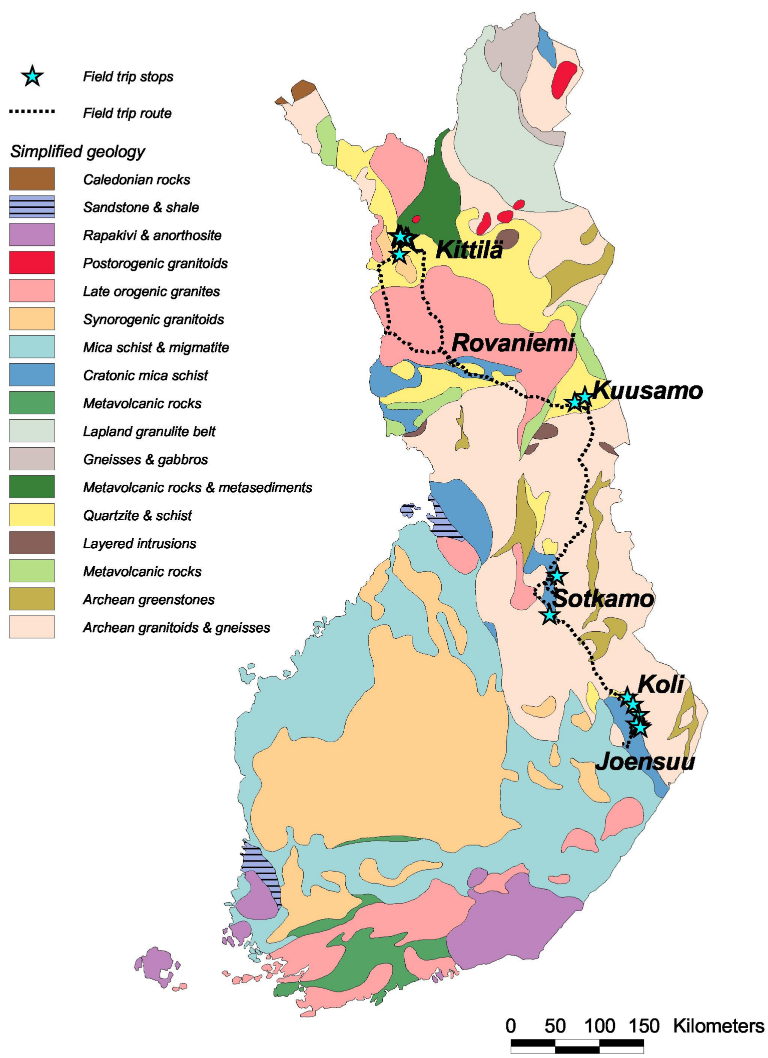


Fig. A1/1. The route and stops of the field trip. Geological map from GTK databases (see Fig.1).

Tuesday, 26th September: Kittilä

- Laavivuoma deposit: highly radioactive erratics of the boulder fan; outcrops and drilling sites of lode LI; partly caved-in trenches of lode LII.
- Pahtavuoma-U deposit: restored (covered with soil) trench at lode UIII (see Inkinen 1979), radioactive conformable vein in sulphide-bearing unit across a fresh trench, related to lode PII, both within the limits (red line, Fig. A1/2) of the concession held by Outokumpu Mining Oy.
- Aakenusvaara deposit: trenches & drilling sites.

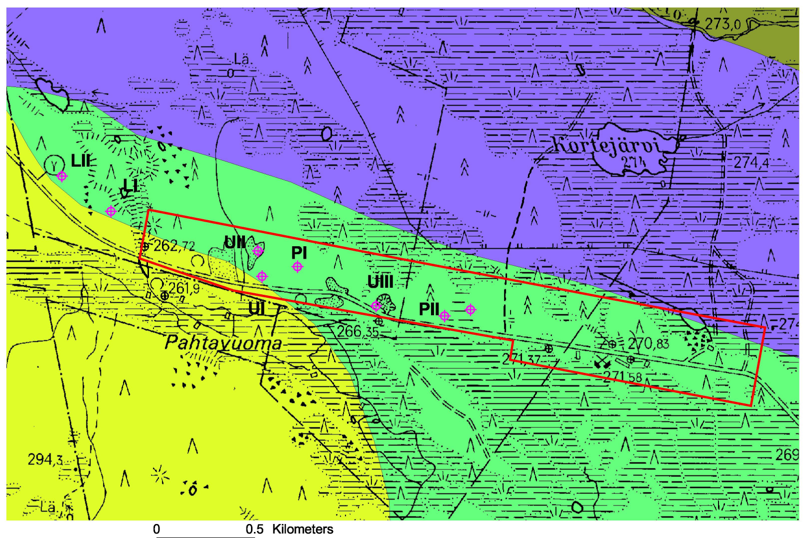


Fig. A1/2. Lodes of the Laavivuoma (LI, LII) and Pahtavuoma-U (UI-III, PI-II) deposits. Lithological outlines (from the 1 : 1 Mill. map database, Korsman et al. 1997) are not precise in the detailed scale of this figure. Yellow: Lainio Group quartzite; green: Savukoski Group metavolcanics and metapelites (upper); purple: Savukoski Group metasediments (lower); see Lehtonen et al. (1998). Base map: National Land Survey of Finland, licence no 13/MYY/00.

Wednesday, 27th September: Kolari

- Kesänkitunturi deposit: local frost-generated rubble on top of the fell, above treeline (Fig. A1/3a). U & Cu in grey Lainio Group quartzite, until now under concession of Outokumpu Mining Oy.

Fig. A1/3a. Kesänkitunturi deposit, looking northeast. Photo O. Äikäs.

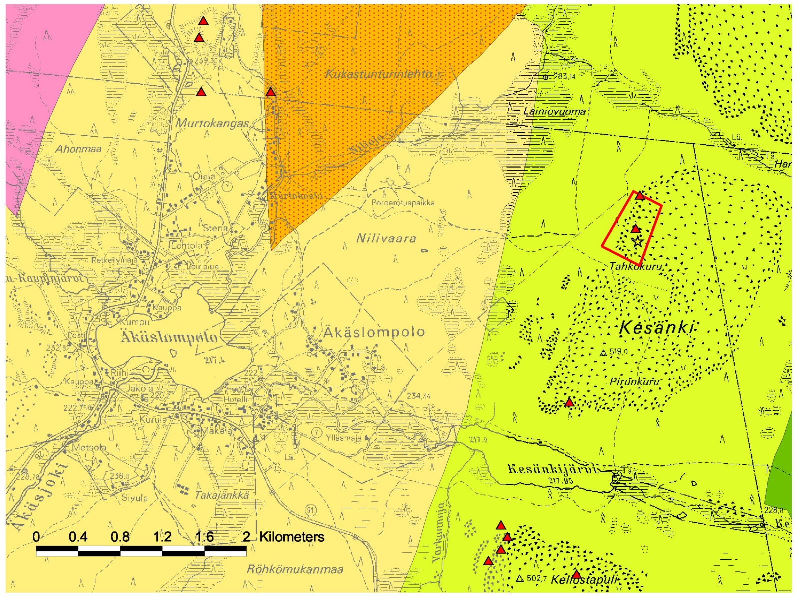
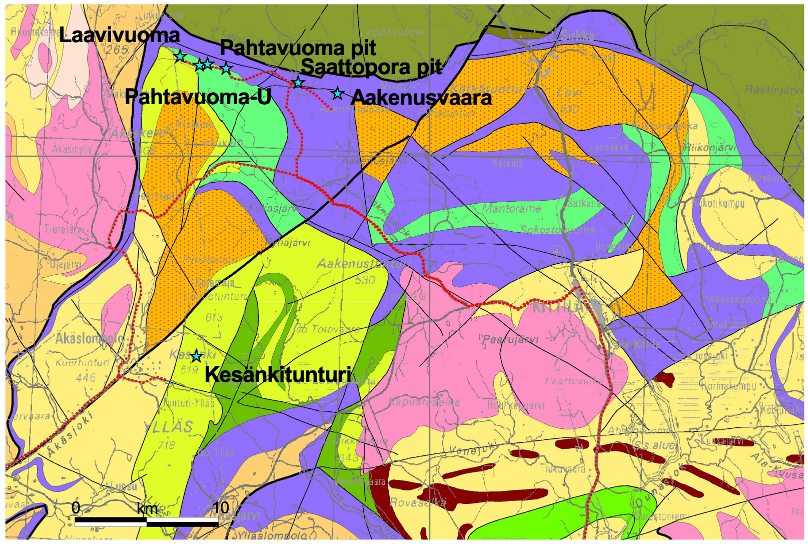


Fig. A1/3b. Kesänkitunturi deposit within the concession limits (red line). Triangles denote U ore indications of the LOHKAKANTA database of GTK. Lithology: purple – granite; pale yellow – Sodankylä Group quartzite; greenish yellow – Lainio Group quartzite; orange: Kumpu Group quartzite (see Korsman et al. 1997, Lehtonen et al. 1998). Base map: National Land Survey of Finland, licence no 13/MYY/00.

On the basis of the field visits of the first two days, the unconformity between the youngest sedimentary unit, the Kumpu Group (Fig. A1/4), and the older Palaeoproterozoic units might be an interesting target for uranium exploration in the future. This topic demands further stratigraphic discussions with the geologists from Rovaniemi in order to find out the position and extent of the Kumpu group rocks in Central Lapland as well as possible locations of observed (outcropping) sub-Kumpu unconformities.



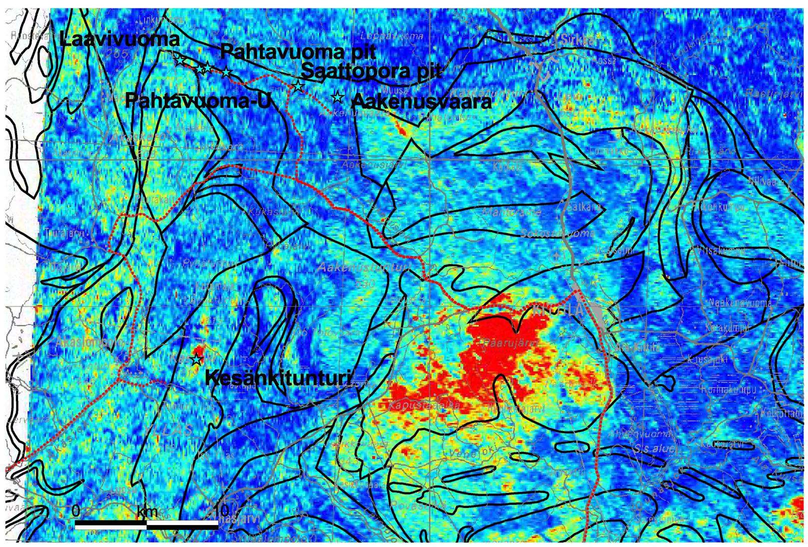
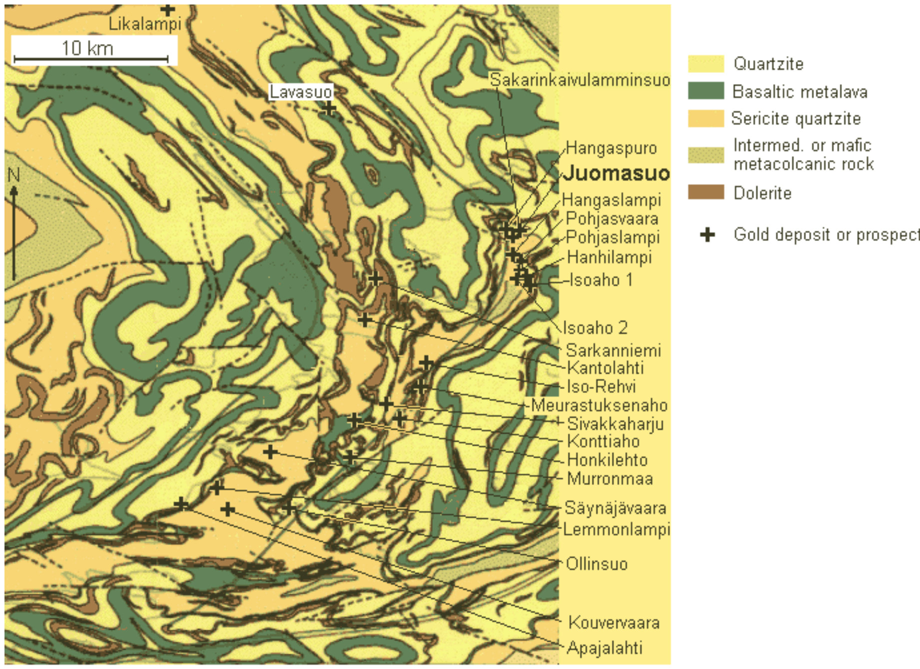


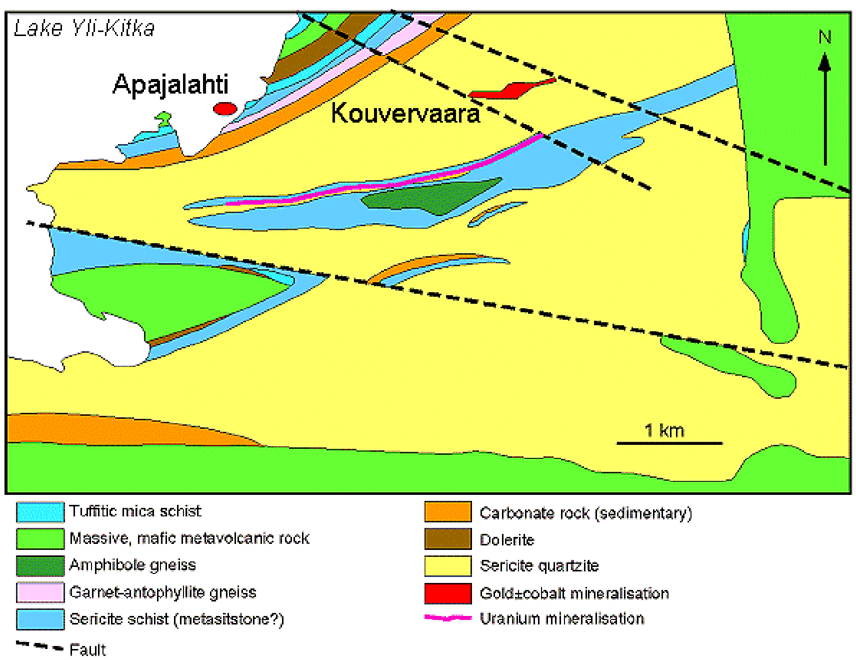
Fig. A1/4. Field trip targets west of Kittilä on geological map (upper; see Korsman et al. 1997) and on low-altitude aeroradiometric U channel map (lower; GTK geophysical database, see Fig. 2) with lithological boundaries. The Kumpu Group quartzites are shown in orange colour. The granite west of Kittiä shows an enhanced U radiation response. For stratigraphic and age references, see Lehtonen et al. (1998). Base map: National Land Survey of Finland, licence no. 13/MYY/00.

Thursday, 28th September: Kuusamo

- At Konttiaho, U±Au bearing breccia pipes in completely altered metasediments: dissolution/collapse breccias; multiple albitisation).
- Western end of the uraniferous horizon of Kouvervaara-U in sericite quartzite (Fig. A1/5).



Deposits and prospects in the Kuusamo Schist Belt. Geology from Silvennoinen (1992).
Solid and dashed, curved lines indicate boundaries between lithological units, faults and shear zones



Geology of the Kouvervaara–Apajalahti area, after Kuronen (1981) and Vuokko (1988).

Fig. A1/5. Location of Konttiaho and Kouvervaara deposits in the Kuusamo area (upper); regional geology of Kouvervaara (lower); maps copied from GTK Gold Page (see Eilu 1999).

Friday, 29th September: Paltamo & Sotkamo

- Nuottijärvi deposit: uraniferous phosphatic breccia. The outcrops are in bad shape, and bush covers most of the surroundings today, unlike in Fig. A1/6.
- Another group of radioactive breccia outcrops was visited at Miesjärvi, 2 km SE of Nuottijärvi, where fragments of Jatulian quartzite are embedded in calcareous matrix.

Fig. A1/6. Nuottijärvi outcrop, photos by O. Äikäs 1988. The two inserts down left show the rusty uraniferous & phosphatic matrix enclosing fragments of carbonate+calc-silicate rock.

- Talvivaara, Sotkamo: test pits in the low-grade Ni-Cu-Zn deposit comprising black shales, black sands and black schists as host rocks, with uranium contents between 10 and 40 ppm.

Saturday, 30th September: the Koli area (Fig. A1/7)

- Ipatti deposit near Koli village: outcrops & ore boulder, U with magnetite in subarkosite.
- Hermanni-2, old pit in quartzite.
- Paukkajanvaara mine area: Kunnansuo pit (conglomerate & diabase); quartzite near the restored site of the Mårtensson shaft & open pit.
- Riutta, mainly sericite-quartz schists: pitchblende in the old Ristimonttu pit; in polished samples from Unimonttu trench; and in caved-in trenches at the site of "Boulder-fan-three". On the way, visit to a quarry south of Riutta, where extensive dissolution/collapse breccia (Fig. A1/8) in Jatulian quartzite was sampled and photographed. Two thin sections were made of the breccia for COGEMA after the trip.
- The last stop of the excursion was diamictite exposure at Kyykkä, NW of Riutta.

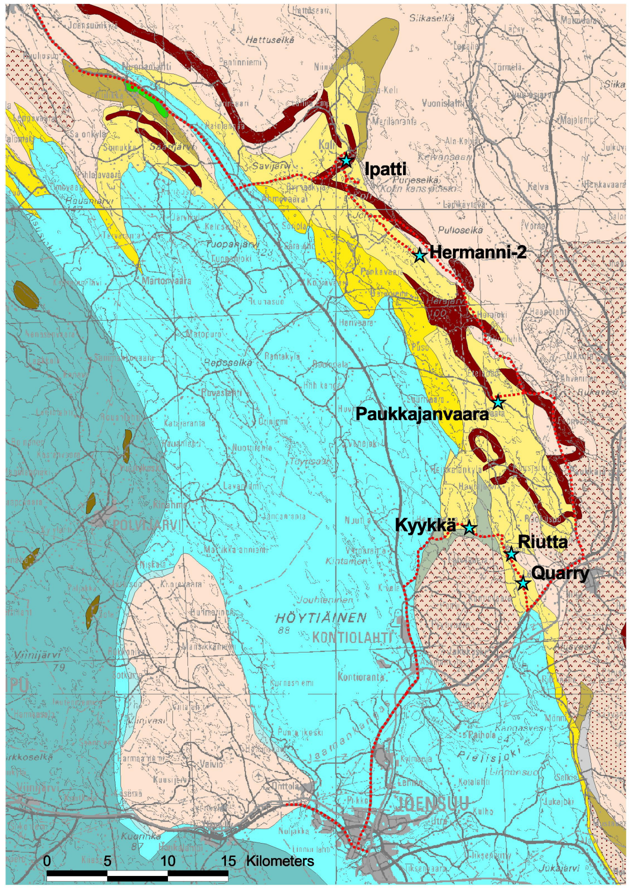


Fig. A1/7. Field trip stops in the Koli area. Geology from Korsman et al. 1997. Base map: National Land Survey of Finland, licence no. 13/MYY/00.

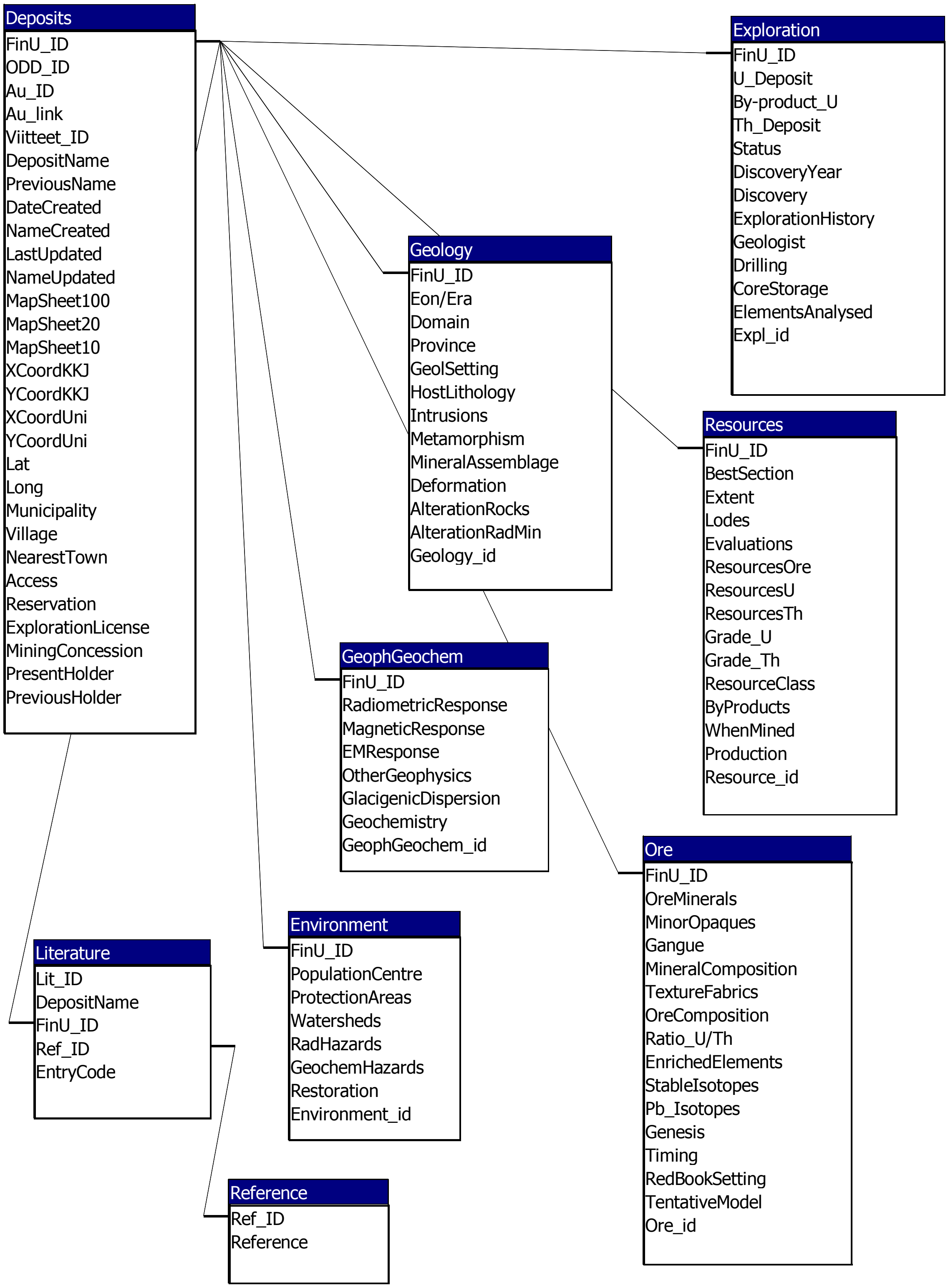
Fig. A1/8. Quarry wall facing south, Kuusoja, Eno. The height of the wall exceeds five metres. The dark patches are of (unoxidized?) quartzite, the lighter rock is brecciated quartzite cemented by a mass of epidote, albite and (drusy) quartz. Photos & mosaic by O. Äikäs.

Appendix 2 - Relationships of the tables in database FinU

Text (a MS Access Report) as Snapshot file Finu_1_app2.snp

Microsoft Access Snapshot Viewer is needed to open the file; Snapshot viewer (in Finnish!) can be downloaded e.g. from http://officeupdate.microsoft.com/finland/2000/downloaddetails/snapshot_viewer.asp. The program has been copied on the attached disk as well (snpvw90.exe).

Relationships for Finu_1
29. 12. 2000



Appendix 3 - Description of a record in the FinU database

FIELD	DESCRIPTION
Table: DEPOSITS	
FinU_ID	Identification code for FinU database
ODD_ID	Identification code for MALMIKANTA database
Au_ID	Identification code for Fingold database
Au_link	WWW link to the GTK Gold Page
Viitteet_ID	Identification code for LOHKAKANTA database
DepositName	Present name of deposit
PreviousName	Previous or other name(s) of the deposit
DateCreated	Date of feeding the data
NameCreated	Name of the data collector
LastUpdated	Date when updated
NameUpdated	Name of the updating person
MapSheet100	Map sheet 1 : 100 000
MapSheet20	Map sheet 1 : 20 000
MapSheet10	Map sheet 1 : 10 000
XCoordKKJ	X coordinate (national KKJ system) in metres
YCoordKKJ	Y coordinate (national KKJ system) in metres
XCoordUni	X coordinate (national uniform system) in metres
YCoordUni	Y coordinate (national uniform system) in metres
Lat	Latitude in decimal degrees, transformed from KKJ to WGS-84
Long	Longitude in decimal degrees, transformed from KKJ to WGS-84
Municipality	
Village	
NearestTown	Distance and direction to the nearest town(s) by road
Access	Type of roads to the area, distance to nearest roads
Reservation	Claim reservation expiry date, if recent; note of quarantine
ExplorationLicense	Mining registry claim number in the database of the Ministry of Trade and Industry
MiningConcession	Concession number in the database of the Ministry of Trade and Industry
PresentHolder	Company presently holding the mineral rights in the area; if none: “Open for acquisition”
PreviousHolder	Names of companies, years

FIELD	DESCRIPTION
Table: EXPLORATION	
FinU_ID	
U_Deposit	Tick if uranium deposit
By-product_U	Tick if uranium by-product deposit
Th_Deposit	Tick if thorium deposit
Status	Mapped prospect; Drilled prospect; Deposit; Mine, closed
DiscoveryYear	Year of the discovery in bedrock
Discovery	Description of the actions that led to the discovery
ExplorationHistory	Case history: which organisation, when, what?
Geologist	Geologist(s) in charge of exploration, their organisations
Drilling	Amount and years of diamond drilling by organisation
CoreStorage	Availability of drill cores (mainly from the LOPPI database)

FIELD	DESCRIPTION
ElementsAnalysed	Elements analysed, by methods

Table: RESOURCES

FinU_ID	
BestSection	Mainly given as drill core sections, length at percentage of metal
Extent	Lateral or 3D extent of mineralised area
Lodes	Description of lodes in the deposit
Evaluations	Summary and reference of feasibility study or other evaluations
ResourcesOre	Tonnage of ore (in million tonnes)
ResourcesU	Tonnage of uranium (in tonnes)
ResourcesTh	Tonnage of thorium (in tonnes)
Grade_U	Average grade of uranium (%)
Grade_Th	Average grade of thorium (%)
ResourceClass	Red Book resource class (OECD 2000)
ByProducts	Possible by-products or co-products
WhenMined	Years of mining operations
Production	Total production (in tonnes of uranium or other metals)

Table: ORE

FinU_ID	
OreMinerals	Major radioactive and other ore minerals
MinorOpaques	Accessory radioactive and ore minerals
Gangue	Valueless minerals of the ore
MineralComposition	Composition of ore minerals
TextureFabrics	Textures and fabrics in the ore
OreComposition	Composition of the ore, U and Th abundances
Ratio_U/Th	Average or representative U/Th if given
EnrichedElements	Elements enriched in the ore
StableIsotopes	C, O, S isotope data/results from the deposit
Pb_Isotopes	U/Pb isotope data/results from the deposit
Genesis	Genetic interpretations of the mineralisation
Timing	Summarised timing based on isotopic data and field relationships
RedBookSetting	Category in the Red Book classification
TentativeModel	Classification proposal by the data collector

Table: GEOLOGY

FinU_ID	
Eon/Era	Archaean/Palaeoproterozoic/if younger: period?
Domain	Domain or complex after Korsman *et al.* (1997)
Province	Region, belt or other subarea within the domain
GeolSetting	Description of local geological setting
HostLithology	Description of host rocks
Intrusions	Intrusive rocks in the area
Metamorphism	Metamorphic history, grades,
MineralAssemblage	Metamorphic mineral assemblages; index minerals
Deformation	Deformation history
AlterationRocks	General alteration in the area, alteration in host rocks and in wall rocks

FIELD	DESCRIPTION
AlterationRadMin	Alteration of radioactive minerals

Table: GEOPHYSGEOCHEM

FinU_ID	
RadiometricResponse	Response on radiometric survey, including Rn
MagneticResponse	Response on magnetic survey
EMResponse	Response on electromagnetic survey
OtherGeophysics	e. g. Gravimetric survey, seismic sounding
GlacigenicDispersion	Distribution of ore material in till and as glacial erratics
Geochemistry	Response on geochemical methods

Table: LITERATURE

Lit_ID	
DepositName	As in Table: Deposits
FinU_ID	
Ref_ID	
EntryCode	Reference number in a list for a single deposit in database

Table: ENVIRONMENT

FinU_ID	
PopulationCentre	Distance to nearest population centre, if any
ProtectionAreas	Distance to and type of environmentally protected areas
Watersheds	Watersheds near the deposit
RadHazards	Possible radioactive hazards caused by the deposit
GeochemHazards	Possible geochemical hazards caused by the deposit
Restoration	Restoration and decommissioning operations

Table: REFERENCE

Ref_ID	
Reference	References to publications and unpublished reports and sources

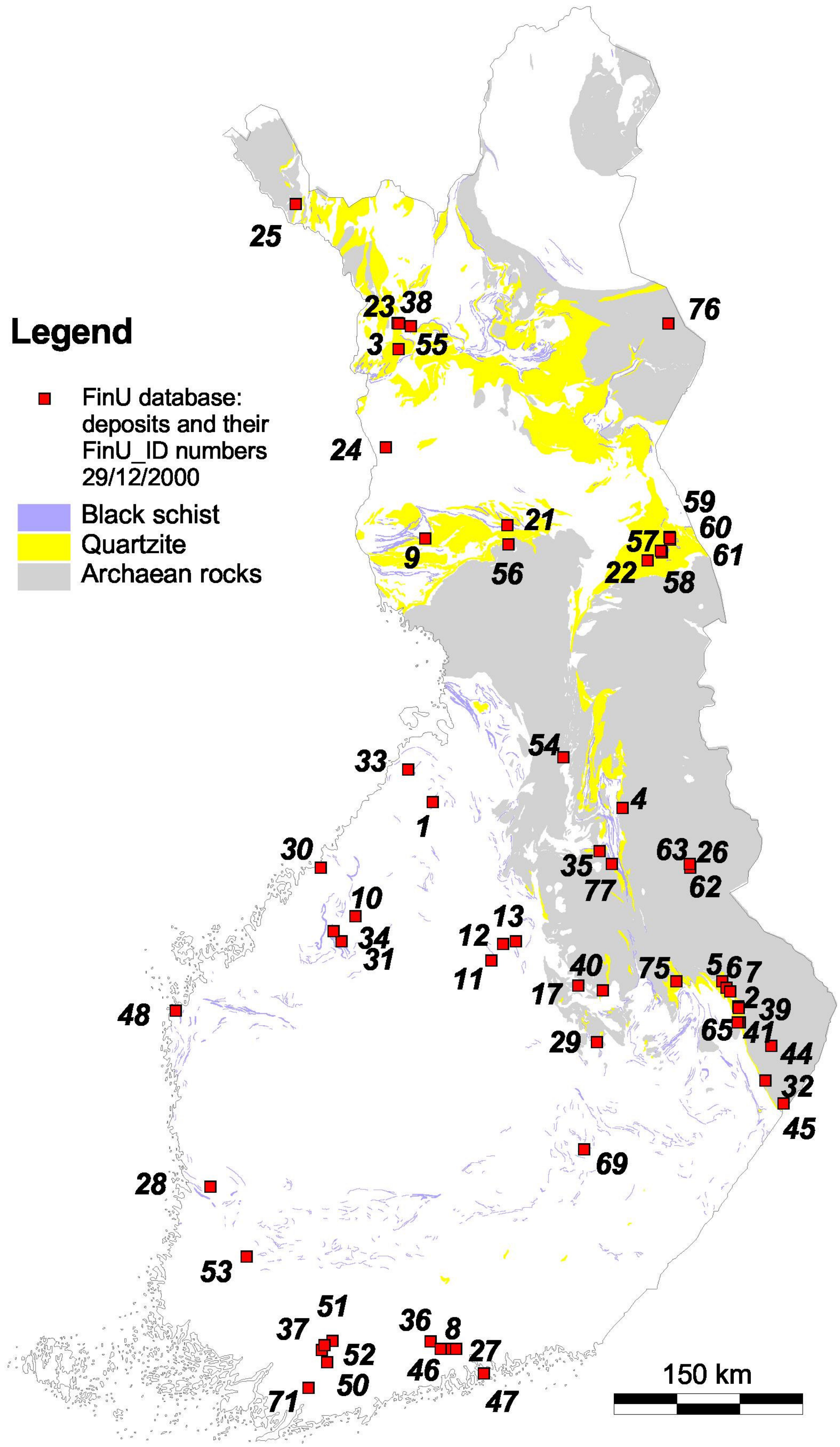
Appendix 4 – List and map of deposits and occurrences in the FinU database

FinU ID	MALMI-KANTA ID	Name	Type (Tentative model)	Page in App. 5	Map Sheet	X Coord. (KKJ)	Y Coord. (KKJ)	Municipality
1	145	Vihanti-U	Phosphorite	1	2434 05 D	7145700	2555420	Vihanti
2	255	Paukkajanvaara	Unconformity?	6	4331 01 A	6980500	4501000	Eno
3	274	Kesänkitunturi	Sandstone	10	2732 05 A	7503500	2511250	Kolari
4	275	Nuottijärvi	Phosphorite	14	3434 08 A	7141800	3561400	Paltamo
5	276	Ipatti	Sandstone	18	4313 09 C	7001000	4489400	Lieksa
6	277	Martinmonttu	Sandstone	21	4313 11 B	6996000	4492500	Lieksa
7	278	Hermanni-2	Sandstone	24	4313 11 C	6993220	4494930	Kontiolahti
8	279	Lakeakallio	Intrusive/sheared	27	3022 01 A	6712280	3423920	Askola
9	280	Mustamaa	Phosphorite	31	2631 11 C	7354240	2539530	Tervola
10	296	Köyhäjoki	Volcanic?	34	2323 11 C	7052500	2498500	Kaustinen
11	304	Lemmetty	Intrusive	37	3312 11 C	7020760	3457360	Keitele
12	308	Pyylehto	Intrusive/migmatite	41	3314 03 C	7034000	3466500	Pielavesi
13	309	Savijärvi	Phosphorite	44	3314 06 D	7036000	3477000	Pielavesi
17	313	Toso	Phosphorite	48	3331 09 C	7001000	3526260	Siilinjärvi
21	347	Ranta-Tulkkivaara	Phosphorite	52	3613 06 B	7366410	3470100	Rovaniemen Mlk
22	351	Kouvervaara-U	Sandstone	55	4522 09 D	7337500	4445750	Kuusamo
23	377	Laavivuoma	Vein?	59	2741 01 C	7524220	2509100	Kittilä
24	394	Orajärvi #	Intrusive	63	2641 03 D	7424950	2504800	Pello
25	395	Palkiskuru	Metasomatite?	66	1834 01 C	7613570	1546250	Enontekiö
26	439	Kapusta	Intrusive/migmatite	69	4324 03 C	7093200	4468220	Kuhmo
27	463	Särkijärvi	Intrusive/sheared??	73	3022 01 C	6712430	3429330	Askola
28	527	Harjakangas	Phosphorite	76	1144 04 A	6831500	1552600	Noormarkku
29	532	Puutosmäki	Unconformity?	80	3244 01 B	6955790	3541170	Vehmersalmi
30	533	Ruotsalo	Phosphorite	84	2324 02 C	7089530	2469080	Kälviä
31	535	Isokylä	Phosphorite	88	2314 09 C	7031800	2488400	Veteli
32	537	Eronlampi	Intrusive/migmatite	91	4241 04 C	6921000	4519800	Kiihtelysvaara
33	539	Ylipää-S *	Phosphorite	94	2441 11 A	7170450	2534600	Pattijoki
34	540	Manderbacka	Phosphorite	97	2314 09 B	7039795	2481400	Kruunupyy
35	555	Losonvaara	Phosphorite	100	3433 01 B	7107500	3543250	Sotkamo
36	611	Onkimaa	Intrusive/migmatite	104	2044 10 B	6718100	2573600	Mäntsälä
37	614	Palmottu	Intrusive/migmatite	107	2023 09 D	6707350	2487440	Nummi-Pusula
38	662	Pahtavuoma-U	Vein?	111	2741 04 A	7523670	2510490	Kittilä
39	663	Ruunaniemi	Sandstone	116	4242 03 B	6979530	4501220	Eno
40	672	Temo	Phosphorite	119	3333 02 D	6997000	3545800	Nilsiä
41	673	Riutta	Unconformity?	123	4242 02 B	6967960	4501510	Eno
44		Revonkylä-U	Intrusive/migmatite	127	4241 09 D	6948160	4525590	Eno
45		Sääperi #	Conglomerate	130	4232 11 A	6902000	4533600	Värtsilä
46		Luhti	Intrusive?	133	2044 10 C	6712500	2581800	Askola
47		Käldö	Intrusive/sheared??	136	3021 11 A	6692800	3451300	Pernaja
48	253	Korsnäs *	Intrusive/breccia??	139	1242 05 B	6967700	1512400	Korsnäs
50		Kovela #	Intrusive	142	2023 11 B	6697890	2492220	Nummi-Pusula
51		Hyrkkölä	Intrusive	145	2024 10 C	6714900	2495700	Nummi-Pusula

52		Kopila	Intrusive	148	2024 07 C	6711260	2489730	Somero
53		Huittinen	Intrusive	151	2112 01 B	6778500	2424810	Huittinen
54		Puokio	Intrusive	154	3441 06 A	7181960	3514600	Puolanka
55		Aakenusvaara	?	157	2741 07 A	7522180	2520170	Kittilä
56		Kuohunki-U	Intrusive/migmatite	161	3613 05 A	7351000	3470800	Rovaniemen mlk.
57	349	Konttiaho *	Au	165	4611 10 C	7343500	4457800	Kuusamo
58	340	Sivakkaharju *	Au	168	4611 10 C	7344600	4457000	Kuusamo
59	350	Juomasuo *	Au	171	4613 02 B	7355400	4464230	Kuusamo
60	590	Pohjaslampi *	Au	174	4613 02 A	7353400	4464500	Kuusamo
61		Hangaslampi *	Au	177	4613 02 A	7354500	4464400	Kuusamo
62		Hepo	Intrusive/migmatite	180	4324 03 C	7092230	4468120	Kuhmo
63		Löttö	Intrusive/migmatite	184	4324 03 D	7095300	4468040	Kuhmo
65		Matari	Surficial/peat	188	4242 02 B	6968150	4450400	Kontiolahti
69		Näärinki	Phosphorite	191	3231 11 A	6870700	3531200	Juva
71	(210)	Malmberg-U	Vein?	195	2014 06 D	6676770	2478180	Kisko
75	(446)	Petrovaara-U	Volcanic?	198	4311 12 A	7003050	4452900	Juuka
76	281	Sokli #*	Intrusive/surficial	201	4723 04 A	7524000	4471000	Savukoski
77	267	Talvivaara *	Black shale	204	3344 06 B	7099650	3551900	Sotkamo

Thorium occurrence or deposit
* Uranium as possible by-product

Fig. A4/1. Location of the database entries. Geological units from GTK databases based on Arkimaa et al. (2000) and Korsman et al. (1997).


Legend
FinU database: deposits and their FinU_ID numbers 29/12/2000
Black schist
Quartzite
Archaean rocks
150 km
25
23 38
3 55
76
24
59
60
61
21
57
9
56
22
58
54
33
1
4
30
63 26
35
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Appendix 5 - List of FinU database / 29 December 2000

Text (a MS Access Report) as Snapshot file Finu_1_app5.snp

Microsoft Access Snapshot Viewer is needed to open the file; Snapshot viewer (in Finnish!) can be downloaded e.g. from http://officeupdate.microsoft.com/finland/2000/downloaddetails/snapshot_viewer.asp. The program has been copied on the attached disk as well (snpvw90.exe).

Deposit

Name **Vihanti-U**

FinU_ID	1	U- deposit?	☑
ID of Malmikanta	145	U as by-product?	☐
Last updated	8.12.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Phosphorite deposit		
Eon or Era	Palaeoproterozoic		
Geological domain	Svecofennian		
Geological province	Vihanti area of the Savo schist belt		

Location

Map sheet	2434 05 D			
Coordinates	X (KKJ)	7145700	Latitude	64.4055
	Y (KKJ)	2555420	Longitude	25.14557
Municipality	Vihanti			
Village	Lampinsaari			
Nearest town	13 km SE of Vihanti, 80 km S of Oulu			
Access	Paved road & railroad to the deposit. Airport at Oulu.			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	633/, 1107, 2165
Holder of mineral rights	Outokumpu Mining Oy
Previous holders	
Status of development	Mine, closed
Economic evaluation	Outokumpu 1976 [4] No positive economic significance [11]
Red Book class	RAR >130 $/kg U
Mining operations	The Vihanti zinc mine was closed in 1992 [12]. The uranium ore was not mined, but some tunnels were driven through the uraniferous zone in the 1980s. Although mainly separate from the sulphide ore lodes, the uranium deposit is here ranked as 'mine, closed' because of its location within the mined-out sulphide deposit.
Ore (million tonnes; in situ)	2.5
Contained U (tonnes; in situ)	710
% U	0.0284
% Th	
U production (tonnes)	
Best section(s)	In drill core sections from various parts of the deposit 0.06 to 0.15 % U

	and 14.4 to 25.5 % P2O5 in lengths of 0.30 to 1.50 m of core [6]
Extent of mineralisation	Plate-like body, 5-20 m thick, length 1.1 km along strike, plunging 400 m; conformable with the sulphide ore bodies [4]
Lodes	The uraniferous body occurs at the hanging wall part of the sulphide ore deposit, partly interfingering with the sulphide orebodies Hautakangas, Isoaho, and Hautaräme [6].

Exploration

Year of discovery	1974
Discovery	[4]: 1955-56: radiometric studies in the mine; 0.001-0.024 U determined in drill core samples from Zn ore; low gamma radiation levels. 1971: Rn monitoring of the mine air & water; enhanced contents in the hanging wall part of the deposit. 1973-74: radiometric logging & U analyses of drill cores led to the discovery of the uraniferous rocks.
Case history	[12, 13]: Layman sample from pyritic boulder in 1936; discovery of zinc ore by GTK in 1947; production of sulphide ores by Outokumpu from 1954 to 1992. [4]: Since 1973, radiometric logging of drill cores; additional diamond drilling in the mine; explorational tunnel through the mineralised zone; concentration tests; evaluation. Late 1970s: Helsinki University, bacterial leaching tests [5].
Diamond drilling	Massive drilling during the operation of the zinc mine
Drill core availability	GTK/Loppi: over 200 cores from the Vihanti area
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Outokumpu: R. Sarikkola, K. Pelkonen, E. Rauhamäki, O.-P. Isomäki

Ore

Ore minerals	Uraninite, uraniferous apatite [6]
Accessory ore minerals	Non-homogeneous U-Pb and U-Ti minerals, uranium thucolite [6] Pyrite, pyrrhotite, chalcopyrite, sphalerite, galena [6]
Gangue	Calc-silicates, carbonate, quartz, plagioclase [6]
Composition of minerals	Fluorapatite with up to 0.126 % U [6]; apatite concentrates with 650 and 440 ppm U contained 0.5 and 4.5 ppm Th, respectively [17]
Texture and fabrics of ore	Subhedral uraninite, grain size 0.005 mm. Apatite grain size 0.01 to 0.05 mm [6].
Composition of ore	Two main types of uranium ore: phosphorite-banded dolomite and phosphatic (apatite-bearing) quartz-plagioclase gneiss [4, 6]

U/Th	750
Enriched elements	U, P
Stable isotopes	
Pb isotopes	Whole rock date: 1876+-2 Ma [7]

Geology

Geological setting	The Vihanti VHMS-deposit within the Raahe-Ladoga Zone, a collisional boundary zone between the Archaean continent and Svecofennian litosphere [13].
Host lithology	Phosphatic "Lampinsaari-type" rocks: calc-silicate rocks ("skarn"), dolomite, and felsic volcanic rocks that show phosphorite interbeds and apatite impregnation [4, 6, 13].
Intrusions	Alpua gabbro at 1901+-12 Ma [10].

Metamorphism/Deformation/Alteration

Metamorphic history	Amphibolite facies regional metamorphism [3]
Metamorphic index minerals	Garnet is common in the metasediments; andalusite, sillimanite, cordierite, staurolite and orthoamphibole occur in the Orijärvi area 5 km NW of Malmberg [3].
Deformation history	Folded & faulted.
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	The tailings area of the mine may contain radioactive rock mixed with the sulphide ore that was mined in the early years of the mine from the upper parts of the deposit [20].
Geochemical hazards	
Restoration	

Conclusions

Timing	Whole rock dating indicates metamorphism about 1880 Ma ago; deposition of uranium took place no more than 100 Ma before metamorphism [6, 7].
Genetic reasoning	
Tentative FinU model	Metamorphic phosphorite

References

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Deposit

Name **Paukkajanvaara**

FinU_ID	2
ID of Malmikanta	255
Last updated	
Link to Fingold	
Red Book geologic setting	Unconformity-related deposit or sandstone deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Koli area

U- deposit? ☑

U as by-product? ☐

Th- deposit? ☐

Location

Map sheet	4331 01 A			
Coordinates	X (KKJ)	6980500	Latitude	62.92815
	Y (KKJ)	4501000	Longitude	30.01649
Municipality	Eno			
Village	Hutunvaara			
Nearest town	Joensuu			
Access	Airport at Joensuu. Distance to main road 1.5 km, gravel road to the deposit.			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	1247/1A
Holder of mineral rights	Open for acquisition
Previous holders	Atomienergia Oy 1958-1973
Status of development	Mine, closed
Economic evaluation	
Red Book class	
Mining operations	[2]: Experiments with open pit mining (Mårtensson & Kunnansuo) and hand sorting pilot plant in 1958; underground mining (Mårtensson) and operation of adic leaching -- neutralising precipitation plant 1959-1961. Mårtensson orebody was exhausted 1961. Mining by Atomienergia (MTI statistics): total ore output 40325 tonnes, 1958-1961 annual grade 0.1-0.2 % U.
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.14
% Th	
U production (tonnes)	30

Best section(s)	
Extent of mineralisation	
Lodes	Mårtensson orebody: length 125 m, width 3 m, height 20 m. Smaller Kunnansuo orebody 180 m E of Mårtensson. Non-economic mineralisation known as "Kunnansuo vein" S of Kunnansuo orebody is composed of a set of pitchblende veins in metadiabase.

Exploration

Year of discovery	1958
Discovery	Layman specimen sent to Atomienergia Oy in 1957. Discovery of Mårtensson orebody by Atomienergia in 1958 [1].
Case history	Atomienergia: 1957-60 ground radiometrics, trenching, diamond drilling, pilot plant mining Outokumpu: 1960-62: diamond drilling at targets south of Paukkajanvaara
Diamond drilling	Atomienergia: drilling started 1958
Drill core availability	GTK/Loppi: 19 drill cores from the area
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Atomienergia: H. Wennervirta, M. Tyni, J. Saastamoinen. Outokumpu: A. Huhma

Ore

Ore minerals	Pitchblende, uranophane [5]
Accessory ore minerals	Coffinite [13]: (Kunnansuo vein) coffinite, brannerite, gummite
Gangue	Quartz, sericite
Composition of minerals	Kunnansuo vein: [13, p. 35]
Texture and fabrics of ore	
Composition of ore	
U/Th	
Enriched elements	U
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Basal units of the Herajärvi Group clastics: Koli Fm. quartzite and

	conglomerate, separated from the Archaean basement gneisses by sericite-quartz schist of the Hokkalampi paleosol [16]. The metasediments and their basement are cut by two sets of mafic sheets and intrusions ("metabasites"; metadiabase dykes), karjalites (about 2.2 Ga) and tholeiites (2.1-1.97 Ga).
Host lithology	Mårtensson & Kunnansuo orebodies: gently dipping units of quartz-pebble conglomerate and quartzite where these are cut by a vertical dyke of metadiabase ("ore diabase"). The mineralisation continues along the diabase contact down to the sericite-quartz schist unit and, in a lesser amount, into the basement [6]. Kunnansuo vein: alteration zones in mafic dyke ("karjalite") [13].
Intrusions	Mafic sills and dykes, both of the two sets are present [12, 13].

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration	Environmental monitoring by STUK [14, 15, 17]. Restoration in 1993: 1.5 km2 treated, Mårtensson shaft and pit covered with blasted wall rock and soil, tailings areas and waste rock piles covered with soil up to 2 m thick.

Conclusions

Timing

Genetic reasoning

Tentative FinU model	Palaeoproterozoic unconformity-related deposit or epigenetic sandstone deposit

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Deposit

Name **Kesänkitunturi**

FinU_ID	3
ID of Malmikanta	274
Last updated	28.12.2000
Link to Fingold	
Red Book geologic setting	Sandstone deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kittilä greenstone area of the Central Lapland Greenstone Belt

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	2732 05 A
Coordinates	X (KKJ) 7503500 Latitude 67.61852
	Y (KKJ) 2511250 Longitude 24.26038
Municipality	Kolari
Village	
Nearest town	40 km NE of Kolari, 5 km ENE from Äkäslompolo
Access	Paved road at Äkäslompolo, 3 km walk uphill along touristic paths

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	1985/1a
Holder of mineral rights	Outokumpu Mining Oy 1977-2000 (?)
Previous holders	
Status of development	Drilled prospect
Economic evaluation	Outokumpu 1973, based on diamond drilling
Red Book class	RAR >130 $/kg U
Mining operations	
Ore (million tonnes; in situ)	1.45
Contained U (tonnes; in situ)	950
% U	0.065
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	Stratabound mineralisation, a few hundred metres long; 3 km S at Kellostapuli Outokumpu found radioactive boulders and outcrops of the same type of mineralisation [3, 4].
Lodes	Two zones about 200 m apart, with nearly vertical lenticular bodies of

	U + Cu. These lenses are mostly a few tens of metres long, but may reach lengths up to 100-150 m. The thicknesses of the lenses are usually 3-6 m, but may be up to 15-20 m [4].

Exploration

Year of discovery	1965
Discovery	Regional indications of uraniferous boulders in 1965 by Outokumpu
Case history	Outokumpu 1965-1974: regional radiometric survey of quartzite areas: discovery of local radiometric boulder fields on the SW slopes of Kesänkitunturi. Radiometric ground survey; IP measurement; regional water and stream sediment geochemistry; percussion drilling; diamond drilling. Aeroradiometric test survey. Helsinki University 1978-79: tests on bacterial leaching of uranium ores [5].
Diamond drilling	Outokumpu: 45 drill holes 1969-71
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	No outcrops; gamma radiation response from local ore boulders; aeroradiometric tests [1, 3]
Magnetic Response	
Electromagnetic response	IP measurement succeeded to show the sulphide-bearing zones that include the uraniferous lenses [1]
Other geophysics	Radiometric bore hole logging systematically. Rn survey from water samples in the area
Glacigenic dispersion	Local boulder fields on the slopes of the hill
Geochemical dispersion	
Geologist(s)	Outokumpu: A. Huhma, R. Sarikkola

Ore

Ore minerals	Uraninite
Accessory ore minerals	Chalcopyrite, pyrite
Gangue	Quartz, sericite, biotite
Composition of minerals	
Texture and fabrics of ore	Stratiform dissemination of uraninite: dust-like fine-grained uraninite in the matrix between the quartz clasts [4, 5].
Composition of ore	2.2 m drill core section [5]: 0.17 % U, 0.20 % Cu, 91.20 % SiO2, 0.13 % TiO2, 4.32 % Al2O3, 0.85 % Fe2O3, 0.29 % FeO, 0.02 % Mn, 0.49 % MgO, 0.06 % CaO, 0.03 % Na2O, 1.21 % K2O, 0.07 % P2O5, 0.14 % CO2, 1.02 % H2O+, 0.13 % H2O-, 0.42 % S. There is no thorium in the deposit [3].
U/Th	
Enriched elements	U, Cu
Stable isotopes	
Pb isotopes	Uraniferous V-Fe-oxide 1747+-5 Ma [10]

Geology

Geological setting	Ylläs Formation quartzites of the Lainio Group metasediments and metavolcanics [8, 9]. The Lainio Group rests disconformably on top of older Proterozoic schists and is discordantly overlain by younger clastics of the Kumpu Group [8].
Host lithology	Sericite quartzite [2, 8]
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	Deformation of the Lainio Group supracrustal rocks during the main phase of the Svecokarelian orogeny [8].
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	5 km from the Äkäslompolo village, 5 km from the Yllästunturi ski slopes
Protection areas	The deposit is located above tree line on a gently sloping fell in a touristic scenery [4, 6]. The area belongs to the Natura programme as part of the "Ylläs-Aakenus" protection area (http://www.vyh.fi/luosuo/n2000/lap/kittila.htm).
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	Dates from the same Group - underlying intermediate volcanics (Latvavuoma Formation): 1883+-5 Ma; granite pebble in conglomerate, Ylläs Formation: 1888+-16 Ma [8].
Genetic reasoning	
Tentative FinU model	Palaeoproterozoic sandstone deposit

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Deposit

Name **Nuottijärvi**

FinU_ID	4
ID of Malmikanta	275
Last updated	
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeproterozoic
Geological domain	Karelian
Geological province	Kainuu schist belt

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	3434 08 A
Coordinates	X (KKJ) 7141800 Latitude 64.36959
	Y (KKJ) 3561400 Longitude 28.26812
Municipality	Paltamo
Village	Härmänmäki
Nearest town	38 km NE of Kajaani
Access	Gravel road to the deposit, distance from paved road 4 km; distance from railroad 1.2 km. Airport at Kajaani.

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	2131/1a
Holder of mineral rights	Outokumpu Mining Oy
Previous holders	
Status of development	Drilled prospect
Economic evaluation	Evaluation in 1969 by Outokumpu
Red Book class	
Mining operations	Concentration tests by movable plant 1965
Ore (million tonnes; in situ)	2.50
Contained U (tonnes; in situ)	1000
% U	0.04
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	At Nuottijärvi limited to the orebody; further (but smaller) mineralisations have been found in the area.
Lodes	A wedge-shaped body petering out to the depth of 150 m; the surface

	section is 400 m long and up to 90 m wide; the orebody dips to the west at the angle of 45 degrees.

Exploration

Year of discovery	1959
Discovery	Systematic radiometric survey of quartzite belts: discovery of the Nuottijärvi outcrop by Outokumpu.
Case history	1959-1960: geological mapping, ground radiometrics, Rn survey. 1962: diamond drilling started - discovery of anomalous P contents. 1963-64: airborne & ground geophysics. 1965: on-site concentration tests (867 tonnes of ore treated) 1969: diamond drilling.
Diamond drilling	1959-65: 20 drill holes, 1969: 23 drill holes
Drill core availability	GTK/Loppi: 42 drill cores from the area
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	The low-thorium Nuottijärvi ore has been used in building calibration pads for gamma spectrometers.
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Outokumpu: A. Huhma, R. Sarikkola

Ore

Ore minerals	Uraninite, uraniferous apatite
Accessory ore minerals	Thucolite Pyrrhotite, sphalerite, galena
Gangue	Quartz, carbonate, tremolite, feldspar, phlogopite, scapolite, Ba-feldspar, sphene
Composition of minerals	[8]: 1200 ppm U & 1.7 ppm Th and 710 ppm U & 2.4 ppm Th in apatite concentrates
Texture and fabrics of ore	Multiple breccia (collapse breccia?). Uraninite (< 5 microns) occurs as separate grains and as inclusions in sphene, apatite, sulphides, and carbon ("thucholite").
Composition of ore	
U/Th	
Enriched elements	U, P, Ba, Ti
Stable isotopes	
Pb isotopes	From uranium thucolite: 1897+-7 Ma [3]

Geology

Geological setting	The Nuottijärvi deposit is located between Upper Kalevian mica schists and Jatulian quartzites within turbiditic mica gneisses of the Lower

	Kalevian unit [9]. Hanging wall rock: graphite-bearing monotonous mica schist, separated by a shear zone from a thin unit of (turbiditic) mica gneiss, followed by the host breccia. On the footwall side the breccia is followed by turbiditic mica gneiss, with garnet- and garnet+amphibole-bearing interbeds; the mica gneiss is followed by a grey quartzite (biotite-bearing).
Host lithology	Phosphatic feldspar-phlogopite rock; carbonate rock, tremolite rock; cherty quartzite in a multiple breccia (interpreted as a collapse breccia) [1, 2].
Intrusions	Metadiabase dykes cut across the Jatulian quartzite in the area

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre	
Protection areas	
Watersheds	Outcrop (and the test pit area) within 50 m of a creek and 150 m from the shore of lake Nuottijärvi. The southern end of the orebody continues (unexposed) under the NW corner of the lake.
Radioactive hazards	
Geochemical hazards	
Restoration	No restoration has been done in the test pit area [11].

Conclusions

Timing	Deposition of the phosphatic host unit 1900-2080 Ma ago [3].
Genetic reasoning	
Tentative FinU model	Metamorphic phosphorite

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11 Anon. 1999. Finland. In: Environmental activities in uranium mining and milling. Paris: OECD, 88-89.

Deposit

Name **Ipatti**

FinU_ID	5
ID of Malmikanta	276
Last updated	
Link to Fingold	
Red Book geologic setting	Sandstone deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Koli area

U- deposit? ☑

U as by-product? ☐

Th- deposit? ☐

Location

Map sheet	4313 09 C
Coordinates	X (KKJ) 7001000 Latitude 63.11191
	Y (KKJ) 4489400 Longitude 29.7868
Municipality	Lieksa
Village	Koli
Nearest town	67 km N of Joensuu, 28 km SW of Lieksa
Access	Airport at Joensuu. Distance to paved road 0.5 km. Connection to Lieksa by ferry (winter road on ice).

Resources/Mining

Reservation	
Exploration license number	2220/1, 3009/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Outokumpu Oy 1970-75, 1979-1984
Status of development	Drilled prospect
Economic evaluation	Outokumpu: R. Sarikkola 1970
Red Book class	RAR >130 $/kg U
Mining operations	
Ore (million tonnes; in situ)	0.071
Contained U (tonnes; in situ)	59
% U	0.083
% Th	
U production (tonnes)	
Best section(s)	DH 17: 0.75 m / 0.242 % U
Extent of mineralisation	Non-uniform surface section 1-5 m by 200 m
Lodes	One steeply dipping, curved ("sabre-like") body

Exploration

Year of discovery	1969
Discovery	Ground radiometrics: boulder tracing
Case history	Outokumpu 1969-79: Radiometric boulder tracing & mapping; geological mapping; ground magnetic survey; percussion drilling (lithogeochemistry); trenching; diamond drilling. GTK 1983: detailed geological mapping; lithogeochemistry (IAEA working group on uranium geology contribution).
Diamond drilling	19 drill holes 1969-1970
Drill core availability	GTK, Loppi: all cores
ElementsAnalysed	
Radiometric response	Outokumpu: detailed radiometric survey (boulders, outcrops & trenches), good response. GTK: airborne radiometric survey; no response on aeroradiometric maps.
Magnetic Response	Outcrop scale: magnetite dissemination in the uraniferous body.
Electromagnetic response	
Other geophysics	Detailed Rn survey. Radiometric drill hole logging.
Glacigenic dispersion	0.7 km long, narrow boulder fan from the exposure towards SE.
Geochemical dispersion	
Geologist(s)	Outokumpu: R. Sarikkola GTK: O. Äikäs

Ore

Ore minerals	Pitchblende
Accessory ore minerals	Uranophane
Gangue	Quartz, sericite, feldspar
Composition of minerals	Pitchblende, uranophane; magnetite - microprobe data in [3]
Texture and fabrics of ore	
Composition of ore	
U/Th	35
Enriched elements	U, Fe
Stable isotopes	
Pb isotopes	

Geology

Geological setting	The host unit is the Arkosite Member of the Jero Formation in the Palaeoproterozoic pile of the Herajärvi Group metasediments [1].
Host lithology	Channel-fill conglomerate and grit unit in a sequence of arkosic to subarkosic fluvial sediments, with interbeds of mudstone. The conglomerate pebbles are dominantly quartz, with minor feldspar and rare magnetite and tourmaline-quartz rock.
Intrusions	Mafic dykes cut the metasedimentary sequence regionally.

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	Secondary uranium minerals in joints and cracks within the mineralised beds [3]

Environment

Population centre	Distance from the Koli villageis less than 0.5 km
Protection areas	Distance to the border of the Koli National Park is less than 0.5 km
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Palaeoproterozoic sandstone deposit

References

1 Kohonen, J. & Marmo, J. 1992. Proterozoic lithostratigraphy and sedimentation of Sariola and Jatuli-type rocks in the Nunnanlahti-Koli-Kaltimo area, eastern Finland: implications for regional basin evolution models. Geological Survey of Finland, Bulletin 364. 67 p

2 Marmo, J., Kohonen, J., Sarapää, O. & Äikäs, O. 1988. Sedimentology and stratigraphy of the lower Proterozoic Sariola and Jatuli Groups in the Koli-Kaltimo Area, eastern Finland. Geological Survey of Finland, Special Paper 5, 11-28.

3 Äikäs, O. & Sarikkola, R. 1987. Uranium in lower Proterozoic conglomerates of the Koli area, eastern Finland. IAEA TECDOC 315, 189-234.

4 Äikäs, O. 1989. Ipatin uraaniesiintymän tutkimukset Kolilla 1983-84. Geological Survey of Finland, unpublished report M19/4313/-89/1/60. 18 p. (in Finnish)

5 Piirainen, T., Honkamo, M. & Rossi, S. 1974. A preliminary report on the geology of the Koli area. Bulletin of the Geological Society of Finland 46, 161-166.

6 Anon. 1982. IUREP (International Uranium Resources Evaluation Project) Orientation Phase mission. Summary Report: Finland. Paris: OECD Nuclear Energy Agency. 24 p.

7 Anon. 1981. IUREP (International Uranium Resources Evaluation Project) orientation phase mission report: Finland. OECD Nuclear Energy Agency. 104 p.

Deposit

Name **Martinmonttu**

FinU_ID	6
ID of Malmikanta	277
Last updated	
Link to Fingold	
Red Book geologic setting	Sandstone deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Koli area

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	4313 11 B
Coordinates	X (KKJ) 6996000 Latitude 63.06713
	Y (KKJ) 4492500 Longitude 29.84844
Municipality	Lieksa
Village	Koli
Nearest town	Joensuu
Access	Gravel road from Koli, distance from the road 100 m

Resources/Mining

Reservation	
Exploration license number	1274/1-24
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Atomienergia Oy
Status of development	Drilled prospect
Economic evaluation	
Red Book class	RAR >130 $/kg U
Mining operations	Test pit: some concentration tests were made at the Paukkajanvaara pilot plant by Atomienergia.
Ore (million tonnes; in situ)	0.02
Contained U (tonnes; in situ)	20
% U	0.10
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	Length along the strike of foliation & bedding 100 m [2]. One of the two non-economic bodies along the uraniferous horizon at the Herajärvi isthmus.

Lodes	Lenticular pocket with gradual margins, long axis parallels the strike of foliation. Rich ore in the core of the pocket as a conformable plate [2].

Exploration

Year of discovery	
Discovery	Found in the 1950s (1958?) during the ground radiometric survey of the Koli quartzite belt.
Case history	Atomienergia: radiometric boulder tracing & ground radiometric survey; geological mapping; trenching; diamond drilling. Outokumpu: diamond drilling 1961.
Diamond drilling	Atomienergia: 14 drill holes 1959
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	Many of the small mineralisations of the Herajärvi isthmus were found by Rn emanometry [6].
Magnetic Response	
Electromagnetic response	
Other geophysics	Atomienergia & Outokumpu: radiometric drill hole logging
Glacigenic dispersion	Over 2000 radioactive boulders along the Herajärvi isthmus [2, 3], probably forming several overlapping boulder fans.
Geochemical dispersion	
Geologist(s)	Atomienergia: H. Wennervirta Outokumpu: A. Huhma

Ore

Ore minerals	Pitchblende
Accessory ore minerals	
Gangue	Quartz
Composition of minerals	
Texture and fabrics of ore	Fine-grained mass of pitchblende and goethite cementing rounded quartz clasts [2, 3, 4]. Hematite as pseudomorphs after magnetite.
Composition of ore	
U/Th	
Enriched elements	U, Fe
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Quartzite Mb of the Koli Fm in the Jatulian Herajärvi Group metasediments [1]
Host lithology	Hematite-stained quartzite with interbedded thin quartz-pebble conglomerate pockets

Intrusions	Possible unexposed dyke of metadiabase west of the deposit

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre	
Protection areas	The deposit belongs to the Koli National park.
Watersheds	
Radioactive hazards	Radioactive springs at the base of the slope [6].
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Palaeoproterozoic sandstone deposit

References

1 Kohonen, J. & Marmo, J. 1992. Proterozoic lithostratigraphy and sedimentation of Sariola and Jatuli-type rocks in the Nunnanlahti-Koli-Kaltimo area, eastern Finland: implications for regional basin evolution models. Geological Survey of Finland, Bulletin 364. 67 p

2 Piirainen, T. 1963. Kolin jakson uraanimalmeista tunnettujen uraaniesiintymien valossa. Manuscript. Univ. Helsinki, Geol. Min. Inst. (in Finnish)

3 Piirainen, T. 1968. Die Petrologie und die Uranlagerstätten des Koli-Kaltimogebiets im finnischen Nordkarelien. Bull. Comm. Géol. Finlande, n:o 237, 99 p.

4 Äikäs, O. & Sarikkola, R. 1987. Uranium in lower Proterozoic conglomerates of the Koli area, eastern Finland. IAEA TECDOC 315, 189-234.

5 Marmo, J., Kohonen, J., Sarapää, O. & Äikäs, O. 1988. Sedimentology and stratigraphy of the lower Proterozoic Sariola and Jatuli Groups in the Koli-Kaltimo Area, eastern Finland. Geological Survey of Finland, Special Paper 5, 11-28.

6 Wennervirta, H. 1968. Application of geochemical methods to regional prospecting in Finland. Bull. Comm. géol. Finlande 234, p. 1-91.

Deposit

Name **Hermanni-2**

FinU_ID	7
ID of Malmikanta	278
Last updated	8.12.2000
Link to Fingold	
Red Book geologic setting	Sandstone deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Koli area

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	4313 11 C
Coordinates	X (KKJ) 6993220 Latitude 63.04224
	Y (KKJ) 4494930 Longitude 29.8966
Municipality	Kontiolahti
Village	Kotaniemi
Nearest town	Joensuu
Access	Gravel road 9 km from Koli; distance from road 150 m

Resources/Mining

Reservation	
Exploration license number	1274/1-24
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Atomienergia Oy 1958-
Status of development	Drilled prospect
Economic evaluation	
Red Book class	RAR >130 $/kg U
Mining operations	Test pit: concentration test at the Paukkajanvaara pilot plant by Atomienergia.
Ore (million tonnes; in situ)	0.02
Contained U (tonnes; in situ)	16
% U	0.08
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	100 m along the strike of foliation & bedding [2, 4]. One of the two non-economic bodies along the uraniferous horizon at the Herajärvi isthmus.

Lodes	Lenticular pocket with gradual margins, long axis parallels the strike of foliation. Rich ore in the core of the pocket as a conformable plate [2].

Exploration

Year of discovery	
Discovery	Found in the 1950s (1958?) during the ground radiometric survey of the Koli quartzite belt.
Case history	Atomienergia: radiometric boulder tracing & ground radiometric survey; geological mapping; trenching; diamond drilling. Test pit, ore dressing tests at the Paukkajanvaara mine [2, 3, 6, 7]. Outokumpu. diamond drilling in the 1960s.
Diamond drilling	Atomienergia: 14 drill holes 1959
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Over 2000 radioactive boulders along the Herajärvi isthmus [2, 3], probably forming several overlapping boulder fans.
Geochemical dispersion	
Geologist(s)	

Ore

Ore minerals	Pitchblende
Accessory ore minerals	Hematite
Gangue	Quartz
Composition of minerals	
Texture and fabrics of ore	Fine-grained mass of pitchblende and goethite cementing rounded quartz clasts [2, 3, 4]
Composition of ore	
U/Th	168
Enriched elements	U, Fe
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Quartzite Mb of the Koli Fm in the Jatulian Herajärvi Group metasediments [1]
Host lithology	Hematite-stained quartzite with interbedded thin quartz-pebble conglomerate pockets
Intrusions	Possible unexposed dyke of metadiabase west of the deposit

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas 3 km SE off the limit of the Koli National Park.

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Palaeoproterozoic sandstone deposit

References

0 Anon. 1999. Finland. In: Environmental activities in uranium mining and milling. Paris: OECD, 88-89.

1 Kohonen, J. & Marmo, J. 1992. Proterozoic lithostratigraphy and sedimentation of Sariola and Jatuli-type rocks in the Nunnanlahti-Koli-Kaltimo area, eastern Finland: implications for regional basin evolution models. Geological Survey of Finland, Bulletin 364. 67 p

2 Piirainen, T. 1963. Kolin jakson uraanimalmeista tunnettujen uraaniesiintymien valossa. Manuscript. Univ. Helsinki, Geol. Min. Inst. (in Finnish)

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4 Äikäs, O. & Sarikkola, R. 1987. Uranium in lower Proterozoic conglomerates of the Koli area, eastern Finland. IAEA TECDOC 315, 189-234.

5 Marmo, J., Kohonen, J., Sarapää, O. & Äikäs, O. 1988. Sedimentology and stratigraphy of the lower Proterozoic Sariola and Jatuli Groups in the Koli-Kaltimo Area, eastern Finland. Geological Survey of Finland, Special Paper 5, 11-28.

6 Räisänen, K. 1961. Atomienergia Oy:n toimesta suoritetut uraanimalmien louhinta- ja rikastuskokeilut vv. 1958--1961. With an English summary. Vuoriteollisuus 19, 34-43.

7 Wennervirta, H. 1968. Application of geochemical methods to regional prospecting in Finland. Bull. Comm. géol. Finlande 234, p. 1-91.

Deposit

Name **Lakeakallio**

FinU_ID	8
ID of Malmikanta	279
Last updated	
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Granite migmatite belt of southern Finland

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	3022 01 A
Coordinates	X (KKJ) 6712280 Latitude 60.51403 Y (KKJ) 3423920 Longitude 25.61187
Municipality	Askola
Village	Vakkola
Nearest town	17 km N of Porvoo
Access	300 m from main road, dirt roads to the area

Resources/Mining

Reservation	
Exploration license number	1167/1-7, 1179/1-2, 1208/1-5, 2389/1, 2885/1
Mining concession number	1255/1a
Holder of mineral rights	Open for acquisition
Previous holders	Imatran Voima Oy 1956-59; mining concession 1958- Outokumpu Oy 1972-73 GTK 1978-80
Status of development	Drilled prospect
Economic evaluation	
Red Book class	
Mining operations	Experimental mining (open pits) by Imatran Voima Oy (MTI statistics): 557 tonnes ore with grades 0.11 and 0.12 % U3O8 in 1958 and 1959.
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.1
% Th	
U production (tonnes)	0.5
Best section(s)	Drill core section by GTK at IVO's test pit: 6 m at 0.1 % U, 0.04 % Th, 0.027 % Mo [4]
Extent of mineralisation	Two IVO test pits 200 m apart, another mineralisation 175 m further to

	ESE
Lodes	Historical test pits Lakeakallio NW and Lakeakallio S; Lakeakallio ESE revealed by GTK in 1979. All three lodes are nest-like enrichments of uranium, with dimensions limited to a few tens of metres. Numerous radioactive erratics S and SE of Lakeakallio suggest presence of similar but unexposed mineralisations in the host zone [4].

Exploration

Year of discovery	1958
Discovery	Carborne & ground radiometric survey in the Askola area by Imatran voima Oy (IVO) since 1957
Case history	IVO 1957-59 (?): radiometric survey; experimental operations with two small pits and concentration tests. Outokumpu 1972: aeroradiometric test survey (joint project with the Ministry of Trade and Industry [1]. GTK 1977: One drill hole connected to the study of the rich "Alho boulders" about 6 km SSE of Lakeakallio [2, 4]. 1978-80: detailed exploration at Lakeakallio in order to find continuations for the historical mineralisation [4].
Diamond drilling	GTK 1977, 1979-80: 23 drill holes
Drill core availability	GTK/Loppi: all GTK drill cores
ElementsAnalysed	
Radiometric response	Before restoration the old workings caused clear gamma anomalies in radiometric surveys (both ground and airborne). Detailed scintillometry at Lakeakallio showed that the granitic neosome veins are slightly radioactive in general [4].
Magnetic Response	Detailed ground magnetics by GTK; a local minimum around the pit Lakeakallio S [4].
Electromagnetic response	VLF profiles revealed shear zones [4]
Other geophysics	
Glacigenic dispersion	S and SE of Lakeakallio radioactive granite erratics with 0.01-0.1 % U and up to 0.25 % Th, often with some molybdenite. The boulders occur in a train 3 km long [4]. Deposits of sand that cover the till blankets cause difficulties for boulder tracing in the area.
Geochemical dispersion	
Geologist(s)	Outokumpu: R. Sarikkola GTK: H. Appelqvist

Ore

Ore minerals	Uraninite [4]
Accessory ore minerals	Monazite, zircon, molybdenite, pyrite [4]
Gangue	Feldspars, quartz, biotite, garnet
Composition of minerals	
Texture and fabrics of ore	The ore minerals occur at grain margins of the gangue and in microcracks of the rock [4]. Uraninite crystals are 0.2 to 0.4 mm in diameter [7].

Composition of ore	
U/Th	2.5
Enriched elements	U, Th, Mo
Stable isotopes	
Pb isotopes	Zircon ca. 1750 Ma, uraninite ca. 600 Ma [4]

Geology

Geological setting	Veined gneiss (migmatite), with mica gneiss and hornblende gneiss as paleosomes, granitic veins as neosomes. This veined gneiss is further intruded by granitic to granodioritic veins [3, 4].
Host lithology	At Lakeakallio S and SE mineralisations the uraniferous rock is a garnet-bearing granite or granodiorite [4]. At Lakeakallio NW there is radioactivity in granite near the contact with amphibolite [3].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	Garnet in host granite. The uranium contents do not have any correlation with the distribution of garnet in the host [4].
Deformation history	
Alteration of rocks	Hematisation in and near shear zones; hematised zeolite (after K-feldspar) in shear zones [4]
Alteration of U/Th minerals	Remobilised uraninite in microcracks radiating from euhedral primary uraninite [4]

Environment

Population centre	New housing area of the municipality is under construction close to Lakeakallio, with the nearest houses about 100 m west of the old pit Lakeakallio NW.
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	Restoration of the historical pits, remnants of concentration plant, and tailings areas done by IVO and STUK (the Radiation and Nuclear Safety Authority) [8].

Conclusions

Timing	Within error limits, the zircon data plot on a chord suggesting original formation at 1835 Ma, representing intrusion of late orogenic Svecofennian pegmatites, and an episodic lead loss in Palaeozoic time (410 Ma). Uraninite is suggested to be syngenetic with the host (late-orogenic Svecofennian granite to granodiorite) and (partly) remobilised at 600 Ma [4, 7].
Genetic reasoning	Supergene enrichment (remobilisation) during Palaeozoic in a sheared Svecofennian uranium mineralisation [7]

References

1 Ketola, M., Piiroinen, E. & Sarikkola, R. 1975. On feasibility of airborne radiometric surveys for uranium exploration in Finland. Tiivistelmä: Aeroradiometristen mittausten käyttömahdollisuuksista uraaninetsinnässä Suomessa. Geological Survey of Finland, Report of Investigation 7. 43 p.

2 Appelqvist, H. & Kinnunen, K. 1977. Raportti geologisen tutkimuslaitoksen uraanitutkimuksista Askolan-Porvoon alueella 1976-1977. 12 p. Geological Survey of Finland, unpublished report M19/3022/77/1/10. (in Finnish)

3 Anon. 1981. IUREP (International Uranium Resources Evaluation Project) orientation phase mission report: Finland. OECD Nuclear Energy Agency. 104 p.

4 Appelqvist, H. 1982. Uraanitutkimukset Askolan Lakeakallion alueella vuosina 1978- 1980. 23 p. Geological Survey of Finland, unpublished report M 19/3022/-82/1/60. (in Finnish)

5 Nieminen, K. & Yliruokanen, I. 1974. Trace element analysis of granitic and radioactive rocks by spark source mass spectrometry with electrical detection. Bulletin of the Geological Society of Finland 46 (2), 167-176.

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7 Vaasjoki, M., Appelqvist, H. & Kinnunen, K. Palaeozoic remobilization and enrichment of Proterozoic uranium mineralization in the East-Uusimaa area, Finland. Geological Survey of Finland. Unpublished manuscript. 20 p.

8 Anon. 1999. Finland. In: Environmental activities in uranium mining and milling. Paris: OECD, 88-89.

Deposit

Name **Mustamaa**

FinU_ID	9
ID of Malmikanta	280
Last updated	
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Peräpohja schist belt

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	2631 11 C
Coordinates	X (KKJ) 7354240 Latitude 66.27786
	Y (KKJ) 2539530 Longitude 24.87618
Municipality	Tervola
Village	Runkaus
Nearest town	60 km SW of Rovaniemi, 30 km N of Tervola
Access	

Resources/Mining

Reservation	
Exploration license number	2936/1, 2965/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Rautaruukki Oy 1978-82
Status of development	Drilled prospect
Economic evaluation	Non-economic because of low grade of uranium and probable difficulties in concentration of this type of ore [3]. Rough estimate of average grade is given in [4].
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.01
% Th	
U production (tonnes)	
Best section(s)	10 cm long pieces of drill core: 0.05-0.1 % U, 4.6-18 % P2O5; averages of sections across the mineralised rock: 0.01-0.03 % U, 0.9-3.4 % P2O5. For example DH 10: 18 m at 0.0283 % U, 2.59 % P2O5 [3].
Extent of mineralisation	The best part of the deposit (intersected by drilling) is about 500 m

	long, 10 to 40 m thick [3].
Lodes	

Exploration

Year of discovery	1979
Discovery	Radioactive boulders found by Rautaruukki Oy during ground follow-up of aeroradiometric gamma anomalies in 1978.
Case history	Airborne geophysics by Rautaruukki; radiometric boulder tracing, geological mapping, magnetic, electromagnetic, VLF and radiometric ground survey, radon measurements of till and ground water, geochemical sampling of till and humus, and lithogeochemical sampling with percussion drilling; all these preceded diamond drilling, which in 1979 led to the discovery of the deposit in bedrock.
Diamond drilling	1979-1980: 13 drill holes (2120 m)
Drill core availability	GTK/Loppi: one core (R13)
ElementsAnalysed	
Radiometric response	Aeroradiometric gamma anomalies caused by clusters of erratics of uraniferous phosphatic rocks
Magnetic Response	Ground magnetic survey…
Electromagnetic response	VLF, Slingram…
Other geophysics	Rn in ground water and till…
Glacigenic dispersion	The radioactive boulders were traced back to their source in bedrock (about 500 m to the west of the boulders) [2].
Geochemical dispersion	
Geologist(s)	Rautaruukki Oy/ Lapin Malmi Oy: A. Hiltunen, E. Korvuo

Ore

Ore minerals	Unidentified dust-like opaque uranium mineral, apatite
Accessory ore minerals	U-Ti mineral (davidite?). Pyrrhotite, pyrite, chalcopyrite, galena, sphalerite
Gangue	Quartz, carbonate, chlorite, albite, sericite, graphite
Composition of minerals	Davidite(?): 52 % UO_2, 22 % TiO_2, 8 % Y_2O_3, 5 % P_2O_5 and 15 % SiO_2 [2]
Texture and fabrics of ore	Phosphorite is the major uraniferous phase; however, all phosphorite bands do not contain uranium. Uranium is thought to occur either in the apatite lattice or in the dust-like opaques.
Composition of ore	
U/Th	
Enriched elements	
Stable isotopes	
Pb isotopes	

Geology

Geological setting	The host unit is composed of quartzites, mafic volcanic rocks and dolomites of the upper part of Jatuli Group, overlain by black schists that alternate with mica schists (metagraywackes) (Kalevian).
Host lithology	Dolomite, mafic tuff, phosphorite, chlorite schist, marl schist, intermediate tuffite, phyllite, mica schist
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	Regional greenschist facies
Metamorphic index minerals	
Deformation history	Tectonic margins between different rock types. Brecciation.
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Metamorphic phosphorite

References

1 Äikäs, O. 1980. Uraanin jakautuminen eräissä Tervolan Mustamaan uraani-fosforiesiintymän näytteissä. 16 p. Geological Survey of Finland, unpublished report M19/2633/80/1/60. (in Finnish)

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3 Airas, K. 1982. Mustamaa 1-2 jatkotutkimukset. Tutkimustyöselostus 080/2631, 2633/EK/82. Unpublished report, Lapin Malmi. 2 p. (in Finnish)

4 Anon. 1981. IUREP (International Uranium Resources Evaluation Project) orientation phase mission report: Finland. OECD Nuclear Energy Agency. 104 p.

Deposit

Name **Köyhäjoki**

FinU_ID	10
ID of Malmikanta	296
Last updated	
Link to Fingold	
Red Book geologic setting	Volcanic deposit?
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Pohjanmaa schist belt

- [x] U- deposit?
- [ ] U as by-product?
- [ ] Th- deposit?

Location

Map sheet	2323 11 C			
Coordinates	X (KKJ)	7052500	Latitude	63.57392
	Y (KKJ)	2498500	Longitude	23.96618
Municipality	Kaustinen			
Village	Köyhäjoki			
Nearest town	15 km E of Kaustinen			
Access	1.5 km gravel road/dirt road from the occurrence to main road			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Drilled prospect
Economic evaluation	
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	About 20 radioactive boulders, the highest give contents of 0.017-0.072 % U, <0.002 % Th.
Extent of mineralisation	Drilling showed enhanced radioactivity only in one core section 0.6 m long.
Lodes	

Exploration

Year of discovery	1976
Discovery	Regional ground radiometric survey by GTK; radioactive boulders located in 1974; uranium in bedrock was found by drilling in 1976.
Case history	Boulder tracing; geological mapping; geophysical survey; Rn emanometry; diamond drilling
Diamond drilling	1976: 6 drill holes (919 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	U, Th (GSP)
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: B. Lindmark

Ore

Ore minerals	
Accessory ore minerals	
Gangue	
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	
U/Th	
Enriched elements	U, Fe
Stable isotopes	
Pb isotopes	

Geology

Geological setting	The occurrence is located at a transitional zone where mafic volcanic rocks in the NE are bordered by metasediments (graywackes) in the SW. The area is poorly exposed, and in drill cores the lithology includes felsic volcanics and conglomerates with arkosic graywackes.
Host lithology	There are two types of uraniferous boulders: quartz porphyry and magnetite-bearing amphibolite. Uranium is said to favour sheared parts in these rocks; the anomalous radioactivity in one of the drill cores also derived from sheared quartz porphyry.
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model	Metamorphic volcanic/sheared?

References

1 Lindmark, B. 1979. Kaustisen Köyhäjoen uraanitutkimukset v. 1974-1976. 19 p. Geological Survey of Finland, unpublished report M19/2323/79/1/10. (in Finnish)

2 Lonka, A. 1971. Kaustinen. Geological Map of Finland 1:100 000, Pre-Quaternary Rocks, sheet 2323. Geological Survey of Finland.

Deposit

Name **Lemmetty**

FinU_ID	11
ID of Malmikanta	304
Last updated	
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Savo schist belt

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	3312 11 C
Coordinates	X (KKJ) 7020760 Latitude 63.28671
	Y (KKJ) 3457360 Longitude 26.14675
Municipality	Keitele
Village	
Nearest town	15 km NW of Keitele, 112 km NW of Kuopio
Access	

Resources/Mining

Reservation	
Exploration license number	3161/1-2
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1980-81
Status of development	Drilled prospect
Economic evaluation	[2] no economic significance (low grade; widely scattered small bodies; no dimensions at depth).
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Pegmatite pods in trenches, e.g. 7.5 m2, average of 11 samples 0.04 % U, 0.003 % Th.
Extent of mineralisation	Uraniferous pegmatites and granitoids occur in a 1 km by 10 km belt striking NW, known as the Kinturi-Lemmetynvuori area.

Lodes

Exploration

Year of discovery	1975
Discovery	First regional indications of radioactivity in granitoids by GTK in 1966. Systematic uranium exploration was started in 1974; layman samples from outcrops in the Lemmetty area were received 1975.
Case history	[1] 1974: ground radiometrics and diamond drilling in the Kinturi area NW of Lemmetty; 1975-76: evaluation of layman samples from Lemmetty; 1977: ground radiometrics in the Lemmetty area. [2] 1980-81: detailed pedogeochemical litogeochemical sampling; geological mapping; trenching; magnetic and electromagnetic ground survey; diamond drilling. [3] 1981-82: ground follow-up of aeroradiometric gamma-anomalies (regionally). R & D in the interpretation of aeroradiometric data [6] and in the study of young uranium in peat [5, 7].
Diamond drilling	GTK 1981: 6 drill holes (315 m) at Lemmetty
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	Radioactive microcracks in pegmatite minerals; enrichment of uranium from ground water into recent peat was found in the area [3].
Geologist(s)	GTK: E. Ekdahl, O. Äikäs

Ore

Ore minerals	Uraninite
Accessory ore minerals	Clarkeite, soddyite, gummite, uranophane; altered allanite, altered sphene. Molybdenite, chalcopyrite, covellite, chalcocite, (radiogenic) galena [3].
Gangue	Quartz, feldspar, biotite, minor apatite
Composition of minerals	ED-spectra by microprobe from uraninite and secondary uranium minerals [3].
Texture and fabrics of ore	Impregnation. Anhedral to subdhedral uraninite, 0.01-0.2 mm in diameter [3].
Composition of ore	
U/Th	
Enriched elements	U, Mo, Cu
Stable isotopes	
Pb isotopes	

Geology

Geological setting

Host lithology — Pegmatite (microcline, plagioclase, quartz, biotite; apatite, rare tourmaline) as pods, veins and dykes, with thicknesses usually no more than 3 m. The dyke swarms tend to be conformable with the wall rock foliation, at the same time parallelling the NW-SE Kinturi shear zone [3].

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals — Alteration of uraninite to secondary uranium minerals (gummite; uranophane) [3]

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model — Intrusive/pegmatite

References

1 Ekdahl, E. 1978. Selostus Kinturissa suoritetuista U-malmitutkimuksista 1974-1977. 5 p. Geological Survey of Finland, unpublished report M60/3312/78/1/10. (in Finnish)

2 Äikäs, O. 1982. Tutkimustyöselostus Keiteleen ja Pihtiputaan kunnissa valtausalueilla Lemmitty 1-2, kaivosrek.no. 3161 suoritetuista malmitutkimuksista. 5 p. Geological Survey of Finland, unpublished report M06/3312/-82/1/60. (in Finnish)

3 Yli-Kyyny, K. 1986. Keiteleen Lemmetyn geologia ja radioaktiiviset pegmatiitit. Unpublished master's thesis, University of Turku, Department of Geology and Mineralogy. 112 p. (in Finnish)

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6 Talvitie, J., Arkimaa, H. M., Äikäs, O. 1988. Interpretation of airborne radiometric data to predict the occurrence of uranium. IAEA TECDOC 472, 239-242.

7 Äikäs, O., Seppänen, H., Yli-Kyyny, K. & Leino, J. 1994. Young uranium deposits in peat, Finland: an orientation study. Geological Survey of Finland. Report of Investigation 124. 21 p.

Deposit

Name **Pyylehto**

FinU_ID	12
ID of Malmikanta	308
Last updated	
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Savo schist belt [5]; Pielavesi area of the Savo schist belt [4]

U- deposit?	☑
U as by-product?	☐
Th- deposit?	☐

Location

Map sheet	3314 03 C			
Coordinates	X (KKJ)	7034000	Latitude	63.40646
	Y (KKJ)	3466500	Longitude	26.32612
Municipality	Pielavesi			
Village	Koivujärvi			
Nearest town	40 km NW of Pielavesi			
Access	Forest road to the area			

Resources/Mining

Reservation	In quarantine after claim reservation expiry in August, 2000.
Exploration license number	
Mining concession number	
Holder of mineral rights	
Previous holders	
Status of development	Mapped prospect
Economic evaluation	No economic value [3]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.02
% Th	
U production (tonnes)	
Best section(s)	Radioactive spots in outcrops contain 0.015-0.10 % U; these spots are sporadic and always less than 10 m by 10 m in size [3].
Extent of mineralisation	At Pyylehto, uraniferous spots are located in the outcrops in an area of 50 m by 300 m; continuations of this mineralisation occur both in the SW and in the NE along the strike within a distance of more than one km. The Teponniemi showings 5-8 km to the NW belong to the same

type [3].

Lodes: Radioactive zones in the outcrops are 1.5 m thick averaging 0.02 % U, with dip of 45-50 degrees to the SE [3].

Exploration

Year of discovery: 1979

Discovery: Carborne spectrometry by GTK during follow-up of aeroradiometric gamma anomalies in the map sheet area 3321 [1-3].

Case history: Outokumpu 1973: ground radiometrics (boulder tracing) in the area based by a layman sample received in 1973 - radioactive boulders and outcrops located at Teponniemi, 5-8 km NW of Pyylehto [2, 3].
GTK 1974: reconnaissance ground radiometrics in the area [3]. 1979-81: carborne spectrometry 1979 - radioactive outcrops at Pyylehto; low-altitude airborne geophysics 1979; detailed geological mapping, spectrometry & percussion drill sampling at Pyylehto; follow-up of gamma anomalies in the area [2, 3].

Diamond drilling

Drill core availability

ElementsAnalysed: By GSP: U, Th; by Rapiduran: U

Radiometric response: Discovery by carborne spectrometry; the SW continuation of the Pyylehto mineralisation causes a clear U channel anomaly on aeroradiometric maps [2, 3].

Magnetic Response

Electromagnetic response

Other geophysics

Glacigenic dispersion

Geochemical dispersion

Geologist(s): Outokumpu: R. Sarikkola
GTK: O. Äikäs

Ore

Ore minerals: Not determined [3]

Accessory ore minerals

Gangue: Biotite, quartz, feldspars [3]

Composition of minerals

Texture and fabrics of ore

Composition of ore: Low thorium content, generally from <0.001 ppm Th to 0.006 % Th [3]

U/Th

Enriched elements: U

Stable isotopes

Pb isotopes

Geology

Geological setting	Migmatitic mica gneiss (Salonsaari Suite of the Pielavesi area), intruded by a body of porphyritic granite in SW-NE direction [4].
Host lithology	Gradational contact zone of the granite in the NW and the migmatitic mica gneiss (veined gneiss) in the SE, cut by pegmatitic granite veins with sharp contacts; uraniferous spots are conformable to the host lithology and typically show a great amount of granitic leucosome material, quartz, and melanosome nests of coarse biotite [3].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	
Genetic reasoning	Enrichment of uranium associated with the granitisation of the metasedimentary gneiss?
Tentative FinU model	Intrusive/migmatite neosome?

References

1 Äikäs, O. 1988. Aeroradiometristen gamma-anomalioiden maastotarkistukset: 3321 Pyhäjärvi. 2 p. Geological Survey of Finland, unpublished report M19/3321/-88/1/60. (in Finnish)

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5 Kousa, J., Luukas, J., Mäki, T., Ekdahl, E., Pelkonen, K., Papunen, H., Isomäki, O.-P., Penttilä, V.-J. & Nurmi, P. 1997. Geology and mineral deposits of the central Ostrobothnia. Geological Survey of Finland. Guide 41, 43-67.

Deposit

Name **Savijärvi**

FinU_ID	13
ID of Malmikanta	309
Last updated	
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Savo schist belt [9]; Pielavesi area of the Savo schist belt [7, 8].

- [x] U- deposit?
- [ ] U as by-product?
- [ ] Th- deposit?

Location

Map sheet	3314 06 D			
Coordinates	X (KKJ)	7036000	Latitude	63.42523
	Y (KKJ)	3477000	Longitude	26.53596
Municipality	Pielavesi			
Village	Laukkala			
Nearest town	23 km NW of Pielavesi			
Access	1.5 km from gravel road, dirt roads to the area			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Drilled prospect
Economic evaluation	No economic value as a uranium or phosphate deposit [2]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.01
% Th	
U production (tonnes)	
Best section(s)	In drill cores, 4 m at 0.016 % U and 2.33 % P2O5. The length of core sections exceeding 0.01 % U varies from 0.3 to 10.2 m [2].
Extent of mineralisation	At Savijärvi, uraniferous showings in bedrock within a distance of one km along the NE trending host lithology [1, 2]. Similar but poorer showings and indications of uraniferous phosphatic rocks in the 20 km by 30 km area of "Pielavesi phosphatic basin" [2-5].

Lodes	Two separate bodies 200 m apart, representing the same mineralised horizon in the sequence. The gap is caused by a fault interpreted to cut across the sequence. The western body is intensely folded [2].

Exploration

Year of discovery	1974
Discovery	Radioactivity was found in dolomite outcrops at Savijärvi by regional ground radiometric reconnaissance of GTK in 1974, based on a layman specimen received by GTK in 1957 from a similar lithology about 8 km to the SW [1].
Case history	1974: geological mapping, ground radiometrics (scintillometry); magnetic, electromagnetic and gamma spectrometric ground survey (12 km2); diamond drilling [1]. 1980: litogeochemistry by percussion drill - anomalous P contents found in radioactive outcrops. Ground scintillometry - new radioactive outcrops discovered; detailed geological mapping, trenching, litogeochemical sampling; diamond drilling [2].
Diamond drilling	GTK 1974 and 1980: six drill holes (1033 m) [1, 2]
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	By GSP: U, Th; by Rapiduran: U; by INAA: U, Th
Radiometric response	Barely distinguishable uranium channel anomaly on low-altitude radiometric maps; careful ground scintillometry revealed the poorly exposed western body [2].
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: E. Ekdahl [1], O. Äikäs [2]

Ore

Ore minerals	Uraninite [2]
Accessory ore minerals	Pyrrhotite, pyrite, molybdenite [2]
Gangue	Apatite, carbonate, diopside, tremolite, phlogopite, graphite, quartz, plagioclase, scapolite [2]
Composition of minerals	
Texture and fabrics of ore	[2]: Subhedral to euhedral uraninite <0.01-0.5 mm in diameter, often with an oval cross section. Uraninite occurs as dissemination of single grains or as clusters of 2-3 grains: as inclusions in apatite, carbonate, and pyrrhotite, sometimes with a graphite or graphite+molybdenite coating. Pyrrhotite, pyrite, and galena have been found to occur in the radioactive halos around uraninite grains.
Composition of ore	Th contents are low in the uraniferous rocks, <10 ppm [1, 2]
U/Th	20
Enriched elements	U, P

Stable isotopes	In pyrrhotite and pyrite negative values and considerable deviation of d34S values [2]. Carbon isotope determinations indicate that the Savijärvi dolomite belongs to the Svecofennian Domain [6].
Pb isotopes	

Geology

Geological setting	A sequence of metasediments and metavolcanics of the age group 1.93-1.91 Ga [9], divided into four suites [7], all of which are present in the overturned 300+ m thick section at Savijärvi: migmatitic mica gneiss; calc-silicate rocks, dolomite, interbeds of metaphosphorite, metachert black schist, and quartz-feldspar gneiss (felsic metavolcanics); migmatitic amphibolite with mica gneiss interbeds (mafic metavolcanics); mafic metalava [1, 2, 7]. Of these, the calcareous Savijärvi Suite is the host for uranium.
Host lithology	Uranium occurs in phosphatic rocks of the Savijärvi Suite: rare 0.5-1 cm thick interbeds and 1-2 cm wide lenses of phosphorite in dolomite; apatite-impregnated bands in diopside rock; and quartz-feldspar gneiss interbeds in carbonate rocks with banded disseminations of apatite [2].
Intrusions	The supracrustal sequence is intruded by coarse-grained veins of quartz and feldspar [2].

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	Garnet in the hanging wall mica gneiss and in the footwall amphibolite [2].
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	Distance to lake Savijärvi is 600 m. Creek Kiertojoki flows throug the deposit to this lake.
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	Sedimentary; uranium bound in phosphorite and phosphate in a volcanic-sedimentary sequence [2]
Tentative FinU model	Metamorphic phosphorite

References

1 Ekdahl, E. 1976. Raportti Pielavedellä vuonna 1974 suoritetuista U-malmitutkimuksista. 8 p. Geological Survey of Finland, unpublished report M19/3314/76/1/10. (in Finnish)

2 Äikäs, O. 1988. Pielaveden Savijärven uraani-fosforiesiintymä. 25 p. Geological Survey of Finland, unpublished report M19/3314/-88/8/60. (in Finnish)

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Deposit

Name **Toso**

FinU_ID	17
ID of Malmikanta	313
Last updated	17. 7.2000
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kuopio area; Palaeoproterozoic cover on the Archaean craton

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	3331 09 C
Coordinates	X (KKJ) 7001000 Latitude 63.11105
	Y (KKJ) 3526260 Longitude 27.51681
Municipality	Siilinjärvi
Village	Hamula
Nearest town	10 km W of Siilinjärvi, 30 km NW of Kuopio
Access	Forest road to the area

Resources/Mining

Reservation	
Exploration license number	3627/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1984-86 [2]
Status of development	Mapped prospect
Economic evaluation	No economic value [2, 3, 5]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.01
% Th	
U production (tonnes)	
Best section(s)	Measured in trenches: <3-10 m thick sequences of metasediments containing phosphorite bands and phosphatic interbeds grading 0.01-0.3 % U. Single samples from phosphorite and phosphatic interbeds contain up to 0.122 % U and 24.5 % P2O5.
Extent of mineralisation	At Toso, the uraniferous rocks cover a zone 50 m by 150-200 m, covered by overburden (till & regolith) 1-3 m, in places 6-7 m thick.

Same type of mineralisation occurs 2 km SE at Kuivasteenmäki and 3.5 km NE at Vironniemi. Both of these localities are smaller than Toso, each consisting only of a few outcrops, covering radioactive zones of 2-5 m by 50 m and <1-20 m by 80 m, respectively [1-5].

Lodes

Exploration

Year of discovery	1981
Discovery	Discovery of a radioactive outcrop by ground scintillometry during sulphide ore prospecting by Outokumpu.
Case history	Outokumpu: 1968-69 sulphide ore prospecting in the area; 1974 radiometric checking of phosphatic samples from the previous work - Kuivasteenmäki prospect discovered; 1980-82 prospecting for sulphide ore, co-operating with GTK in uranium exploration [1-4]. GTK 1976: ground scintillometry at Kuivasteenmäki. 1979: ground follow-up of aeroradiometric gamma anomalies. 1981-82: uranium analyses of pedogeochemical samples of Outokumpu; pedogeochemical sampling at Toso. 1984-85: trenching, detailed geological mapping, litogeochemical sampling at Toso; discovery of the Vironniemi occurrence by geological analogy [2-5].
Diamond drilling	Outokumpu 1982: one drill hole at Kuivasteenmäki (215 m)
Drill core availability	GTK/Loppi: Kuivasteenmäki core
ElementsAnalysed	
Radiometric response	The occurrences at Toso, Kuivasteenmäki and Vironniemi do not stand out as anomalies on aeroradiometric maps [3].
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	The original discovery site at Toso is the only natural outcrop of uraniferous rock. Percussion drill sampling down to the interface of till and bedrock - in places to the regolith in between - revealed the location of uraniferous rocks in bedrock [2].
Geochemical dispersion	
Geologist(s)	Outokumpu: R. Sarikkola, T. Huhtala GTK: O. Äikäs, H. Lukkarinen

Ore

Ore minerals	Uraninite, apatite [2]
Accessory ore minerals	
Gangue	Carbonate, diopside, serpentine, graphite, quartz [2]
Composition of minerals	
Texture and fabrics of ore	In phosphorite bands: very fine-grained disseminated uraninite between fine-grained apatite grains and as inclusions in apatite. In phosphatic carbonate and calc-silicate rocks: similar inclusions of uraninite also in carbonate and silicates [2].
Composition of ore	Th contents are nil in uraniferous phosphatic specimens [2]

U/Th	
Enriched elements	U, P
Stable isotopes	Carbon isotopes of dolomite samples (unpublished data; to be completed later)
Pb isotopes	

Geology

Geological setting	A metasedimentary sequence of carbonate and calc-silicate rock, chert, and black schist deposited on sathrolitic Archaean gneiss [2].
Host lithology	Phosphorite, phosphatic carbonate rock, and phosphatic calc-silicate rock occurring as thin interbeds in the metasedimentary sequence [2].
Intrusions	Dykes of tonalite and granite intersect both the metasediments and the Archaean basement.

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	Intense folding can be seen in the metasediments in places [2].
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	A forest protection target (LHO080284) intersects the Kuivasteenmäki prospect.
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	Metasedimentary: syngenetic-diagenetic, uranium bound into phosphate
Tentative FinU model	Metamorphic phosphorite

References

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Deposit

Name **Ranta-Tulkkivaara**

FinU_ID	21	U- deposit?	☑
ID of Malmikanta	347	U as by-product?	☐
Last updated		Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Phosphorite deposit		
Eon or Era	Palaeoproterozoic		
Geological domain	Karelian		
Geological province	Peräpohja schist belt		

Location

Map sheet	3613 06 B			
Coordinates	X (KKJ)	7366410	Latitude	66.38809
	Y (KKJ)	3470100	Longitude	26.32743
Municipality	Rovaniemen Mlk			
Village				
Nearest town	37 km SE of Rovaniemi			
Access	Forest road to the area, distance from main road 2 km; 0.6 km from the forest road to the deposit			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Drilled prospect
Economic evaluation	Non-economic occurrence: low grade, small size [1]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	U content in 40 specimens from glacial erratics 0.02-0.3 %. Examples: 0.137 % U & 18.90 % P_2O_5 and 0.079 % U & 5.90 % P_2O_5. Best drill core section: 3 m at 0.0237 % U.
Extent of mineralisation	Not given; length of mineralisation along the strike of host rocks 300 m on the basis of the trenches. 60 radioactive boulders located suggest

	more than one source in bedrock [1].
Lodes	Two uraniferous dolomite units in drill core section, interpreted as a result of repetition due to folding [1].

Exploration

Year of discovery	1984
Discovery	Ground follow-up of aeroradiometric gamma anomalies by GTK: radioactive outcrops and boulders were discovered in 1984.
Case history	1984: detailed geological mapping & radiometric boulder tracing; trenching 1985: geological mapping across a conductor zone in the area; magnetic and EM ground survey 1986: diamond drilling.
Diamond drilling	GTK 1986: 2 drill holes (319 m)
Drill core availability	GTK/Loppi: both cores
ElementsAnalysed	
Radiometric response	Aeroradiometric gamma-anomaly caused by uraniferous boulders and outcrops.
Magnetic Response	
Electromagnetic response	A conductor zone in the area was found to be composed mainly of black schist with graphite and sulphide minerals.
Other geophysics	
Glacigenic dispersion	60 radioactive glacial erratics located about 1-1.2 km E and ENE of the (trenched) outcrops.
Geochemical dispersion	
Geologist(s)	GTK: K. Pääkkönen, M. Kvist

Ore

Ore minerals	Uraninite
Accessory ore minerals	Pyrrhotite, pyrite, chaclopyrite, molybdenite
Gangue	Carbonate, serpentine, calc-silicates, mica (& phlogopite), graphite
Composition of minerals	
Texture and fabrics of ore	[1 & microscopy by O. Äikäs]: Subhedral to euhedral uraninite (< 0.02 mm in diameter) as inclusions in apatite; also in serpentine, mica, and pyrrhotite. Uranium correlates with phosphorite and phosphatic parts of host rocks. Tiny vein-like enrichments of uraninite within phosphorites. Pyrrhotite as thin, compact veins and as a brecciating network.
Composition of ore	
U/Th	
Enriched elements	U, P
Stable isotopes	
Pb isotopes	

Geology

Geological setting	The uraniferous unit is a minor interbed of dolomite in a sequence of mica schist, black schist, calc-silicate rock, and chert (and quartz rock) [1]. This sequence might be a lithostratigraphic counterpart to the Korkiavaara Fm. in the Rovaniemi area [2, 3].
Host lithology	Phosphatic dolomite, phosphorite interbeds in dolomite and in arenites
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	Intense folding
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Metamorphic phosphorite

References

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Deposit

Name **Kouvervaara-U**

FinU_ID	22
ID of Malmikanta	351
Last updated	14. 7.2000
Link to Fingold	
Red Book geologic setting	Sandstone deposit [5]
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kuusamo schist belt

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	4522 09 D
Coordinates	X (KKJ) 7337500 Latitude 66.12566
	Y (KKJ) 4445750 Longitude 28.79562
Municipality	Kuusamo
Village	Vasaraperä
Nearest town	22 km NW of Kuusamo
Access	6 km from paved road, 800 m from dirt road

Resources/Mining

Reservation	
Exploration license number	2938/1-2, 3202/1-3
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1979-86
Status of development	Drilled prospect
Economic evaluation	Uneconomic because of low grade and small thickness. A possibility for better mineralisation still exists in the eastern part of the deposit [5].
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.0385
% Th	
U production (tonnes)	
Best section(s)	The best dill core section is 5 m at 0.0786 U. In average the contents are 0.0385 % U/ 4 m core length. Best radioactive spots in outcrops (from the eastern part) up to 1.5 % U [2, 5].
Extent of mineralisation	Three km long mineralisation following the strike of the bedding in the host unit [5]

Lodes	One discontinuous upright sheet, with a thickness from a few cm to a few m. The dimensions at depth have not been defined [5].

Exploration

Year of discovery	1978
Discovery	Ground radiometrics by Outokumpu 1978: radioactive boulders and outcrops of sericite quartzite were found at Kouvervaara. This material was given to GTK by Outokumpu for further exploration [1, 5].
Case history	Pre-1979: Suomen Malmi Oy, Outokumpu Oy, Kemi Oy - gold and uranium exploration in the Kuusamo area [7]. GTK 1979-84 ground radiometrics (scintillometry) and geophysics, Rn survey tests, geological mapping, pedogeochemical and litogeochemical sampling, trenching, diamond drilling. The work included testing of various exploration methods [4, 5]. Ground geophysics at Kouvervaara-U led to the discovery of the Kouvervaara gold deposit in 1982 [11], which was the starting point for a gold exploration programme in the Kuusamo area [7-10].
Diamond drilling	GTK 1979-82: 25 drill holes (2195 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	[5]: by MCA: U, Th…
Radiometric response	Good response by the radioactive boulder trains on airborne radiometric maps [5, 10]. Radiometric ground survey and aeroradiometric maps have been used as a tool in regional gold exploration arising from the discovery of Kouvervaara-U [7, 10].
Magnetic Response	
Electromagnetic response	
Other geophysics	Results from Rn survey tests were negative with thickness of overburden exceeding 2 m [5]. Radiometric drill hole logging.
Glacigenic dispersion	The deposit is the source for two distinct trains of radioactive boulders: 400 boulders in the Riihivaara train, 100-150 m by 5 km; 30 boulders in the Riihisuo train, <100 m by 2 km [1, 5, 12].
Geochemical dispersion	
Geologist(s)	GTK: H. Pyy, K. Pääkkönen, E. Vanhanen

Ore

Ore minerals	Pitchblende [4], also said to be uraninite [6]
Accessory ore minerals	Brannerite, secondary U minerals; rutile, pyrrhotite, pyrite, linnaeite, molybdenite [4, 6]
Gangue	Quartz, sericite
Composition of minerals	
Texture and fabrics of ore	Dust-like round pitchblende (< 0.065 mm), often as spherical clusters (0.02-0.5 mm in diameter) of pitchblende grains and concentric clusters of pitchblende intergrown with accessory ore minerals, micas, chlorite, and carbonate [4].
Composition of ore	U in mineralised rock from 0.005 to 0.271 %; Th contents are low, usually <0.001 % [2, 5].

U/Th

Enriched elements U

Stable isotopes

Pb isotopes

Geology

Geological setting: Stratabound mineralisation within the Sericite Quartzite Formation of the Palaeoproterozoic Kuusamo volcano-sedimentary belt [9].

Host lithology: Sericite quartzite, sericite schist, interbeds of quartz-pebble conglomerate. The mineralised horizon is stratabound, controlled by the contact of the host sericite quartzite against a garnet- and carbonate-bearing unit of biotite-sericite schist [1, 2, 5].

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks: Sericitisation and albitisation in the sericite quartzite host; albitisation front associated with uranium enrichment [2, 9].

Alteration of U/Th minerals

Environment

Population centre

Protection areas: Protected mire to the ENE of the deposit (Riihisuo, SSO10460)

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model: Palaeoproterozoic sandstone deposit

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Deposit

Name **Laavivuoma**

FinU_ID	23
ID of Malmikanta	377
Last updated	
Link to Fingold	
Red Book geologic setting	Vein deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kittilä Greenstone area of the Central Lapland Greenstone Belt

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	2741 01 C
Coordinates	X (KKJ) 7524220 Latitude 67.80437 Y (KKJ) 2509100 Longitude 24.21147
Municipality	Kittilä
Village	Muotkavaara
Nearest town	30 km E of Muonio, 38 km W of Kittilä
Access	Gravel road to the area, distance from road 150 m

Resources/Mining

Reservation	In quarantine: claim reservation expired in June, 2000
Exploration license number	3572/1-2
Mining concession number	
Holder of mineral rights	
Previous holders	GTK 1984-87
Status of development	Drilled prospect
Economic evaluation	No economic value because of the low grade and small size due to the scattered occurrence of mineralised veins [1, 2].
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.0124
% Th	
U production (tonnes)	
Best section(s)	[1, 2] Averages of 65 erratic boulders: 0.802 % U, 0,0165 % Mo, 0.0843 % Cu, 0.0127 % Co, 0.0168 % Ni, 0.0056 % Zn, 0.183 % Pb, 0 % Ag. Samples from 0.5-5 cm thick veins in the two outcropping areas: 0.01-2.24 % U, 0 % Th. In drill core 8.25 m at 0.0124 % U.
Extent of mineralisation	Sets of uraniferous veins in two outcropping areas 300 m apart; these

	belong to a series of veins that strikes towards SSE forming a zone common with the veins of the Pahtavuoma-U deposit [2].
Lodes	[1, 2]: mineralised outcrops LI (10 m by 30 m) and LII (10 m by 35 m). These differ from the Pahtavuoma-U lodes in their lower contents of other metals.

Exploration

Year of discovery	1983
Discovery	Follow-up of aeroradiometric gamma anomalies by GTK in the surroundings of the Pahtavuoma Cu-Zn-U deposit in 1982 revealed a cluster of radioactive boulders on the slopes of hill Kolvakero, north of Pahtavuoma. Subsequent ground radiometrics led to the discovery of radioactive outcrops at Laavivuoma, west of Pahtavuoma [1, 2].
Case history	1982-83: ground radiometrics (scintillometry), detailed mapping of radioactive boulders [1, 2]. 1983-85: till stratigraphy & boulder transport studies [3-7]; trenching, detailed geological mapping; pedogeochemical and lithogeochemical sampling; petrogaphy including autoradiography (3D models of mineralised specimens); diamond drilling [1, 2].
Diamond drilling	GTK 1984: eight drill holes (617 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	U, Th (MCA), U (INAA), Cu, Co, Ni, Pb, Zn, Mo, Ag (AAS)
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: K. Pääkkönen, M. Kvist

Ore

Ore minerals	Uraninite, pitchblende [2]
Accessory ore minerals	Magnetite, ilmenite, pyrrhotite, arsenopyrite, pyrite, chalcopyrite, molybdenite [2]
Gangue	Amphibole, quartz
Composition of minerals	
Texture and fabrics of ore	Ore minerals in veins 0,5-5 cm thick; oxides as inclusions in brown amphibole, sulphides as coarser grains in quartz. Uraninite as subrounded to subhedral grains 0.02-0.3 mm in diameter. Pitchblende as veinlets or clusters [2].
Composition of ore	No Th present [2]
U/Th	
Enriched elements	U, Mo
Stable isotopes	

Pb isotopes Uraninite 1785+-2 Ma [11]

Geology

Geological setting Savukoski Group metasediments of the Pittarova Formation, in the south overlain (with overturned contact [3]) by mafic volcanics of the Linkupalo Formation, in the north linked by a tectonic contact into younger volcanics of the Kittilä Group [7, 8].

Host lithology Ore minerals, brown amphibole and quartz constitute a set of thin veins that cuts across an amphibole-banded mica schist [2].

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history Oxides - including uraninite - occur as helisitic inclusions in amphibole reflecting previous isoclinal folding; sulphides have overgrown on the helisitic texture. The ore veins generally parallel but also partly transect the axial plane cleavage of the host mica schist [2].

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Vein?

References

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Deposit

Name **Orajärvi**

FinU_ID	24
ID of Malmikanta	394
Last updated	
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Granite complex of Central Lapland

U- deposit?	☐
U as by-product?	☐
Th- deposit?	☑

Location

Map sheet	2641 03 D			
Coordinates	X (KKJ)	7424950	Latitude	66.91437
	Y (KKJ)	2504800	Longitude	24.10551
Municipality	Pello			
Village	Orajärvi			
Nearest town	14 km N of Pello, 110 km WNW of Rovaniemi			
Access	500 m from main road, less than 200 m from dirt road			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Mapped prospect
Economic evaluation	Non-economic occurrence of thorium
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Over 40 radioactive spots, the dimensions and grades of the largests of those only reach 30 cm by 150 cm with 0.16 % U and 2.24 % Th.
Extent of mineralisation	Radioactive spots are scattered in an area of 0.2 km by 0.5 km of exposed bedrock.
Lodes	

Exploration

Year of discovery	1977
Discovery	Radioactive layman sample from bedrock, received by GTK in 1977
Case history	1977: geological mapping & detailed scintillometry; sampling by blasting. Systematic ground radiometrics (spectrometry) by contractor (Suomen Malmi).
Diamond drilling	
Drill core availability	
ElementsAnalysed	by GSP: U, Th
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	Th-bearing rock from this deposit has been used in building calibration pads for calibration of gamma spectrometers.
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: V. Helppi

Ore

Ore minerals	Allanite, anatase
Accessory ore minerals	
Gangue	Quartz, feldspar, biotite
Composition of minerals	Metamict allanite. Mineral identification by X-ray diffraction [1].
Texture and fabrics of ore	
Composition of ore	
U/Th	
Enriched elements	Th, U
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Bedrock lithology in the Orajärvi area comprises reddish granite, porphyritic granite, pegmatite, and minor granodiorite. Mica schist enclaves are rare occurring in granites south of Orajärvi.
Host lithology	Radioactive pods and nests occur in a set of quartz veins striking NW. The quartz veins are usually situated within pegmatite bodies.
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Intrusive/pegmatite/quartz vein

References

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Deposit

Name **Palkiskuru**

FinU_ID	25
ID of Malmikanta	395
Last updated	
Link to Fingold	
Red Book geologic setting	Metasomatite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	

U- deposit? ☑

U as by-product? ☐

Th- deposit? ☐

Location

Map sheet	1834 01 C		
Coordinates	X (KKJ) 7613570	Latitude	68.6017
	Y (KKJ) 1546250	Longitude	22.13082
Municipality	Enontekiö		
Village			
Nearest town	34 km NW of Kaaresuvanto		
Access	Distance to nearest road 7 km		

Resources/Mining

Reservation	
Exploration license number	3226/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1981-1986
Status of development	Drilled prospect
Economic evaluation	Non-economic because of limited size [1]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	U content in drill core sections from mineralised albitite 0.02-0.5 % [1]
Extent of mineralisation	Length 200 m, dipping west at 30 degrees and petering out at depth after 40 m; the thickness of the mineralised body on the surface is no more than 5 m [1].
Lodes	

Exploration

Year of discovery	1980
Discovery	Discovery of radioactive outcrop during ground follow-up of aeroradiometric gamma anomalies by GTK.
Case history	1980-83: geochemical sampling, radiometric boulder tracing, detailed geological mapping, diamond drilling.
Diamond drilling	GTK 1981-83: 20 drill holes (879 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	500 m by 900 m gamma anomaly area on U channel aeroradiometric map
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	K. Pääkkönen

Ore

Ore minerals	Davidite
Accessory ore minerals	
Gangue	Albite, carbonate, quartz, rutile, biotite
Composition of minerals	High-Cr davidite; 4.36 % UO2, 0.81 % Th [1]
Texture and fabrics of ore	Davidite occurs as bands up to 2 cm wide; as impregnation or as scattered crysts; and as a brecciating network. Davidite crystals can be 1 cm in diameter.
Composition of ore	
U/Th	
Enriched elements	U, Th, Ti, Fe, Cr, La, Ce
Stable isotopes	
Pb isotopes	Davidite ca. 1750 Ma, sample A61 [2]

Geology

Geological setting	The deposit is located near the eastern contact of a diabase dyke that cuts across Archaean granodiorite. At this contact there is an alteration zone formed by an alaskitic rock (albite-K-feldspar-quartz rock) [1].
Host lithology	Uranium occurs in albitite which forms veins and nests in alaskite. This albitite is a coarse-grained albite-davidite rock [1].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Metasomatite/albitite?

References

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Deposit

Name **Kapusta**

FinU_ID	26
ID of Malmikanta	439
Last updated	17. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Archaean
Geological domain	Karelian
Geological province	Archaean basement gneisses east of the Tipasjärvi greenstones, the southernmost part of the Archaean Kuhmo-Suomussalmi greenstone belt.

U- deposit?	☑
U as by-product?	☐
Th- deposit?	☐

Location

Map sheet	4324 03 C			
Coordinates	X (KKJ)	7093200	Latitude	63.93773
	Y (KKJ)	4468220	Longitude	29.34864
Municipality	Kuhmo			
Village	Vepsä			
Nearest town	30 km SW of Kuhmo			
Access	Gravel road to the area			

Resources/Mining

Reservation	Claim reservation in 2000
Exploration license number	3548/2
Mining concession number	
Holder of mineral rights	
Previous holders	GTK 1983-85 [2]
Status of development	Mapped prospect
Economic evaluation	No economic value [2]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.05
% Th	
U production (tonnes)	
Best section(s)	0.03-0.32 % U, 0.005-0.60 % Th and 0.02-0.35 % Mo in best boulders, with U/Th = 8.0. Across trenches, samples correspond to 1-2 m at 0.05 % U [2].
Extent of mineralisation	Radioactive pods and nests in an area 100 m by 150 m area at Kapusta;

	in a larger area of 1 km by 3 km, Kapusta represents one of the many uraniferous showings [2-6].
Lodes	

Exploration

Year of discovery	1982
Discovery	Reconnaissance ground radiometrics by Kajaani Oy 1982: radioactive outcrops and boulders found at Kapusta; ground follow-up of aeroradiometric gamma anomalies by GTK 1982-83: discovery of the Kapusta boulders and outcrops in 1983 [2, 4].
Case history	Kajaani Oy 1973-79: sulphide ore prospecting 1-2 km north of Kapusta, based on a chalcopyrite-bearing layman sample received in 1972 [1, 2]. GTK 1983-85: ground scintillometry (25 km2); detailed radiometric boulder tracing; trenching; lithogeochemical sampling by percussion drilling; geological mapping [2, 3, 4].
Diamond drilling	
Drill core availability	
ElementsAnalysed	By GSP: U, Th [2]
Radiometric response	80 m by 100 m gamma anomaly on U channel aeroradiometric map, caused by radioactive outcrops and boulders at Kapusta [2].
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	A pronounced fan of >80 radioactive boulders, with a glacial discharge from NW; thin till cover (<0.5 m) at Kapusta allowed to find out that there are several source outcrops at the head of the fan. Preglacial regolith was found in one of the trenches [2].
Geochemical dispersion	
Geologist(s)	Kajaani: T. Kopperoinen GTK: O. Äikäs

Ore

Ore minerals	Uraninite [2]
Accessory ore minerals	Unidentified secondary uranium minerals; molybdenite; rutile, ilmenite [2]
Gangue	Quartz, biotite, feldspars [2]
Composition of minerals	
Texture and fabrics of ore	Uraninite and secondary uranium minerals as dissemination, often followed by molybdenite. The best parts in the rocks are those rich in biotite. Rutile and ilmenite occur separately from the uranium minerals. Part of uranium is in secondary minerals as coatings on fracture surfaces [2].
Composition of ore	U/Th 1-4
U/Th	
Enriched elements	U, Th, Mo [2]

Stable isotopes	
Pb isotopes	

Geology

Geological setting	A chain of discontinuous occurrences of paragneiss (mica gneiss and amphibolite) areas within the TTG-type granitoids and gneisses [1, 3]. At Kapusta, the amphibolite occurs as <10 m thick conformable zones in the mica gneiss; both of these rocks show migmatitic banding [2].
Host lithology	At Kapusta uranium is hosted by pods and nests of quartz rock, quartz biotite rock and quartzose pegmatite that occur along the eastern margin of the local body of gneissose granite; these nests are located both within the granite and in the paragneiss migmatites [2].
Intrusions	Reddish, gneissose granite ("Kapusta granite") is located in the area in a N-S directed irregular body, with gradual contacts with the gneisses. Coarse-grained pegmatitic granites are common in the area as veins, pods, and dykes in other rocks. A set of 10-20 m wide metadiabase dykes strikes in the area from SE to NW; the metadiabase is suggested to be Palaeoproterozoic in age [2, 3].

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	Garnet porphyroblasts in mica gneiss and in amphibolite [3]
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	Yellow and brownish secondary radioactive minerals as disseminations and as coatings on fracture surfaces [2].

Environment

Population centre	
Protection areas	Protected mire 5 km to the SW (SSO110362); protected old forest 2 km to the SE (AMO110128).
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	Palaeoproterozoic mineralisation in Archaean terrain?
Genetic reasoning	
Tentative FinU model	Intrusive/migmatite neosome/pegmatite

References

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Deposit

Name **Särkijärvi**

FinU_ID	27
ID of Malmikanta	463
Last updated	
Link to Fingold	
Red Book geologic setting	Intrusive deposit? Unconformity-related deposit [5]?
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Granite migmatite belt of southern Finland

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	3022 01 C
Coordinates	X (KKJ) 6712430 Latitude 60.51636
	Y (KKJ) 3429330 Longitude 25.71028
Municipality	Askola
Village	Särkijärvi
Nearest town	14 km N of Porvoo
Access	200 m from main road

Resources/Mining

Reservation	
Exploration license number	3360/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1981-84
Status of development	Drilled prospect
Economic evaluation	No economic signicance. Shows evidence of uranium enrichment in this province [2].
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Several tens of boulders with 0.1-3.5 % U. Hand specimen from a hematite + goethite bearing nest in altered granite next to a shear zone in bedrock contained 1 % U. No radioactivity in the drill cores [2].
Extent of mineralisation	

Lodes

Exploration

Year of discovery	1984
Discovery	Radioactive layman sample (0.17 % U) from a glacial erratic boulder, received by GTK in summer 1981.
Case history	1976: high Rn contents in ground water at Särkijärvi; hydrogeochemical mapping by GTK [1]. 1981: radiometric boulder tracing. 1981-84: percussion drilling; geophysical survey (magnetic, EM, seismic); trenching; Rn survey ("alphaCARD"); diamond drilling [2, 5].
Diamond drilling	GTK 1982 and 1984: three drill holes
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Narrow, 100 m long train of radioactive boulders. At least one source in bedrock was localised by trenching.
Geochemical dispersion	High Rn contents in ground water in this area
Geologist(s)	GTK: H. Appelqvist

Ore

Ore minerals	Uraninite
Accessory ore minerals	Unindentified (secondary) yellow U-mineral Native copper; scheelite
Gangue	Hornblende, plagioclase, epidote
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	
U/Th	
Enriched elements	U, Cu, Fe
Stable isotopes	
Pb isotopes	Uraninite from altered granite boulder: 440 Ma [5]

Geology

Geological setting	Migmatitic hornblende gneiss and granite typical of the province
Host lithology	Goethite-stained shear zone cutting across the lithology. In uraniferous boulders the host rocks are hornblende gneiss and hematised granite [2, 5].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	
Alteration of rocks	Microcracks in the rocks are filled by a mass of hematite+goethite; in one of the drill cores native copper was found in such a crack. Hornblende is chloritised. Mica gneiss and hornblende gneiss are reported to have altered into chlorite-epidote rock. Trenching at the site of soil Rn anomalies showed that there are pedogeogenic uranium anomalies in till.
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	High radon contents in water in a schoolhouse 500 m SW of the deposit [1]
Geochemical hazards	
Restoration	

Conclusions

Timing	Uranium mineralisation in the hematised shear zone is suggested to reflect the process of supergene uranium mineralization in the Phanerozoic about 440 Ma ago [2, 5].
Genetic reasoning	
Tentative FinU model	Intrusive/sheared & altered host/Olympic Dam??

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Deposit

Name **Harjakangas**

FinU_ID	28
ID of Malmikanta	527
Last updated	
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Tonalite migmatite belt of southern Finland

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	1144 04 A
Coordinates	X (KKJ) 6831500 Latitude 61.58743
	Y (KKJ) 1552600 Longitude 21.98699
Municipality	Noormarkku
Village	Harjakangas
Nearest town	11 km SE of Noormarkku, 23 km NE of Pori
Access	500 m from gravel road, dirt road to the deposit

Resources/Mining

Reservation	
Exploration license number	2518/1-9, 2604/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Outokumpu Oy 1975-77
Status of development	Drilled prospect
Economic evaluation	No economic value [2]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Averages of the three clusters of radioactive boulders: Harjakangas 0.07 % U, 9.67 % P2O5 (n=14); Nälkälampi 0.02 % U, 3.55 % P2O5 (n=9), Niinikangas 0.06 % U, 6.30 % P2O5 (n=24). 1-1.5 m thick uraniferous bed in the Harjakangas trench averages 0.0245 % U, 4.19 % P2O5 (n=6). Drill core sections from Niinikangas: 3 m at 0.0155 % U, 2.18 % P2O5 and 10 m at 0.008 % U, 0.91 % P2O5 [1, 2].

Extent of mineralisation	Starting from the Harjakangas outcrop in the S, radioactive phosphatic boulders have been found in a three km long zone first striking to the N but bending finally to the NE past Niinikangas.
Lodes	Harjakangas outcrop (trench): one gently dipping, folded uraniferous bed 1-1.5 m thick [1]. Niinikangas: uraniferous drill core sections with lengths less than two metres, in one drilling profile. The source of Nälkälampi boulders in bedrock is not known [1, 2].

Exploration

Year of discovery	1974
Discovery	Layman sample from outcropping bedrock from Harjakangas, map sheet 1143 06, received by Outokumpu in 1974.
Case history	Outokumpu 1974-76: radiometric boulder tracing and trenching at Harjakangas; ground magnetic and electromagnetic survey; ground radiometrics (scintillometry) and boulder tracing on the magnetic anomaly further north - discovery of the Nälkälampi and Niinikangas boulder trains, map sheet 1144 04; diamond drilling at Niinikangas in 1976.
Diamond drilling	Outokumpu 1976: two drill holes (395 m)
Drill core availability	
ElementsAnalysed	U, Th, P, Cu, Zn, Pb, S
Radiometric response	Ground radiometrics revealed radiometric erratics. The Harjakangas outcrop and boulders did not produce an anomaly worth of checking during the follow-up of aeroradiometric anomalies (airborne geophysics in this area were carried out in 1985) [7, 8].
Magnetic Response	An anomaly zone from the magnetic ground survey was used to direct radiometric search for uraniferous boulders [1].
Electromagnetic response	An electromagnetic anomaly was found to parallel the magnetic anomaly at Niinikangas. Graphitic interlayers and minor sulphides were found in the drill cores [2].
Other geophysics	
Glacigenic dispersion	About 50 radioactive glacial erratics, forming three different clusters or fans [1].
Geochemical dispersion	
Geologist(s)	Outokumpu: R. Sarikkola, J. Mustala

Ore

Ore minerals	Uraninite, apatite [1, 3]
Accessory ore minerals	Pyrrhotite, chalcopyrite, molybdenite
Gangue	Diopside, tremolite, olivine, carbonate, phlogopite, scapolite, quartz, graphite
Composition of minerals	From apatite concentrate: 290 ppm U and 0.5 ppm Th in apatite [3]
Texture and fabrics of ore	Tiny uraninite inclusions in fine-grained (<0.1 mm) apatite, similar subhedral uraninite grains between apatites. Fine-grained apatite (and uranium with it) mostly forms thin (<0.5 cm) bands and streaks in carbonate and calc-silicate rocks [Microscopy by O. Äikäs].

Composition of ore	There is no Th in the uraniferous rocks.
U/Th	
Enriched elements	U, P
Stable isotopes	
Pb isotopes	

Geology

Geological setting	The uraniferous rocks belong to migmatitic metasediments within the Pomarkku Block of tonalite and biotite-plagioclase gneiss, close to the NNW trending Pori Shear Zone [4, 6]. Distance to the mesoproterozoic sandstone in the SW is 12 km.
Host lithology	Most of the radioactive boulders are phosphatic carbonate rocks and calc-silicate rocks, with a few blocks of fine-grained phospahtic quartz-feldspar gneiss. The Harjakangas outcrop is a solitary occurrence of carbonate rock in the hinge of folded migmatitic mica gneiss, with the fold axis plunging gently towards NNW [1, 5]. In the Niinikangas profile calcareous interbeds form a 100 m thick sequence within the migmatiic miga gneiss; part of these interbeds are uraniferous and phosphatic [2]. At both localities, graphite-bearing interbeds are present. The mica gneiss is intruded by pegmatite veins.
Intrusions	At Harjakangas, a dyke of Subjotnian (Mesoproterozoic) diabase is exposed next to the S of the uraniferous outcrop.

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	Intense folding during the Svecokarelian orogeny
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Metamorphic phosphorite

References

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Deposit

Name **Puutosmäki**

FinU_ID	29
ID of Malmikanta	532
Last updated	17. 7.2000
Link to Fingold	
Red Book geologic setting	Unconformity-related deposit?
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kuopio area; Palaeoproterozoic cover on the Archaean craton

U- deposit? ☑

U as by-product? ☐

Th- deposit? ☐

Location

Map sheet	3244 01 B
Coordinates	X (KKJ) 6955790 Latitude 62.7041
	Y (KKJ) 3541170 Longitude 27.80101
Municipality	Vehmersalmi
Village	Puutosmäki
Nearest town	26 km SE of Kuopio
Access	200 m from paved road, dirt roads in the area

Resources/Mining

Reservation	In quarantine: claim reservation expired in September, 2000.
Exploration license number	2598/1-3
Mining concession number	
Holder of mineral rights	
Previous holders	GTK 1976
Status of development	Drilled prospect
Economic evaluation	No economic value [1, 2, 4]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Drill cores: in fertile granite up to 0.0036 % U, 0.0 % Th [1, 4]; specimens of pitchblende vein from the old pit >10 % U [1]; specimens from quartzite close to the pit up to 0.26 % U [4].
Extent of mineralisation	At Puutosmäki, separate radioactive spots in different lithologies in an area of < 1 km2 [1, 4]. In the area N of Puutosmäki, similar radioactive outcrops in a zone 2 km by 12 km along the strike of the

	Palaeoproterozoic quartzites [4].
Lodes	

Exploration

Year of discovery	1969
Discovery	Pitchblende vein was found in an old trench by a field group of Outokumpu in 1969 while checking the radioactivity of the area on the basis of a layman sample received in 1967. The original discovery was made by Atomienergia or Imatran Voima [4].
Case history	Outokumpu 1968-69: ground scintillometry at Puutosmäki and in the area N of Puutosmäki [4]. GTK 1973-76: reconnaissance ground scintillometry; geological mapping; carborne spectrometry; Rn emanometry; ground spectrometry; diamond drilling [1]. 1981: low-altitude aerogeophysical survey; 1984-85: ground follow-up of aeroradiometric gamma anomalies [3, 4].
Diamond drilling	GTK 1976: three drill holes (271 m) [1]
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	By GSP: U, Th [1]
Radiometric response	Good response on uranium channel aeroradiometric maps where not covered by sand [3, 4]
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	The area next to the Puutosmäki trench is covered by glacifluvial sand: no response was gained by Rn emanometry of this mineralisation through the overburden [1].
Geochemical dispersion	
Geologist(s)	Outokumpu: A. Huhma, R. Sarikkola GTK: E. Ekdahl [1], O. Äikäs [4]

Ore

Ore minerals	Uraninite [4]
Accessory ore minerals	Galena, secondary uranium minerals, pyrite [4]
Gangue	Biotite, quartz, feldspars [4]
Composition of minerals	
Texture and fabrics of ore	Vein: botryoidal uraninite, grain size <0.001-0.003 mm; the thickness of veins up to 1 cm [4]
Composition of ore	
U/Th	
Enriched elements	U
Stable isotopes	
Pb isotopes	

Geology

Geological setting	A zone of Jatulian quartzite, dolomite and amphibolite in N-S direction, with a tectonic contact against the Archaean basement in the west, occurring at the limb of a large-scale syncline between slices of overthrusted basement.
Host lithology	At Puutosmäki and in this zone in general: 1) pitchblende (uraninite) veins and vein-like mineralisations in the Archaean granitic gneisses, the best of these occurring at Puutosmäki where there is a pyritic biotite gneiss enclave in the gneiss [1, 2, 4]; 2) Uraniferous spots and stratabound nests in Jatulian schists, mainly in quartzite [1, 2, 4]; 3) Pockets and impregnations of radioactive minerals in Proterozoic granites and pegmatites that intersect both the basement and the schists [1, 4].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre	A schoolhouse is located 300 m N of the Puutosmäki trench.
Protection areas	The northern part of the mineralised zone covers shores and islands of lake Etelä-Kallavesi, with a protection area (RSO080082) intersecting the northern end of the zone.
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	Uranium was carried by red even-grained granites that migmatise the other rocks [1]. Close resemblance to the unconformity-type pitchblende deposits [2].
Tentative FinU model	Unconformity-related?/Vein?/Intrusive?/Sandstone; overlapping models?

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4 Äikäs, O. 1988. Uraanimalmiaiheiden arviointia: Puutosmäki ja Etelä-Kallaveden saaret Vehmersalmella ja Kuopiossa. 11 p. Geological Survey of Finland, unpublished report M19/3244/-88/2/60. (in Finnish)

Deposit

Name **Ruotsalo**

FinU_ID	30
ID of Malmikanta	533
Last updated	
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Pohjanmaa schist belt

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	2324 02 C
Coordinates	X (KKJ) 7089530 Latitude 63.90473
	Y (KKJ) 2469080 Longitude 23.36656
Municipality	Kälviä
Village	Ruotsalo
Nearest town	15 km NE of Kokkola
Access	Distance from highway less than 1 km; gravel roads in the area.

Resources/Mining

Reservation	Claim reservation expired November, 1997
Exploration license number	2561/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Rautaruukki Oy 1975-79
Status of development	Mapped prospect
Economic evaluation	No economic value [1]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	In 40 samples of phosphatic boulders (P2O5>0.50 %) P2O5 averages 4.23 % and U 0.03 %, ranging up to 8.68 % and 0.10 %, respectively [2].
Extent of mineralisation	Up to 3 km long zone situated at the western part of the Ruotsalo quartz-feldspar gneiss unit, composed of a few radioactive outcops and four trains of radioactive boulders [1, 2].

Lodes	At Rimmi farm there are two clusters of outcrops 200 m apart, showing a 3-4 m thick, gently dipping sequence of quartz-feldspar gneiss with 10-12 lenticular phosphatic interbeds. These interbeds are 0.1 to 25 cm thick, and most of them are uraniferous (0-0.035 % U) [1].

Exploration

Year of discovery	1975
Discovery	This occurrence was found on the basis of a pyrrhotite-bearing rock sample sent by a local farmer to Rautaruukki Oy. Field work done by the company revealed uraniferous, phosphatic rocks in a few outcrops and in erratic boulders, forming four groups in a zone 2.5-3 km long [1, 2].
Case history	Rautaruukki 1974-75: radiometric boulder tracing and ground radiometrics; geological mapping; airborne geophysical survey (50 km2) [1]. GTK 1976: extended ground radiometrics (scintillometry); geological mapping; magnetic and electromagnetic profile survey [2].
Diamond drilling	
Drill core availability	
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Rautaruukki: E. Mattila GTK: O. Äikäs

Ore

Ore minerals	Uraninite, apatite [2]
Accessory ore minerals	Pyrrhotite, pyrite, chalcopyrite; unidentified U-Ti-Fe mineral; rutile [2]
Gangue	Quartz, plagioclase, K-feldspar, graphite, biotite [2]
Composition of minerals	Apatite concentrate 144 ppm U (from a rock with 24 ppm U and 0.9 ppm Th) [2, 3]. Autoradiography indicates that part of the uranium in the rock is included in the apatite lattice [2].
Texture and fabrics of ore	The grain size of apatite is generally 0.01-0.05 mm. Uranium correlates with phosphatic interbeds although autoradiography shows that there are tiny uraniferous opaque minerals also as inclusions in silicates. Most of these minerals are subhedral uraninite, <0.01 mm in diameter, but a possibly secondary U-Ti-Fe mineral phase was also found to favour the edges of sphene [2].
Composition of ore	Very low thorium content [2]
U/Th	
Enriched elements	U, P

Stable isotopes

Pb isotopes

Geology

Geological setting	In Ruotsalo, an oval area 2 km by 3 km is covered by a flat-lying unit of quartz-feldspar gneiss, presumably felsic volcanic rock. With an unexposed extension to the west, it is surrounded by migmatitic mica gneisses (veined gneiss of greywacky origin). In the transition zone, there are interbeds of calc-silicate rocks and carbonate rock in the quartz-feldspar gneiss, together with interbeds of black schist [2, 4, 5]. The sequence represents the supracrustal rocks of the age group 1.89-1.88 Ga within the accretionary arc complex of central and western Finland [6].
Host lithology	The uraniferous parts in the rocks are mostly phosphatic interbeds in barren quartz-feldspar gneiss. The phosphatic beds are composed of phosphorite (fine-grained apatite-quartz-graphite rock) or of phosphatic quartz-feldspar gneiss, a phosphorite diluted by plagioclase xenocrysts or fragments of quartz-feldspar rock. Streaky disseminations of iron sulphides parallel to bedding are common in the uraniferous and barren rocks.
Intrusions	All rocks in the area are cut by veins and pods of pegmatite granite, up to 20 m wide [2].

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	Interpreted as an anticlinal core, the flat Ruotsalo quartz-feldspar gneiss reflects polyphase folding [2].
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Metamorphic phosphorite

References

1 Nuutilainen, J. 1980. Tutkimustyöt "Vähäjärvi 1" valtausalueella. Rautaruukki Oy Malminetsintä, unpublished report. 3 p. (in Finnish)

2 Äikäs, O. 1988. Kälviän Ruotsalon uraani-fosforiesiintymä. 43 p. Geological Survey of Finland, unpublished report M19/2324/-88/1/60. (in Finnish)

3 Rehtijärvi, P. 1983. REE patterns for apatites from Proterozoic phosphatic metasediments, Finland. Bulletin of the Geological Society of Finland 55 (1), 77-82.

4 Neuvonen, K. J. 1961. Kannus. Geological Map of Finland 1:100 000, Pre-Quaternary Rocks, sheet 2324. Geological Survey of Finland.

5 Neuvonen, K. J. 1971. Kallioperäkartan selitys, lehti 2324 Kannus. With an English summary. Geological Map of Finland 1:100 000, Explanation to the map of rocks, sheet 2324. Geological Survey of Finland. 28 p.

6 Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Bedrock map of Finland 1:1 000 000. Espoo: Geological Survey of Finland.

Deposit

Name **Isokylä**

FinU_ID	31
ID of Malmikanta	535
Last updated	
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Pohjanmaa schist belt [3]

U- deposit?	☑
U as by-product?	☐
Th- deposit?	☐

Location

Map sheet	2314 09 C			
Coordinates	X (KKJ)	7031800	Latitude	63.38803
	Y (KKJ)	2488400	Longitude	23.76439
Municipality	Veteli			
Village	Räyrinki			
Nearest town	11 km S of Veteli, 14 km E of Evijärvi			
Access	100 m of main road			

Resources/Mining

Reservation	
Exploration license number	2519/1-6, 2541/1-2
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1974-76
Status of development	Drilled prospect
Economic evaluation	Non-uniform low-grade mineralisation, no economic significance
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.019
% Th	
U production (tonnes)	
Best section(s)	Drill core: 2.5 m at 0.019 % U, < 0.001 % Th [1]
Extent of mineralisation	Radioactive outcrops in an area 0.5 km by 1 km. 1-5 m long radioactive intersections from 19 to 83 m in the GTK drill core. Radioactive phosphatic boulders of the same type were found by Outokumpu at Vistbacka (Småbönders) 7 km NW of Isokylä.

Lodes

Exploration

Year of discovery	1959
Discovery	Layman samples from boulders west of lake Räyrinki, received by Atomienergia Oy.
Case history	Atomienergia 1959: boulder tracing. Outokumpu 1965-66: boulder tracing, ground radiometrics, geological mapping, trenching. GTK 1974-76: geological mapping, boulder tracing, magnetic and EM ground survey, carborne spectrometry, ground scintillometry, Rn emanometry, diamond drilling.
Diamond drilling	GTK 1974: one drill hole (152 m)
Drill core availability	GTK/Loppi: one core
ElementsAnalysed	U, Th, Cu, Au, Ag
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Atomienergia. J. Saastamoinen Outokumpu: A. Huhma GTK: B. Lindmark

Ore

Ore minerals	Uraninite, apatite
Accessory ore minerals	Pyrrhotite, pyrite, chalcopyrite
Gangue	Quartz, plagioclase, hornblende, diopside, carbonate
Composition of minerals	
Texture and fabrics of ore	Tiny uraninite inclusions in fine-grained apatite; possibly part of the uranium in the apatite lattice. Inclusions of uranium minerals also in sphene, hornblende, and plagioclase.
Composition of ore	Mineral separation test by Outokumpu with a rock containing 0.026 % U, 2.25 % P2O5, 0.17 % Ti, 1.30 % Ba, 0.01 % Cu and 0.01 % Ni.
U/Th	
Enriched elements	U, P, Ba
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Mafic metavolcanic rocks (lavas; agglomerate) of the Isokylä belt with pyroclastics, metatuffs and carbonate-bearing calc-silicate rocks in the eastern part of the belt [2, 3]. The Isokylä belt is surrounded by

metagraywackes.

Host lithology — Fine-grained phosphatic quartz-feldspar gneiss (intermediate tuff/tuffite?), phosphatic carbonate-bearing calc-silicate rocks, apatite-carbonate cement in brecciated plagioclase porphyries.

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model — Metamorphic phosphorite

References

1 Lindmark, B. 1977. Raportti uraanitutkimuksista Räyringin ja Småböndersin välisessä vulkaniittivyöhykkeessä Vetelin ja Kruunupyyn kunnissa v. 1974-1976. Geological Survey of Finland, unpublished report M19/2314/77/1/10. 17 p. (in Finnish)

2 Pipping, F. & Vaarma, M. 1992. Evijärvi. Geological Map of Finland 1:100 000, Pre-Quaternary Rocks, sheet 2314. Geological Survey of Finland.

3 Vaarma, M. & Pipping, F. 1997. Alajärven ja Evijärven kartta-alueiden kallioperä. Summary: Pre-Quaternary rocks of the Alajärvi and Evijärvi map-sheet areas. Geological Map of Finland 1:100 000, Explanation to the maps of Pre-Quaternary Rocks, sheets 2313 and 2314. Geological Survey of Finland. 83 p.

4 Vaarma, M. & Kähkönen, Y. 1994. Geochemistry of the Paleoproterozoic metavolcanic rocks at Evijärvi, western Finland. Geological Survey of Finland, Special Paper 19, 47-59.

5 Äikäs, O. 1976. Selvitys uraani-fosforiesiintymien geologisesta ja mineralogisesta tutkimuksesta vuonna 1975. 3 p. Geological Survey of Finland, unpublished report M60/1143/76/1. (in Finnish)

Deposit

Name **Eronlampi**

FinU_ID	32
ID of Malmikanta	537
Last updated	14. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Archaean
Geological domain	Karelian
Geological province	Archaean basement

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	4241 04 C		
Coordinates	X (KKJ) 6921000	Latitude	62.3938
	Y (KKJ) 4519800	Longitude	30.3797
Municipality	Kiihtelysvaara		
Village	Viesimo; Huhtilampi		
Nearest town	48 km SE of Joensuu		
Access	300 m from forest road		

Resources/Mining

Reservation	
Exploration license number	2476/1-3
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1974-76
Status of development	Drilled prospect
Economic evaluation	No economic value [3]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	From Mustalampi [2, 3] in trench 0.3 m at 1.8 % U, 0.45 % Th, 0.36 % Mo
Extent of mineralisation	Several small uranium showings on the west side of a granite body, related to a faulted shear zone over a distance of at least 3.5 km [2, 3].
Lodes	Two drilled prospects, Eronlampi in the south and Mustalampi in the

	north

Exploration

Year of discovery	1974
Discovery	Uranium anomalies in stream sediment samples [1, 4]
Case history	1974-76: ground radiometrics, trenching, diamond drilling
Diamond drilling	GTK 1975: five drill holes (759 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	U anomalies in organic stream sediments. Partly hydromorphic uranium anomalies in till [4].
Geologist(s)	GTK: E. Räisänen

Ore

Ore minerals	Uraninite [2]
Accessory ore minerals	Thorite, molybdenite, magnetite, galena [2]
Gangue	Quartz, biotite, feldspars, apatite [2]
Composition of minerals	
Texture and fabrics of ore	Subhedral to euhedral uraninite (0.2-1.2 mm) accompanied by minor molybdenite in quartzose veins and bodies, often associated with biotite [2, 3].
Composition of ore	U/Th from 1 to 3 [3]
U/Th	
Enriched elements	U, Th, Mo, P
Stable isotopes	
Pb isotopes	[2]: uraninite 2340 Ma (GTK A677)

Geology

Geological setting	1.5 km by 10 km body of cataclastic (Archaean) granite extends to the NNW through the basement gneisses within a distance of 3 km from the margin of the Palaeoproterozoic schist belt in the west [3].
Host lithology	Between the granite and the younger schist belt there are numerous quartzose veins and pods in the basement paragneisses (amphibolite and mica schists) in association with a set of fracture zones also trending NNW. Radioactive minerals are hosted by these quartz veins and lenses, often where there is a seam of biotite around the quartz pods [2, 3].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	Palaeoproterozoic mineralisation in Archaean terrain?
Genetic reasoning	
Tentative FinU model	Intrusive/migmatite neosome/pegmatite/quartz vein

References

1 Geologinen tutkimuslaitos 1976. Kertomus toiminnasta vuonna 1975. Summary: Annual report on the activities of the Geological Survey of Finland for the year 1975.

2 Pekkarinen, L.J. 1979. The Karelian formations and their depositional basement in the Kiihtelysvaara - Värtsilä area, East Finland. Geological Survey of Finland. Bulletin 301. 141 p.

3 Anon. 1981. IUREP (International Uranium Resources Evaluation Project) orientation phase mission report: Finland. OECD Nuclear Energy Agency. 104 p.

4 Väänänen, P. 1976. Eronlampi: uranium and radiation determinations from till samples. Journal of Geochemical Exploration 5, 214-218.

Deposit

Name **Ylipää-S**

FinU_ID	33
ID of Malmikanta	539
Last updated	14. 7.2000
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Savo schist belt (Central Ostrobothnia area) [3]

- [ ] U- deposit?
- [x] U as by-product?
- [ ] Th- deposit?

Location

Map sheet	2441 11 A			
Coordinates	X (KKJ)	7170450	Latitude	64.63022
	Y (KKJ)	2534600	Longitude	24.71967
Municipality	Pattijoki			
Village	Kastellinperä			
Nearest town	16 km ESE of Raahe			
Access	200 m to dirt road			

Resources/Mining

Reservation	In quarantine: claim reservation expired in May, 2000.
Exploration license number	2772/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Outokumpu Oy 1977-81
Status of development	Drilled deposit
Economic evaluation	No economic value as a zinc deposit [2]; nor does the uranium occurrence have any economic significance.
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Weakly radioactive uraniferous and phosphatic rock was found in two drill holes as an about 10 m thick zone [2].
Extent of mineralisation	
Lodes	

Exploration

Year of discovery	1977
Discovery	Primarily a zinc prospect, discovery based on layman's samples from sphalerite-bearing boulders in the mid-1950s [2]. Uraniferous phosphorite was found in drill core during regional exploration in the surroundings of the Vihanti zinc mine by Outokumpu [1, 2].
Case history	GTK, exploration since mid-1950s: diamond drilling in the area [2]. Malminetsijä Oy, late 1960s [2]. Outokumpu 1960s (?), 1977, 1981: ground magnetic and electromagnetic survey, diamond drilling [2].
Diamond drilling	GTK: 4 holes/492 m; Malminetsijä: 1 hole/181 m; Outokumpu: 4
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	By AAS: Cu, Zn, Ni, Co, Pb, Ag, S [2]
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Outokumpu: T. Mäkelä, J. Vesanto [2]

Ore

Ore minerals	
Accessory ore minerals	
Gangue	
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	No information on the mode of occurrence of uranium. This showing belongs to the same cluster of uraniferous phosphorites as Vihanti-U at Lampinsaari [1].
U/Th	
Enriched elements	U, P
Stable isotopes	
Pb isotopes	

Geology

Geological setting	An unexposed sequence of "Lampinsaari type rocks" consisting of quartz-feldspar schist, calc-silicate rocks and dolomite, graphite gneiss, mica gneiss, and biotite-hornblende gneiss, with some interfingering granodiorite gneiss [2].
Host lithology	Phosphatic calc-silicate rocks, dolomite, and quartz-feldspar schists. This uraniferous zone occurs next to the S of the sphalerite-bearing zone, both parallel to the strike of their host rocks. These host rocks are interpreted

	as calcareous felsic volcanics [2].
Intrusions	Granite, aplite granite and diorite veins or dykes in drill cores [2]

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	
Genetic reasoning	Sedimentary; uranium bound in phosphorite and phosphate in a volcanic-sedimentary sequence.
Tentative FinU model	Metamorphic phosphorite

References

1 Rauhamäki, E. 1979. Vihannin kaivoksen uraani-fosforimineralisaatio. In: Parkkinen, M. (ed.) Uraaniraaka-ainesymposiumi (1979). Vuorimiesyhdistys. Sarja B 27, 65-79. (in Finnish)

2 Vesanto, J. 1982. Kaivoslain 19 §:n mukainen tutkimustyöselostus. Pattijoki, Ylipää III 2441 11 A. Outokumpu Oy Vihannin kaivos, unpublished report 080/2441/JJV/82, 2 p. (in Finnish)

3 Kousa, J., Luukas, J., Mäki, T., Ekdahl, E., Pelkonen, K., Papunen, H., Isomäki, O.-P., Penttilä, V.-J. & Nurmi, P. 1997. Geology and mineral deposits of the central Ostrobothnia. Geological Survey of Finland. Guide 41, 43-67.

Deposit

Name **Manderbacka**

FinU_ID	34
ID of Malmikanta	540
Last updated	
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Pohjanmaa schist belt

U- deposit?	☑
U as by-product?	☐
Th- deposit?	☐

Location

Map sheet	2314 09 B			
Coordinates	X (KKJ)	7039795	Latitude	63.45945
	Y (KKJ)	2481400	Longitude	23.62345
Municipality	Kruunupyy			
Village	Manderbacka; Småbönders			
Nearest town	14 km SW of Veteli, 20 km NE of Evijärvi			
Access	100 m from dirt road			

Resources/Mining

Reservation	
Exploration license number	2541/1-2
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1975-76
Status of development	Drilled prospect
Economic evaluation	
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Drill core: 0.5 m at 0.026 % U, 0.003 % Th
Extent of mineralisation	Not known; some 30 radioactive erratics and weakly uraniferous sections in one drill core are the only indications of mineralisation.
Lodes	

Exploration

Year of discovery	1976
Discovery	Outokumpu 1965: ground scintillometry, three radioactive boulders found at Vistbacka, 3.5 km SSE of Manderbacka occurrence. GTK 1974: radiometric boulder tracing - new boulders at Manderbacka; discovery by drilling 1976.
Case history	Outokumpu 1965-66: boulder tracing, ground radiometrics, geological mapping, trenching. GTK 1974-76: geological mapping, boulder tracing, magnetic and EM ground survey, carborne spectrometry, ground scintillometry, Rn emanometry, diamond drilling.
Diamond drilling	GTK 1976: three drill holes (491 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	U, Th, P, Cu, Ni, Co, Zn, S
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Outokumpu: A. Huhma GTK: B. Lindmark

Ore

Ore minerals	Uraninite?, apatite
Accessory ore minerals	Pyrrhotite
Gangue	Quartz, feldspars, carbonate, diopside
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	
U/Th	8.7
Enriched elements	U, P, Fe, S
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Mafic metavolcanic rocks (lavas; agglomerate) of the Isokylä belt with pyroclastics, metatuffs and carbonate-bearing calc-silicate rocks in the eastern part of the belt [2, 3]. The Isokylä belt is surrounded by metagraywackes. The Manderbacka occurrence is situated in the NW part of the belt.
Host lithology	In drill core: 100 m calcareous arkosite, 15 m calcareous amygdaloidal metavolcanic rock, 30 m calc-silicate rock, 20 m intermediate

agglomerate and tuffite [1]. The host unit is the arkosite with phosphatic interbeds containing radioactive portions 0.5-2 cm thick (core lengths).

Intrusions	Minor veins of pegmatitic granite in the sequence

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model	Metamorphic phosphorite

References

1 Lindmark, B. 1977. Raportti uraanitutkimuksista Räyringin ja Småböndersin välisessä vulkaniittivyöhykkeessä Vetelin ja Kruunupyyn kunnissa v. 1974-1976. Geological Survey of Finland, unpublished report M19/2314/77/1/10. 17 p. (in Finnish)

2 Pipping, F. & Vaarma, M. 1992. Evijärvi. Geological Map of Finland 1:100 000, Pre-Quaternary Rocks, sheet 2314. Geological Survey of Finland.

3 Vaarma, M. & Pipping, F. 1997. Alajärven ja Evijärven kartta-alueiden kallioperä. Summary: Pre-Quaternary rocks of the Alajärvi and Evijärvi map-sheet areas. Geological Map of Finland 1:100 000, Explanation to the maps of Pre-Quaternary Rocks, sheets 2313 and 2314. Geological Survey of Finland. 83 p.

4 Loukola-Ruskeeniemi, K. 1991. Suomen proterotsooisten mustaliuskeiden uraanipitoisuudesta. 2 p. Geological Survey of Finland, unpublished report M19/3344/-91/1/30. (in Finnish)

Deposit

Name **Losonvaara**

FinU_ID	35
ID of Malmikanta	555
Last updated	18. 7.2000
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kainuu schist belt

U- deposit?	☑
U as by-product?	☐
Th- deposit?	☐

Location

Map sheet	3433 01 B			
Coordinates	X (KKJ)	7107500	Latitude	64.06472
	Y (KKJ)	3543250	Longitude	27.88243
Municipality	Sotkamo			
Village				
Nearest town	23 km SSE of Kajaani			
Access	Forest roads to the area			

Resources/Mining

Reservation	
Exploration license number	2382/1-2
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Outokumpu Oy 1972-75 [1]
Status of development	Drilled prospect
Economic evaluation	No economic value [1, 3]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.036
% Th	
U production (tonnes)	
Best section(s)	Average content in the Losonvaara boulder samples 0.035 % U; range in samples from Kokkomäki trenches from 0.02 to 0.12 % U; in Losonalussuo drill core 14 m at 0.036 % U, 0.07 % Cu and 2.8 % P2O5 [3].
Extent of mineralisation	Two separate prospects are known 1.5 km apart; no lateral extent can be given for these.

Lodes	Kokkomäki: uraniferous phosphatic rocks were exposed in trenches and verified with two drill holes. Dipping 60-70 degrees to the S, this lode is stratiform and 15-20 m thick, extending to the depth of 100 m. The lateral extent remains unknown. Losonalussuo: uraniferous rocks were intersected in one drill core only, and no dimensions are given for this prospect [1, 3].

Exploration

Year of discovery	1972
Discovery	In 1959, a field group of Atomienergia Oy reported weakly radioactive, sulphide-bearing boulders from the slopes of Losonvaara. Outokumpu Oy carried out radiometric boulder tracing here in 1966 and again in 1971, when the boulders were re-found at Rikkola. In 1972 radioactivity was found in bedrock at Kokkomäki, almost 4 km NW of Rikkola.
Case history	Outokumpu 1971: detailed radiometric boulder tracing - Losonvaara boulder train located. 1972-75: extended ground radiometrics - discovery of Kokkomäki prospect; trenching; geological mapping; pedogeochemical sampling - U anomaly at Losonalussuo; diamond drilling - discovery of Losonalussuo prospect [3]. GTK 1977: pedogeochemical sampling to the N of the Losonalussuo prospect.
Diamond drilling	Outokumpu 1973-75: nine drill holes (1471 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Over 100 radioactive boulders constitute a narrow train 2 km long from Rikkola to the NW, ending at the western slopes of Losonvaara. No natural outcrops of uraniferous rock have been found in the area.
Geochemical dispersion	
Geologist(s)	Outokumpu: R. Sarikkola GTK: P. Ervamaa

Ore

Ore minerals	Uraninite, apatite
Accessory ore minerals	Pyrrhotite, chalcopyrite, pyrite, molybdenite; unidentified secondary uranium minerals
Gangue	Biotite, quartz, amphibole; tremolite, diopside,scapolite; chlorite, fluorite
Composition of minerals	From apatite concentrate: 950 ppm U in apatite [5]
Texture and fabrics of ore	Fresh, euhedral uraninite (<0.01 mm) occurs as inclusions in apatite, biotite and pyrrhotite, and as intergranular grains between apatites. In biotite, titanite and apatite there are also non-opaque radioactive inclusions of an unidentified mineral or minerals of the same size.

	Minor secondary radioactive minerals form yellow, isotropic intergranular masses in a few surface specimens.
Composition of ore	Very low thorium content: nil in five phosphatic samples analysed
U/Th	
Enriched elements	U, P, F, Cu, Mo
Stable isotopes	
Pb isotopes	

Geology

Geological setting	The rocks in the area comprise Archaean basement gneiss and local equivalents of the metasediments of the Palaeoproterozoic Vuokatti and Sotkamo Groups [6]. Zones of black schist locally associated with calc-silicate rocks follow the folded main body of the Sotkamo Group metaturbidites near the Vuokatti Group quartzites.
Host lithology	Kokkomäki - three main types can be distinguished: biotite rock, biotite-apatite rock and biotite-amphibole-apatite rock, occurring as 0.5-1 m thick interlayers in calcareous quartzites. Losonalussuo: a 20-cm section of fine-grained, dark grey metaphosphorite composed of granular apatite (<0.1 mm); plagioclase, biotite, quartz, and pyrite. More common are phosphatic calc-silicate rocks with scattered disseminations of pyrite and with varying amounts of apatite and different calc-silicate minerals. Pale green amphibole, diopside and calcic plagioclase are the most common of these, with characteristic porphyroblastic sphene. In the Losonvaara boulders the main types of uraniferous rocks are phosphatic calc-silicate rocks and metaphosphorite.
Intrusions	Metadiabase dykes and other mafic sills occur along the unconformity between the Archaean basement and the Vuokatti Group quartzites. The Palaeoproterozoic Kajaani granite west of this area is represented here by a number of tourmaline- and beryl-bearing pegmatite bodies.

Metamorphism/Deformation/Alteration

Metamorphic history	Syndeformational metamorphism in conditions of amphibolite facies. A retrograde metamorphic phase possibly associated with the emplacement of the Kajaani granite.
Metamorphic index minerals	Garnet and staurolite in metaturbidites
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Metamorphic phosphorite

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Deposit

Name **Onkimaa**

FinU_ID	36
ID of Malmikanta	611
Last updated	
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Granite migmatite belt of southern Finland

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	2044 10 B
Coordinates	X (KKJ) 6718100 Latitude 60.5667 Y (KKJ) 2573600 Longitude 25.33883
Municipality	Mäntsälä
Village	
Nearest town	8 km S of Mäntsälä, 56 km NNE of Helsinki
Access	50-150 m to main roads, dirt roads to the deposit

Resources/Mining

Reservation	
Exploration license number	1217/1, 2440/1-2
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Private prospector 1957-59 GTK 1974-77
Status of development	Drilled prospect
Economic evaluation	GTK 1974, in situ -resources 320 t U3O8; non-economic deposit [2]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	2.72
Contained U (tonnes; in situ)	272
% U	0.01
% Th	
U production (tonnes)	
Best section(s)	Best drill core sections: 0.022-0.04 % U
Extent of mineralisation	1-2 m wide, 1 km long zone of radioactive rock
Lodes	20 m by 500 m tentative ore body (most uniform part of the mineralised zone), evaluated to the depth of 50 m [2]

Exploration

Year of discovery	1972
Discovery	Radioactivity in bedrock, found in 1972 during carborne radiometric survey carried out by a contractor (Suomen Malmi) for GTK.
Case history	1972-73: ground radiometrics and Rn survey; detailed radiometrics & geological mapping; diamond drilling.
Diamond drilling	GTK 1972-73: 8 drill holes
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: H. Appelqvist

Ore

Ore minerals	Uraninite
Accessory ore minerals	Zircon, molybdenite
Gangue	Quartz, feldspars, biotite
Composition of minerals	Identified by microprobe [2]
Texture and fabrics of ore	
Composition of ore	
U/Th	3
Enriched elements	
Stable isotopes	
Pb isotopes	Synorogenic granodiorite 1873+-16 Ma, late orogenic pegmatite granite 1835+-28 Ma [6]

Geology

Geological setting	Onkimaa granodiorite, with a diameter of 9 km, was found to host several radioactive occurrences. The best of these - the Onkimaa deposit - is located at the NW contact of the granodiorite body, against the upright, migmatitic mica gneiss of this area [1, 2]
Host lithology	The uraniferous rock is coarse-grained, in places quartzose granodiorite or pegmatitic granite that forms a set of several metres thick veins at the contact between the Onkimaa granodiorite and the migmatitic mica gneiss [1, 2]
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	
Genetic reasoning	Uranium mineralisation syngenetic with late orogenic pegmatite dykes [6]
Tentative FinU model	Intrusive/migmatite neosome/pegmatite

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Deposit

Name **Palmottu**

FinU_ID	37
ID of Malmikanta	614
Last updated	28.12.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Granite migmatite belt of southern Finland

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	2023 09 D
Coordinates	X (KKJ) 6707350 Latitude 60.47672
	Y (KKJ) 2487440 Longitude 23.76838
Municipality	Nummi-Pusula
Village	
Nearest town	15 km E of Pusula; 80 km NW of Helsinki
Access	Gravel road to the area

Resources/Mining

Reservation	
Exploration license number	3243/1-2, 3312/1, 5165/1, 6313/1
Mining concession number	
Holder of mineral rights	GTK (claim "Palmottujärvi 1", expiring 2001); Palmottu deposit is open for acquisition
Previous holders	GTK
Status of development	Drilled prospect
Economic evaluation	GTK: in situ estimate down to the depth of 200 m. Not economically feasible [9]
Red Book class	RAR 80-130 $ kg/U
Mining operations	
Ore (million tonnes; in situ)	1.083
Contained U (tonnes; in situ)	1000
% U	0.11
% Th	
U production (tonnes)	
Best section(s)	The uraniferous pegmatite and granite veins contain 0.1-0.2 % U (with 0-0.1 % Th). The thickness of these veins varies from less than one metre to almost 30 m in the best cross section [9].

Extent of mineralisation	
Lodes	The main orebody is discontinuous with a total length of 400 m and thickness from 1 to 15 metres. The dip of the orebody is 225/80, plunge 315/30; the depth dimension reaches down to 300 metres [2, 9]. Later drillings showed that the mineralisation continues below the depth of 450 m [8].

Exploration

Year of discovery	1980
Discovery	Airborne geophysical survey in 1979. Ground follow-up of aeroradiometric gamma anomalies by GTK in 1980 [1, 9]
Case history	GTK 1980-84: geological mapping, radiometric boulder tracing, geophysical and geochemical survey, percussion drilling, trenching, diamond drilling; prospecting in the surroundings looking for similar targets [2, 9]. Beginning 1988, the Palmottu Analogue Project has been studying the deposit [3-6].
Diamond drilling	GTK: 1981-84 62 drill holes (9.1 km), 1994-96 15 drill holes
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	Airborne: U & Th channel anomaly
Magnetic Response	Airborne & ground magnetics
Electromagnetic response	Airborne & ground (VLF, Slingram) EM surveys
Other geophysics	Drill hole logging; seismic survey
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: E. Räisänen, R. Blomqvist

Ore

Ore minerals	Uraninite
Accessory ore minerals	Coffinite, monazite, zircon, apatite Molybdenite, pyrrhotite, pyrite
Gangue	Silicates
Composition of minerals	High-Th uraninite and coffinite [4, 6-8]; uraninite is altered into uranium silicate phases along the borders and fractures.
Texture and fabrics of ore	Impregnation of euhedral uraninite with average grain size less than 0.3 mm. Uranium is associated with the parts of rock rich in biotite [4,6].
Composition of ore	
U/Th	2
Enriched elements	
Stable isotopes	
Pb isotopes	Discordant dates from uraninites, 1741 and 1678 Ma [6, 9]

Geology

Geological setting	Migmatitic metasediments and metavolcanics, intruded by granitic rocks [9]
Host lithology	The host rocks are coarse-grained feldspar-quartz-biotite pegmatites and sheared veins of guartzose granite rich in biotite [2, 9].
Intrusions	Extensive Perniö granite is located a few km to the W and NW of Palmottu [2, 3, 9]

Metamorphism/Deformation/Alteration

Metamorphic history	Granulite facies conditions (west Uusimaa granulite complex [5]; regional metamorphism & migmatisation during the Svecokarelian orogeny 1.9-1.8 ga ago. Uranium mineralisation related to the latest orogenic events 1.8-1.7 Ma ago.
Metamorphic index minerals	Garnet, hypersthene, cordierite in mica gneiss [4]
Deformation history	Three to four deformation phases; major shear zones and hinges of folds favoured uranium mobilisation and concentration [2, 5]. In a more detailed scale, there is a block structure in the bedrock [5].
Alteration of rocks	A secondary silicate mineral, possibly coffinite forms alteration rims around uraninite [6, 8]. Young secondary uranium minerals (uranophane) in fractures [8].
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	The deposit is located at the SE corner of the lake Iso-Palmottu, partly under the lake.
Radioactive hazards	Introduction of uranium into the ground water has been studied by the Palmottu Analogue Project [3-8, 10, 11].
Geochemical hazards	
Restoration	

Conclusions

Timing	Late orogenic Perniö granite west of Palmottu: 1830 Ma [9]
Genetic reasoning	
Tentative FinU model	Intrusive/migmatite neosome/pegmatite

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Deposit

Name **Pahtavuoma-U**

FinU_ID	38	U- deposit?	☑
ID of Malmikanta	662	U as by-product?	☐
Last updated	28.12.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Vein deposit		
Eon or Era	Palaeoproterozoic		
Geological domain	Karelian		
Geological province	Kittilä greenstone area of the Central Lapland Greenstone Belt		

Location

Map sheet	2741 04 A			
Coordinates	X (KKJ) 7523670		Latitude	67.79939
	Y (KKJ) 2510490		Longitude	24.24437
Municipality	Kittilä			
Village	Muotkavaara			
Nearest town	38 km NW of Kittilä, 180 km NNW of Rovaniemi			
Access	Gravel road to the area. Railway at Rautuvaara within a distance of 60 km			

Resources/Mining

Reservation	Expired June, 2000
Exploration license number	2240/1-4
Mining concession number	2240/1a
Holder of mineral rights	Outokumpu Mining Oy
Previous holders	
Status of development	Deposit
Economic evaluation	Two best lodes total 140000 tonnes ore (in situ), grading 0.39 % U; technical estimate gives 300000 tonnes with 0.19 % U [2].
Red Book class	
Mining operations	The Pahtavuoma Cu-Zn-U deposit contained four separate copper orebodies and six zinc orebodies; two of the copper orebodies have been mined out during the operations of the nearby Saattopora gold mine [3, 6].
Ore (million tonnes; in situ)	0.3/0.03 % U
Contained U (tonnes; in situ)	
% U	0.19
% Th	
U production (tonnes)	
Best section(s)	Drill core section: 0.53 m at <8 % U [2]

	Glacial erratics from lode UI: 0.1-16 % U, 0.1-3 % Mo; the diameters of the boulders are not more than 20 cm [10]
Extent of mineralisation	The three known uranium orebodies cover an area of 150 m by 700 m within the Pahtavuoma Cu-Zn-U deposit. Uranium exploration by GTK showed that anomalous zone including the Pahtavuoma orebodies extends over 2 km in length [9, 10].
Lodes	U-I, U-II and U-III. The lodes are thin, subvertical veins (lenses), with thicknesses varying from a few cm to several metres. The lengths of the lodes are 100 m, as are their depths, too. Each lode is composed of more than one parallel vein, in which uranium occurs in rich pods or nests [2]. According to the glacial erratics, the ore types for these lodes are: U I - U-Mo; U II - U-(Mo); U III - U-(Mo). Two other outcropping lodes were located, with PI - U-(Mo) and PII - U-Zn [10].

Exploration

Year of discovery	1971
Discovery	Radioactivity was detected in drill cores by Outokumpu during exploration for copper ore [2].
Case history	About 10 years of exploration by Outokumpu in the Kittilä area before the discovery of copper ore at Pahtavuoma in 1970 [2]. Since 1971: ground radiometrics, airborne radiometric test (1972 [1]), Rn test surveys, pre-concentration tests [2]. GTK 1982-85: follow-up of aeroradiometric gamma anomalies revealed rich uraniferous boulders N of Pahtavuoma-U; these were traced to their sources in bedrock, resulting in discoveries of new mineralisations in addition to the three located previously by Outokumpu [9, 10].
Diamond drilling	Outokumpu: 1971-
Drill core availability	GTK/Loppi: >50 drill cores from the years 1971-74
ElementsAnalysed	
Radiometric response	Exposures (outcrop in trench) produce gamma anomalies on uranium channel maps [1]
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Complicated system of glacially transported ore boulders [9-15]
Geochemical dispersion	
Geologist(s)	Outokumpu: R. Sarikkola, O. Inkinen, T. Korkalo GTK: K. Pääkkönen, M. Kvist

Ore

Ore minerals	Uraninite, pitchblende [4, 10]
Accessory ore minerals	Thucolite Pyrrhotite, chalcopyrite, molybdenite, ilmenite, arsenopyrite, galena, sphalerite, native silver, magnetite [2, 10]
Gangue	Carbonate [39], brown amphibole, quartz [10]
Composition of minerals	

Texture and fabrics of ore	Fine-grained uraninite occurs in thin veins in association with pigmentous graphite and hematite [4]. Intergrowths of uraninite, thucolite, pyrrhotite and molybdenite [2]. [10]: U-Mo type: subrounded uraninite < 0,2 mm in diameter; pitchblende veinlets and clusters, in places colloidal with microflakes of molybdenite. U-Zn type: ore minerals as veins or clusters, with magnetite as idiomorphic grains or stripes, and uraninite grains as stripes or as in matrix of microbreccia.
Composition of ore	Low Th; U in a vein 1.5 % [4]
U/Th	
Enriched elements	U, Cu, Ag, Mo
Stable isotopes	
Pb isotopes	Uraninite 1781+-68 Ma [4]; the sample (A766) is from a granitic vein cutting the Cu ore [17]

Geology

Geological setting	Savukoski Group metasediments of the Pittarova Formation, in the south overlied (with an overturned contact [3]) by mafic volcanics of the Linkupalo Formation, in the north linked by a thrust fault into younger volcanics of the Kittilä Group [7, 8].
Host lithology	Carbonate veins and skarn breccias in chloritic and micaceous schists, graphitic phyllites, and metacherts [3, 6]. Two main types at Pahtavuoma according to the ore boulders [10]: U-Mo type veins are composed of ore minerals, amphibole, and quartz, cutting across mylonitic albite schist, mica schists and phyllites. U-Zn type ore occurs in carbonate- and calc-slicate-bearing albite-amphibole schist.
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	The metamorphic grade increases from upper greenschist to amphibolite facies from the east to the west in the area [3, 10].
Metamorphic index minerals	
Deformation history	The uraniferous veins at Pahtavuoma are connected to shear zones/ fractures younger than the main deformational event. These veins show a low angle with bedding [10].
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	The area belongs to the Natura programme as part of the "Ylläs-Aakenus" protection area (http://www.vyh.fi/luosuo/n2000/lap/kittila.htm).
Watersheds	
Radioactive hazards	
Geochemical hazards	

Restoration	The old trench of lode UIII is covered with soil [FinU field trip 2000].

Conclusions

Timing	A late phase of metamorphism associated with postorogenic granitic intrusions together with isotopic dates from various uranium mineralisations suggest that uranium was mobile in Lapland about 1780 Ma ago [17].
Genetic reasoning	
Tentative FinU model	Vein?

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Deposit

Name **Ruunaniemi**

FinU_ID	39
ID of Malmikanta	663
Last updated	
Link to Fingold	
Red Book geologic setting	Sandstone deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Koli area

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	4242 03 B		
Coordinates	X (KKJ) 6979530	Latitude	62.91945
	Y (KKJ) 4501220	Longitude	30.02082
Municipality	Eno		
Village	Hutunvaara		
Nearest town	53 km N of Joensuu		
Access	Airport at Joensuu; 700 m from gravel road		

Resources/Mining

Reservation	
Exploration license number	3010/1
Mining concession number	1443/2a, 1443/3-5a
Holder of mineral rights	Open for acquisition
Previous holders	Atomienergia Oy: concessions 1963-72 Outokumpu Oy: claim 1979-84
Status of development	Drilled prospect
Economic evaluation	By Outokumpu in the 1960s
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	0.112
Contained U (tonnes; in situ)	157
% U	0.14
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	Ruunaniemi represents the stratabound uranium deposits on the western shore and under the lake Ylä-Paukkaja. Three separate deposits are listed in the Outokumpu files: Sikovaara, Ruunaniemi, and Paukkajanjärvi, covering an area of about 0.5 km by 1 km. These are

	also described as the ore deposits of Ylä-Paukkajanjärvi [3].
Lodes	

Exploration

Year of discovery	1957
Discovery	Radiometric ground survey by Atomienergia in the late 1950s produced over 600 uraniferous erratic blocks in the area south and southeast of lake Ylä-Paukkaja [6]. First radioactive outcrop was located in 1957 [3].
Case history	Atomienergia 1957-1960: boulder tracing; ground radiometrics; geological mapping Outokumpu: 1961-63, 1968: geological mapping; Rn emanometry; trenching; diamond drilling
Diamond drilling	Outokumpu: 47 drill holes
Drill core availability	GTK/Loppi: 37 drill cores, 1961-62 and 1968
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Over 600 uraniferous erratic SE of the lake
Geochemical dispersion	
Geologist(s)	Outokumpu: A. Huhma

Ore

Ore minerals	Pitchblende, coffinite [5], hematite
Accessory ore minerals	Uranophane, magnetite, goethite
Gangue	Quartz, sericite
Composition of minerals	Uraniferous goethite: 2.1 % Al_2O_3, 15.9 % SiO_2, 1.1 % V_2O_3, 53.2 % Fe_2O_3, 27.6 % UO_2 [5] Vanadiferous magnetite (coulsonite) and muscovite (roscoelite) [3, 6]
Texture and fabrics of ore	Fine-grained mass of pitchblende and goethite cementing rounded quartz clasts [3, 6]
Composition of ore	
U/Th	
Enriched elements	U, V, Fe
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Quartzite Mb of the Koli Fm in the Jatulian Herajärvi Group metasediments [1]
Host lithology	Hematite-stained quartzite

Intrusions	Mafic dykes (metadiabase) cut the metasedimentary sequence regionally

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	Partly under the lake Ylä-Paukkaja
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Palaeoproterozoic sandstone deposit

References

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Deposit

Name **Temo**

FinU_ID	40
ID of Malmikanta	672
Last updated	18. 7.2000
Link to Fingold	
Red Book geologic setting	Phosphorite deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kuopio area; Palaeoproterozoic cover on the Archaean craton

- [x] U- deposit?
- [ ] U as by-product?
- [ ] Th- deposit?

Location

Map sheet	3333 02 D
Coordinates	X (KKJ) 6997000 Latitude 63.07323
	Y (KKJ) 3545800 Longitude 27.90274
Municipality	Nilsiä
Village	Murtolahti
Nearest town	25 km E of Siilinjärvi, 50 km NE of Kuopio
Access	Paved road to the area

Resources/Mining

Reservation	GTK: claim reservation 1977-78
Exploration license number	1735/1-31, 2138/1-2
Mining concession number	
Holder of mineral rights	Open for acquisition.
Previous holders	Outokumpu Oy 1963-71
Status of development	Drilled prospect
Economic evaluation	Uneconomic occurrence because of the discontinuities and diluting barren interbeds and dykes [1, 7, 8]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.015
% Th	
U production (tonnes)	
Best section(s)	Samples across mineralized zones (exceeding 3 % P2O5) in trenches by Outokumpu: 3-7 m at 0.003-0.055 % U, 3-4.5 % P2O5. Radioactive drill core sections (GTK) vary from 10 m to 28 m, for instance 18.8 m at 0.028 U (including 6.25 m at 0.053 U).
Extent of mineralisation	Discontinuous, NE striking uraniferous zone covering an area 50-200

	m by 3.5 km [7]
Lodes	Due to folding and faulting, the uraniferous zone is split into four or five subprospects [1, 7]

Exploration

Year of discovery	1963
Discovery	Pyrrhotite-bearing specimen blasted by local farmers from rusty outcropping bedrock and sent to Outokumpu, where the radioactivity was found. Additional samples from the site were found uraniferous and phosphatic in addition to their contents of pyrrhotite and chalcopyrite [1].
Case history	Outokumpu: 1964-66: detailed radiometric survey, geological mapping, ground magnetic, electromagnetic and gravimetric survey. Uncovering of radioactive outcrops; trenching; detailed radiometric mapping of outcrops; litogeochemical percussion drill sampling, detailed geological mapping; diamond drilling; concentration tests [1]. 1974-75: geological mapping, lithogeochemical sampling [2]. GTK 1976-77: geological mapping; Rn test survey (Alpha meter); diamond drilling [5, 7]. 1979-80: low-altitude aerogeophysical survey. Helsinki University: bacterial leaching tests [12-15].
Diamond drilling	Outokumpu 1965-66: four drill holes (793 m) [1]
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	Due to the uncovering of outcrops and trenches, the Temo occurrences stand out distinctly on aeroradiometric U channel maps.
Magnetic Response	The uraniferous zone coincides with magnetic anomalies due to the occurrence of pyrrhotite in the host rocks and wall rocks.
Electromagnetic response	On electromagnetic maps, anomalies due to graphitic mica gneiss and layers of black schist largely outline the uraniferous zone in the SE.
Other geophysics	Gravimetric ground survey delineated the body of anorthositic gabbro
Glacigenic dispersion	Glacial transport from NW is evident on the basis of numerous radioactive boulders, derived from the Temo occurrences, forming several separate boulder fans to the SE of the uraniferous zone.
Geochemical dispersion	Poor response on lake sediment survey as well as in test profiles of organic soil samples
Geologist(s)	Outokumpu: A. Huhma, J. Saastamoinen [1], O. Äikäs [2] GTK: O. Äikäs [2, 5, 11]

Ore

Ore minerals	Uraninite, apatite
Accessory ore minerals	Pyrrhotite, pyrite, chalcopyrite
Gangue	Diopside, tremolite, plagioclase, quartz, biotite, carbonate
Composition of minerals	From apatite concentrate: 295 ppm U, 1.1 ppm Th and 530 ppm U, 0.7 ppm Th in apatite [9]
Texture and fabrics of ore	
Composition of ore	

U/Th	
Enriched elements	U, P, Ba, Cu
Stable isotopes	
Pb isotopes	Whole rock Pb date: 1876+-2 Ma [6]

Geology

Geological setting	Southern part of the NE and N trending Jatulian Nilsiä quartzite belt, with a tectonic, in places overturned contact with the Archaean basement in the W. Temo occurrence is situated in an assemblage of dolomite, calc-silicate rock, and amphibolite on the SE side of the quartzite, stratigraphically overlying the quartzite and underlying migmatitic mica gneisses further SE.
Host lithology	Uranium occurs in three main lithologies: phosphorite lenticles and bands in dolomite and calc-cilicate rock; phosphatic calc-silicate rock; and fine-grained, phosphatic quartz-feldspar gneiss. All of these occur as interbeds and interfingering layers within the calcareous lithologies and layers of amphibolite (mafic volcanics).
Intrusions	Numerous dykes and veins of tonalite, granite and pegmatitic granite intersect the supracrustal rocks as well as the Archaean basement gneisses. A conformable body of anorthositic gabbro lies within the mica gneiss close to the deposit. The mica gneiss is intruded and partly migmatised by a medium to coarse-grained tonalite.

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	Garnet
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	The NE part of the Temo uraniferous zone intersects an active farming area, with the village school situating 150 m off the zone.
Protection areas	
Watersheds	Three ponds and a small lake occur in the area of the uraniferous zone
Radioactive hazards	
Geochemical hazards	
Restoration	The three long trenches from 1965 are uncovered although partly caved in

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Metamorphic phosphorite

References

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Deposit

Name **Riutta**

FinU_ID	41
ID of Malmikanta	673
Last updated	
Link to Fingold	
Red Book geologic setting	Unconformity-related deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Koli area

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	4242 02 B
Coordinates	X (KKJ) 6967960 Latitude 62.81564
	Y (KKJ) 4501510 Longitude 30.02643
Municipality	Eno
Village	Riutta
Nearest town	29 km NE of Joensuu, 7 km NW of Eno
Access	Airport at Joensuu. Gravel road to the deposit, distance from paved road 4 km

Resources/Mining

Reservation	
Exploration license number	1313/12, 14, 17, 20, 23, 24, 27; 3495/1
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Atomienergia Oy 1958-63 Geological Survey of Finland (GTK) 1983-88
Status of development	Drilled prospect
Economic evaluation	
Red Book class	
Mining operations	Test pit ("Ristimonttu") by Atomienergia
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Drill core from Unimonttu: 3.6 m at 0.93 % U. Highly radioactive boulders and blocks from Unimonttu: 1-15 % U, lower grade blocks 0.03-1 % U [5] Atomienergia located several hundreds of radioactive erratics at Riutta,

	with almost a hundred of these exceeding 1 % U [5].
Extent of mineralisation	Pitchblende veins in bedrock within a length of 0.5 km, in three different locations
Lodes	Three occurrences of uranium in bedrock (from N to S): Ristimonttu, Unimonttu (exploration pit/trench, now covered), and a group of shallow trenches S of Unimonttu ("Kolmosviuhka") [5]

Exploration

Year of discovery	1958
Discovery	Radiometric groung survey by Atomienergia in the Koli quartzite belt
Case history	Atomienergia: radiometric boulder tracing; geological mapping; Rn emanometry; trenching; diamond drilling; test pit. Outokumpu: diamond drilling. GTK: U determinations from stream sediment samples of Outokumpu; geological mapping, Rn survey (alphameter); trenching, seismic survey; diamond drilling.
Diamond drilling	Atomienergia: 18 drill holes; Outokumpu: 15 holes; GTK: 24 holes
Drill core availability	GTK/Loppi: 57 cores, including all GTK cores
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	Rn emanometry by Atomienergia [9]; Rn survey by GTK [5]. Seismic survey by Atomienergia and by GTK [8].
Glacigenic dispersion	About 4 km long boulder train of 600 radioactive erratics was located by Atomienergia [3, 4]. At least 100 of these blocks contained 1 % or more U [5]. Four sub-trains can be separated, three of which with a source in bedrock [5, 7]. The mineralisations in bedrock at the heads of the boulder trains are partly covered by thick glacifluvial sands.
Geochemical dispersion	
Geologist(s)	Atomienergia: H. Wennervirta, M. Tyni Outokumpu: A. Huhma GTK: O. Äikäs

Ore

Ore minerals	Pitchblende, pyrite, magnetite, chalcopyrite [4, 5]
Accessory ore minerals	Molybdenite, roscoelite, nolanite [4, 5]
Gangue	Quartz, sericite, chlorite
Composition of minerals	
Texture and fabrics of ore	Pitchblende veins (+- sulphides) in sericite-quartz schists and (at Ristimonttu pit) in pyritic sulphide ore; at Unimonttu pit, also in compact magnetite ore blocks [4, 5]
Composition of ore	
U/Th	

Enriched elements	U, Cu, Pb, Fe, S, V, Mo, +-Au
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Arhaean basement gneisses covered by Palaeoproterozoic Kyykkä and Herajärvi Group metasediments [1]
Host lithology	The mineralised zone represents the Hokkalampi Palaeosol underlying the Herajärvi Group quartzites; at Riutta the palaeosol scavenges the Archaean gneisses [1, 4], comprising sericite-quartz schist, altered garnet-bearing amphibolite, and altered garnet-biotite-plagioclase gneiss as host rocks [5]. Poorly exposed quartzite covering the palaeosol dips gently to the west. The host rocks in the erratics found by Atomienergia in the 1950s are reported as sericite-quartz schists, chlorite schists, quartz rocks, and epidote-bearing altered mafic rocks [5].
Intrusions	Palaeoproterozoic mafic dykes including albitised metadiabases intrude the metasediments and the Archaean basement.

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	Distance from "Ristimonttu" to river Kuusioja 80 m
Radioactive hazards	Riutta was used as a correlation area for monitoring carried out at Paukkajanvaara [10]
Geochemical hazards	
Restoration	The pit "Ristimonttu" remains uncovered [11]

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Palaeoproterozoic unconformity-related deposit

References

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Deposit

Name **Revonkylä-U**

FinU_ID	44
ID of Malmikanta	
Last updated	27. 6.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit?
Eon or Era	Archaean
Geological domain	Karelian
Geological province	

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	4241 09 D
Coordinates	X (KKJ) 6948160 Latitude 62.63713
	Y (KKJ) 4525590 Longitude 30.49567
Municipality	Eno
Village	Revonkylä
Nearest town	42 km E of Joensuu
Access	Airport at Joensuu. Gravel road to the area, 7 km to paved road

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Drilled prospect
Economic evaluation	No evaluation done. On the basis of U/Th ratio much of the uranium may be in a refractory mineral [2]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	In trenches 0.102 % across 4.5 m; 0.0637 % across 7 m; 0.037 % across 7 m [2]
Extent of mineralisation	Highest radioactivity along a zone up to 70 m thick and several hundred metres long. Drilling showed no depth-persistance to the deposit [2]

Lodes	Within the zone of highest radioactivity there are small, gently-plunging pencil-shaped bodies [2]

Exploration

Year of discovery	1978
Discovery	Ground follow-up of aeroradiometric gamma anomalies beginning in 1977
Case history	1978: Ground radiometrics, geological mapping, litogeochemical sampling, pedogeochemical sampling, trenching, percussion drilling, Rn emanometry, diamond drilling [1]
Diamond drilling	1978: 12 drill holes (1124 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	
Radiometric response	Clear U channel anomaly on aeroradiometric maps [4]
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: E. Räisänen

Ore

Ore minerals	Davidite [2]
Accessory ore minerals	Molybdenite
Gangue	Biotite, quartz, plagioclase
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	
U/Th	1
Enriched elements	U, Th, Mo
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Archaean paragneisses: mainly biotite-quartz-plagioclase gneiss with interlayers of migmatitic microcline gneiss, amphibolite, garnet-bearing silicate iron formation rocks, and pods of pegmatite [2, 3]. A mapped Fe deposit (Revonkylä, Malmikanta ID 215) is situated 500 m E of Revonkylä-U.
Host lithology	Highest radioactivity occurs in tightly folded quartzose layers or zones within the paragneiss sequence [2-4].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	Tight folding [2]
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Intrusive/migmatite neosome/pegmatite/quartz vein

References

1 Geologinen tutkimuslaitos 1979. Kertomus toiminnasta vuonna 1978. Summary: Annual report on the activities of the Geological Survey of Finland for the year 1978. Espoo: Geologinen tutkimuslaitos. 81 p.

2 Anon. 1981. IUREP (International Uranium Resources Evaluation Project) orientation phase mission report: Finland. OECD Nuclear Energy Agency. 104 p.

3 Anon. 1982. IUREP (International Uranium Resources Evaluation Project) Orientation Phase mission. Summary Report: Finland. Paris: OECD Nuclear Energy Agency. 24 p.

4 Peltoniemi, M. 1979. Aeroradiometristen gammasäteilymittausten käytöstä uraaninetsintään Suomessa. In: ed. M. Parkkinen Uraaniraaka-ainesymposiumi (1979). Vuorimiesyhdistys. Sarja B 27, 99-119. (in Finnish)

Deposit

Name **Sääperi**

FinU_ID	45	U- deposit?	☐
ID of Malmikanta		U as by-product?	☐
Last updated	29. 6.2000	Th- deposit?	☑
Link to Fingold			
Red Book geologic setting	Quartz-pebble conglomerate deposit		
Eon or Era	Palaeoproterozoic		
Geological domain	Karelian		
Geological province	Kiihtelysvaara - Värtsilä area [2]		

Location

Map sheet	4232 11 A			
Coordinates	X (KKJ)	6902000	Latitude	62.22235
	Y (KKJ)	4533600	Longitude	30.64285
Municipality	Värtsilä			
Village				
Nearest town	72 km SE of Joensuu			
Access	Mineralised rock is visible at a roadcut. 8 km from railroad			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Drilled prospect
Economic evaluation	No economic significance [1]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Average of 15 specimens from outcrops: 0.0123 % U, 0.196 % Th. These represent 2-15 cm thick interbeds of radioactive conglomerate. Best drill core section: one metre at 0.002 % U, 0.01 % Th.
Extent of mineralisation	1.4 km long zone (Sääperi deposit) of discontinuous mineralization as lenticular pockets of conglomerate. Additional two mineralised areas to the NW, at the hinge of a fold.

Lodes	In the Sääperi deposit there are two separate horizons of mineralised conglomerate, with distances of 200 and 300 m from the basement (Archaean).

Exploration

Year of discovery	1972
Discovery	Ground radiometrics based on geological analogy; outcrops discovered by GTK in 1972
Case history	1971 claim reservation; 1972-73 magnetic, electromagnetic and radiometric (scintillometry) ground survey by contractor (Suomen Malmi); 1974 geological mapping and additional scintillometry; 1975 diamond drilling [1]
Diamond drilling	GTK 1975: two drill holes
Drill core availability	GTK/Loppi: both cores
ElementsAnalysed	GPS: U, Th
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: E. Räisänen

Ore

Ore minerals	Brockite, thorite [1]
Accessory ore minerals	Zircon, hematite Metamict alteration products of radioactive minerals
Gangue	Quartz, sericite
Composition of minerals	
Texture and fabrics of ore	2-15 cm thick interbeds of quartz-pebble conglomerate, where the clasts are cemented by a matrix of sericite and quartz, stained reddish by a pigmentation of hematite. The radioactive minerals are in the matric, often following fissures in the rock [1]. Thorite is detrital, brockite authigenic mineral [2].
Composition of ore	
U/Th	
Enriched elements	Th, U
Stable isotopes	
Pb isotopes	

Geology

Geological setting	[1, 2]: 150-400 m thick sequence of basal sericite quartzite member of the Lower quartzite Fm. in this area, resting unconformably on top of a nearly 100 m thick sequence of arkosic rocks (Arkosite Fm.). These

	metasediments also rest unconformably on the Archaean basement. On top of the sericite quartzite there are amygdaloidal mafic volcanic rocks.
Host lithology	The radioactive minerals occur in interbeds and pockets of quartz-pebble conglomerate within the sericite quartzite. Mostly - not always - these conglomerates are stained red by hematite. These thin beds and pockets are interfingering, showing spacing from several tens of centimeters to several metres [1].
Intrusions	Dykes of metadiabase cut across the metasediments and volcanics

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	The Sääperi belt of quartzites is a syncline, with its axis plunging gently to the south. Accordingly, the mineralised horizons dip gently towards SW.
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Quartz-pebble conglomerate

References

1 Räisänen, E. 1975. Selostus Geologisen tutkimuslaitoksen U-Th-malmitutkimuksista Värtsilässä vuosina 1972-1975. 7 p. Geological Survey of Finland, unpublished report M60/4232/75/1. (in Finnish)

2 Pekkarinen, L.J. 1979. The Karelian formations and their depositional basement in the Kiihtelysvaara - Värtsilä area, East Finland. Geological Survey of Finland. Bulletin 301. 141 p.

Deposit

Name **Luhti**

FinU_ID	46	U- deposit?	☑
ID of Malmikanta		U as by-product?	☐
Last updated	4. 7.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Intrusive deposit		
Eon or Era	Palaeoproterozoic		
Geological domain	Svecofennian		
Geological province	Granite migmatite belt of southern Finland		

Location

Map sheet	2044 10 C			
Coordinates	X (KKJ) 6712500		Latitude	60.51488
	Y (KKJ) 2581800		Longitude	25.48599
Municipality	Askola			
Village	Monninkylä			
Nearest town	20 km NNW of Porvoo			
Access				

Resources/Mining

Reservation	
Exploration license number	1254/1-2
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Imatran Voima Oy 1957-59
Status of development	
Economic evaluation	Test pit 1960 [1]
Red Book class	
Mining operations	The ore from this pit has probably been treated at the IVO Lakeakallio pilot plant in 1960.
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	
Lodes	

Exploration

Year of discovery

Discovery

Case history

Diamond drilling

Drill core availability

ElementsAnalysed

Radiometric response

Magnetic Response

Electromagnetic response

Other geophysics

Glacigenic dispersion

Geochemical dispersion

Geologist(s)

Ore

Ore minerals

Accessory ore minerals

Gangue

Composition of minerals

Texture and fabrics of ore

Composition of ore

U/Th

Enriched elements

Stable isotopes

Pb isotopes

Geology

Geological setting

Host lithology — Wall rock is a migmatitic granite, with plenty of apatite [1].

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	Small test pit from 1960 [2], the present state is unknown.

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Intrusive/migmatite neosome?

References

1 Härme, M. 1978. Keravan ja Riihimäen kartta-alueitten kallioperä. Summary: Precambrian rocks of the Kerava and Riihimäki map-sheet areas. Geological Map of Finland 1:100 000, Explanation to the map of rocks, sheets 2043 and 2044. 51 p.

2 Anon. 1999. Finland. In: Environmental activities in uranium mining and milling. Paris: OECD, 88-89.

Deposit

Name **Käldö**

FinU_ID	47
ID of Malmikanta	
Last updated	4. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Granite migmatite belt of southern Finland

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	3021 11 A
Coordinates	X (KKJ) 6692800 Latitude 60.34347 Y (KKJ) 3451300 Longitude 26.115
Municipality	Pernaja
Village	Käldö
Nearest town	31 km ESE of Porvoo
Access	Käldö island, 200 m from mainland, no roads on the island

Resources/Mining

Reservation	
Exploration license number	1118/1-8, 1168/1
Mining concession number	1150/1a
Holder of mineral rights	Open for acquisition
Previous holders	Oy Perno AB 1956-58, mining concession 1956-77
Status of development	Drilled prospect
Economic evaluation	Despite the historic pits and tests, the occurrence is non-economic: no dimensions, low grade
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.0174
% Th	
U production (tonnes)	
Best section(s)	[1, 6]: 11 drill core sections with lengths < 1 m: 0.008-0.65 % U; 7 m at 0.006-0.124 % U, averaging 0.0174 % U. 15 GTK chip samples from radioactive pods: 0.0025-0.128 % U, 0.001-0.005 % Th [4]: 10 samples, up to 0.32 % U & 0.013 % Th
Extent of mineralisation	10 to 50 m wide, 300 m long zone striking NE [4]; additional

	mineralised outcrops up to 2 km to NE along this zone [1]
Lodes	Several small nests and pods of uraniferous rocks within the mineralised zone

Exploration

Year of discovery	1956
Discovery	Private prospector in the 1950s, based on a note of radioactive well in [2].
Case history	[1]: A private company Oy Perno AB was established to study and use the discovery. In the 1950s and 1960s at least a magnetic survey and diamond drilling was carried out by a contractor, Suomen Malmi Oy in 1967[6]. Ore from a test pit was dressed in the pilot plant of Imatran Voima Oy at Lakeakallio. In 1968 Outokumpu did some field work in the area.
Diamond drilling	Perno: one 70 m "old" hole & (Suomen Malmi) five drill holes 1967 [6]
Drill core availability	Not available
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Suomen Malmi 1967: V. Hyppönen Outokumpu 1968: A. Huhma GTK 1979: H. Appelqvist

Ore

Ore minerals	Uranophane, uraninite
Accessory ore minerals	Hematite, goethite
Gangue	Sericite, chlorite, quartz, epidote
Composition of minerals	
Texture and fabrics of ore	Platings of uraninite on shear planes (fracture fillings?); very fine-grained particles of unidentified uranium minerals in completely altered rock.
Composition of ore	
U/Th	
Enriched elements	U, F, Ti, Zr, Ba
Stable isotopes	
Pb isotopes	Uraninite, 587+-39 Ma [1, 5]

Geology

Geological setting	Late kinematic microcline granite, with enclaves (relics) of amphibolite

	and mica gneiss [1, 3, 6]
Host lithology	Altered and sheared, partly mylonitic zone in the migmatitic granite; hematization is present in this zone
Intrusions	Distance between the occurrence and the Mesoproterozoic rapakivi granite in the NE is about 2.5 km along the shear zone.

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	
Alteration of rocks	Hematization in shear zone, alteration of granite to a mass of sericite, chlorite, quartz and epidote [1, 5]
Alteration of U/Th minerals	

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Intrusive/sheared & altered granite?/Olympic Dam??

References

1 Appelqvist, H. 1988. Uraanitutkimukset Pernajan Käldössä vuonna 1979. 9 p. Geological Survey of Finland, unpublished report M19/3021 11/-88/1/60. (in Finnish)

2 Nordström, G. 1917. Undersökning av källvattens radioaktivitet. Öfv. af finska vet. soc. förh. 59. A. N:o 4. 10 p.

3 Laitala, M. 1984. Pellingin ja Porvoon kartta-alueiden kallioperä. Summary: Pre-Quaternary rocks of the Pellinki and Porvoo map-sheet areas. Geological Map of Finland 1:100 000, Explanation to the maps of Pre-Quaternary Rocks, sheets 3012 and 3021. Geological Survey of Finland. 53 p.

4 Nieminen, K. & Yliruokanen, I. 1974. Trace element analysis of granitic and radioactive rocks by spark source mass spectrometry with electrical detection. Bulletin of the Geological Society of Finland 46 (2), 167-176.

5 Vaasjoki, M., Appelqvist, H. & Kinnunen, K. Palaeozoic remobilization and enrichment of Proterozoic uranium mineralization in the East-Uusimaa area, Finland. Geological Survey of Finland. Unpublished manuscript. 20 p.

6 Hyppönen, V. 1968. Uraanimalmitutkimukset Käldön saaressa 1967. Unpublished report, Suomen malmi Oy. 5 p.

Deposit

Name **Korsnäs**

FinU_ID	48
ID of Malmikanta	253
Last updated	4. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit?
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Pohjanmaa schist belt

- [ ] U- deposit?
- [x] U as by-product?
- [ ] Th- deposit?

Location

Map sheet	1242 05 B			
Coordinates	X (KKJ)	6967700	Latitude	62.81286
	Y (KKJ)	1512400	Longitude	21.23947
Municipality	Korsnäs			
Village				
Nearest town	5 km NE of Korsnäs, 45 km SW of Vaasa			
Access				

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Outokumpu Oy
Status of development	Mine, closed
Economic evaluation	
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	In addition to U and Th that occurred in the Pb ore, radioactive boulders were found SE and N of the deposit. These show two possible sources: uraninite and uraniferous apatite in Pb ore boulders in the SE cluster, and possible uraniferous phosphorite in the N cluster. The sources of these clusters in bedrock has not been found.

Lodes	The Pb ore ("Svartören") formed a platy body along the host dyke, with a thickness from 0 to 20 m, length of 300 m and depth 170 m. The dip of this plate was 20-70 degrees E.

Exploration

Year of discovery	1955
Discovery	Galena-bearing boulder of carbonate rock found by a layman 1950; Pb ore deposit discovered by GTK in 1955.
Case history	Mine development by Outokumpu since 1956; mining and production of Pb and apatite (REE) concentrates until 1972.
Diamond drilling	
Drill core availability	GTK/Loppi: 400 drill cores from map sheet 1242 05
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Outokumpu: H. Tuominen, R. Himmi

Ore

Ore minerals	Galena, pyrite, pyrrhotite
Accessory ore minerals	Coffinite [7]
Gangue	K-feldspar, calcite, diopside, plagioclase, scapolite
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	Radioactive veins (thickness 0.5 cm?), level +60 m in the mine: 10 % U, <10 ppm Th [7]
U/Th	
Enriched elements	Pb, REE, Th, U
Stable isotopes	
Pb isotopes	Sphene from Pb ore: 1825 Ma

Geology

Geological setting	The bedrock in the area is composed of migmatitic mica gneiss with interbeds of amphibolite and cherty quartzite. The Pb ore deposit was a dyke controlled by a N-S oriented shear zone.
Host lithology	Controlled by the shear zone, the Pb ore (with U included) was hosted by a carbonate rock, interpreted to prepresent a carbonatite intruded into the shear zone after regional metamorphism.
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	STUK is monitoring the radiological safety of the tailings area [6]
Geochemical hazards	
Restoration	A heap of REE concentrate stored at the premises has been covered by soil [6, 8]

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Intrusive/Olympic Dam??

References

1 Eskola, K., Tuominen, H., Palviainen, M. & Autio, M. 1961. Outokumpu Oy, Korsnäsin kaivos. Vuoriteollisuus 19, 23-33. (in Finnish)

2 Björklund, A. 1966. Om Korsnäs blyglansförekomst och dess geologi. Unpublished master's thesis, University of Helsinki, Department of Geology and Mineralogy. 63 p. (in Swedish)

3 Papunen, H. & Lindsjö, O. 1972. Apatite, monazite and allanite: three rare earth minerals from Korsnäs, Finland. Bulletin of the Geological Society of Finland 44, 123-129.

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5 Papunen, H. 1986. Suomen metalliset malmiesiintymät. 133-214 in Papunen, H., Haapala, I. & Rouhunkoski, P. (eds.) 1986. Suomen malmigeologia: metalliset malmiesiintymät. 317 p. (in Finnish)

6 Annanmäki, M. 1998. Lyijykaivos toi säteilyongelman Korsnäsiin. Alara 7 (1), 18-20. (in Finnish)

7 Rehtijärvi, P. & Lindqvist, K. 1978. Uraani ja torium eräissä uraaniesiintymien näytteissä: tiivistelmä menetelmistä ja tutkimustuloksista. Helsingin yliopisto. Geologian laitos. Tiedonanto 7. 86 p. (in Finnish)

8 Anon. 1999. Finland. In: Environmental activities in uranium mining and milling. Paris: OECD, 88-89.

Deposit

Name **Kovela**

FinU_ID	50
ID of Malmikanta	
Last updated	5. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Granite migmatite belt of southern Finland

- U- deposit? ☐
- U as by-product? ☐
- Th- deposit? ☑

Location

Map sheet	2023 11 B
Coordinates	X (KKJ) 6697890 Latitude 60.39194 Y (KKJ) 2492220 Longitude 23.85568
Municipality	Nummi-Pusula
Village	Kovela
Nearest town	2.5 km W of Nummi
Access	50-800 m from paved road, 100 m from dirt road

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Mapped prospect
Economic evaluation	No economic significance [2]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	120 m2 of outcrop grading 0,5 % Th (0.0255 % U) in the N exposure; similar area with 0,3 % Th (0.0085 % U) in the S exposure. With grades 0.08 % Th the areas are 470 m2 and 2000 m2, respectively.
Extent of mineralisation	The studied exposures are 0.5 km apart; there are more radioactive outcrops of similar type further 0.5 km NNW of the N exposure.

Lodes	S exposure: radioactive area 5-30 m by 150 m. N exposure: radioactive area 10 m by 60 m.

Exploration

Year of discovery	1980
Discovery	Ground follow-up of aeroradiometric gamma anomalies
Case history	1980 ground scintillometry, detailed geological mapping, detailed scintillometry, percussion drill sampling of exposures. 1981 laboratory studies (REE analyses by Kemira laboratories).
Diamond drilling	
Drill core availability	
ElementsAnalysed	U, Th (MCA), La + REE (XRF?)
Radiometric response	Aeroradiometric Th channel anomaly [1, 2]
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: H. Seppänen

Ore

Ore minerals	Monazite
Accessory ore minerals	
Gangue	K-feldspar, plagioclase, quartz, garnet
Composition of minerals	Semiquantitative microprobe runs of monazite: ThO2 up to 34 % (UO2 0.3 %). REE analysis of monazite concentrate showed 20 % ThO2
Texture and fabrics of ore	Impregnated monazite up to 1 mm in diameter. Garnet seems to follow monazite in the rock.
Composition of ore	
U/Th	0.05
Enriched elements	Th, U
Stable isotopes	
Pb isotopes	

Geology

Geological setting	SE part of a microcline granite intrusion, 3 km in diameter. The granite is intruded into the migmatitic mica schists and amphibolites of the area. Mica schist enclaves occur within the granite.
Host lithology	Ligth-coloured granite
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Intrusive

References

1 Seppänen, H. 1980. Raportti aeroradiometristen gamma-säteilyanomalioiden maastotarkistuksista 1980. 5 p. Geological Survey of Finland, unpublished report M19/1841/-80/1/60. (in Finnish)

2 Seppänen, H. 1981. Selostus Kovelan monatsiittiaiheen tutkimuksista Nummi-Pusulan kunnassa 1980-1981. 5 p. Geological Survey of Finland, unpublished report M 19/2023/-81/1/60. (in Finnish)

Deposit

Name **Hyrkkölä**

FinU_ID	51
ID of Malmikanta	
Last updated	5. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Granite migmatite belt of southern Finland

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	2024 10 C
Coordinates	X (KKJ) 6714900 Latitude 60.54466 Y (KKJ) 2495700 Longitude 23.91841
Municipality	Nummi-Pusula
Village	Hyrkkölä
Nearest town	9 km N of Pusula, 22 km W of Karkkila
Access	Less than 100 m to gravel roads

Resources/Mining

Reservation	Reservation expired in May, 1998
Exploration license number	3516/1-2
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1983-86
Status of development	Drilled prospect
Economic evaluation	
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	A widely spaced set of conformable mineralised pegmatite veins, 0.05-0.5 thick covering an area of 130 m x 150 m in surface projection.
Lodes	

Exploration

Year of discovery	1980
Discovery	Carborne scintillometry in the surroundings of the Palmottu deposit [1]
Case history	1983-84: ground radiometrics, trenching, diamond drilling 1990s: mineralogical and chemical research for natural analogy studies of nuclear waste repository [3-5]
Diamond drilling	GTK 1983-84: five drill holes, 1997: two drill holes
Drill core availability	GTK/Loppi: five cores
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Several fans of radioactive boulders in the area, indicating a number mineralised veins [1].
Geochemical dispersion	High contents of U and Rn in ground water wells [6]
Geologist(s)	GTK: E. Räisänen, L. Ahonen

Ore

Ore minerals	Uraninite
Accessory ore minerals	Native copper, hematite, cuprite, chalcocite Uranophane, gummite
Gangue	Quartz, feldspars, tourmaline
Composition of minerals	
Texture and fabrics of ore	Uraninite as dissemination in pegmatites. Native copper as flakes in and between feldspar grains, also around tourmaline grains [4].
Composition of ore	
U/Th	
Enriched elements	U, Th
Stable isotopes	
Pb isotopes	Uraninite 1744 Ma [3)

Geology

Geological setting	Mica gneisses, quartz feldspar gneisses and amphibolites (metasediments and metavolcanics) intruded by granitic rocks
Host lithology	Late-orogenic pegmatitic granite veins conformable with the sequence of metasediments and metavolcanics
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	Low-pressure amphibolite facies
Metamorphic index minerals	

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	Primary U+Cu mineralisation 1.8-1.7 Ga ago in late orogenic pegmatites. Hydrothermal alteration 1.75-1.2 Ma ago with remobilisation of U and Cu [4].
Genetic reasoning	
Tentative FinU model	Intrusive/pegmatite

References

1 Räisänen, E. 1989. Uraniferous granitic veins in the Svecofennian schist belt in Nummi-Pusula, southern Finland. In: Uranium deposits in magmatic and metamorphic rocks: proceedings of a technical committee meeting, Salamanca, 29 September - 3 October 1986. Vienna: International Atomic Energy Agency, 37-44.

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3 Marcos, N. 1996. The Hyrkkölä native copper mineralization as a natural analogue for copper canisters. Tiivistelmä: Hyrkkölän luonnonkupariesiintymä kuparikanisterin luonnonanalogiana. Posiva Report 96-15. 39 p.

4 Marcos, N. & Ahonen, L. 1999. New data on the Hyrkkölä U-Cu mineralization : the behaviour of native copper in a natural environment. Tiivistelmä: Hyrkkölän U-Cu analogia: metallisen kuparin käyttäytyminen luonnollisessa ympäristössä. Posiva Report 99-23. 78 p.

5 Marcos, N., Ahonen, L., Bros, R., Roos, P., Suksi, J., Oversby, V. 1999. New data on the Hyrkkölä native copper mineralization: a natural analogue for the long-term corrosion of copper canisters. In: Wronkiewicz, D. J. & Lee, D. J. (eds.) Scientific Basis for Nuclear Waste Management XXII. Materials Research Society symposium proceedings 556, 825-832.

6 Hyyppä, J. & Juntunen, R. 1983. Nummi-Pusulan kunnan Hyrkkölän kylän kaivovesien uraani- ja radonpitoisuuden tutkimukset v. 1982. 3 p. Geological Survey of Finland, unpublished report P 13.5.3.013. (in Finnish)

Deposit

Name **Kopila**

FinU_ID	52
ID of Malmikanta	
Last updated	5. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Svecofennian
Geological province	Granite migmatite belt of southern Finland

U- deposit? ☑

U as by-product? ☐

Th- deposit? ☐

Location

Map sheet	2024 07 C
Coordinates	X (KKJ) 6711260 Latitude 60.51188
	Y (KKJ) 2489730 Longitude 23.80982
Municipality	Somero
Village	Kopila
Nearest town	16 km NW of Pusula
Access	150 m from nearest gravel roads

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Mapped prospect
Economic evaluation	Non-economic: small dimensions; however, the depth is unknown
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	23 samples along the best part of the occurrence average 0.216 % U, 0.0164 % Th; in these, 9 samples of granite give a mean of 0.11 % U, and 14 samples of mica schists 0.284 % U.
Extent of mineralisation	The area of the host granite exposure is 15 m2. From this, a radioactive mica schist seam extends some 30 m to the NE; further, another 30 m to the SW a radioactive granite vein 0.5 m thick is exposed. The area

	between the two exposures is covered by till down to 5 m thick. The dimensions of the radioactive rock are at least 5 m by 50 m.
Lodes	

Exploration

Year of discovery	1988
Discovery	1982 ground radiometrics and sampling, up to 0.12 % U in bedrock sample. Ground follow-up of aeroradiometric gamma anomalies in the area 1988: additional sampling, >1 % eU.
Case history	1988-89: detailed ground radiometrics (spectrometry), detailed geologic mapping, percussion & pneumatic drill sampling,
Diamond drilling	
Drill core availability	
ElementsAnalysed	U, Th (MCA); Cu, Co, Ni, Zn, Pb, Ag, Mo, Au
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: H. Seppänen

Ore

Ore minerals	Uraninite
Accessory ore minerals	
Gangue	
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	
U/Th	
Enriched elements	U, Th
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Regionally the target is at the contact zone of amphibolite and quartz feldspar gneiss which represent the metasedimentary and metavolcanic palaeosomes of the migmatites in this area.
Host lithology	In detail the mineralised rock is a body of granite, with a seam of radioactive mica gneiss that has a NW contact against amphibolite, SE contact against a red granite.
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Intrusive

References

1 Seppänen, H. 1989. Raportti aeroradiometristen gammasäteilyanomalioiden maastotarkistuksista 1988. Lentoalueet: Somero, Ikaalinen, Kuru, Mäntyharju ja Lappeenranta. 5 p. Geological Survey of Finland, unpublished report M19/2024/-89/1/60. (in Finnish)

2 Seppänen, H. 1991. Raportti uraanitutkimuksista Someron Kopilassa vuosina 1988-1990. 15 p. Geological Survey of Finland, unpublished report M19/2024/-91/1/60. (in Finnish)

Deposit

Name **Huittinen**

FinU_ID	53	U- deposit?	☑
ID of Malmikanta		U as by-product?	☐
Last updated	5. 7.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Intrusive deposit		
Eon or Era	Palaeoproterozoic		
Geological domain	Svecofennian		
Geological province	Tonalite migmatite belt of southern Finland		

Location

Map sheet	2112 01 B			
Coordinates	X (KKJ)	6778500	Latitude	61.10823
	Y (KKJ)	2424810	Longitude	22.60224
Municipality	Huittinen			
Village	Jokisivu			
Nearest town	9 km SSE of Huittinen			
Access	Distance from forest roads 300-600 m			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Mapped prospect
Economic evaluation	So far no economic significance
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Estimates based on gamma spectrometry across outcrops: 15 m by 25 m, averaging 0.011 % eU, 0.008 % eTh; 0-10 m by 30 m, averaging 0.016 % eU, 0.005 % eTh; 5-10 m by 35 m, averaging 0.016 % eU, 0.014 % eTh; all outcrops contain spot-like radioactive highs >0.1 % eU, up to 0.68 % eU.

Extent of mineralisation	Three radioactive outcrops within a distance of 1.2 km in SE-NW direction. In all of these the radioactive rock continues under the overburden.
Lodes	

Exploration

Year of discovery	1991
Discovery	Ground follow-up of aeroradiometric gamma anomalies
Case history	1991: ground radiometrics, 1992: detailed spectrometry and geological mapping
Diamond drilling	
Drill core availability	
ElementsAnalysed	eU, eTh (portable gamma spectrometer)
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: H. Seppänen

Ore

Ore minerals	Not determined
Accessory ore minerals	
Gangue	
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	
U/Th	
Enriched elements	U, Th
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Pegmatitic granites intruded into granodiorites and migmatitic metasediments and metavolcanics. Distance to the NE margin of the Mesoproterozoic sandstone is 13 km.
Host lithology	Pegmatitic granite
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Intrusive/pegmatite

References

1 Seppänen, H. 1992. Raportti aeroradiometristen gammasäteilyanomalioiden maastotarkistuksista Vammalan lentoalueella 1991 ja 1992. 9 p. Geological Survey of Finland, unpublished report M19/2112/-92/1/60. (in Finnish)

Deposit

Name **Puokio**

FinU_ID	54
ID of Malmikanta	
Last updated	6. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kainuu schist belt

- U- deposit? ☑
- U as by-product? ☐
- Th- deposit? ☐

Location

Map sheet	3441 06 A			
Coordinates	X (KKJ)	7181960	Latitude	64.73498
	Y (KKJ)	3514600	Longitude	27.30283
Municipality	Puolanka			
Village	Puokio			
Nearest town	25 km SW of Puolanka, 120 km NW of Kajaani			
Access	250 m from dirt road			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Drilled prospect
Economic evaluation	Uneconomic occurrence
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.01
% Th	
U production (tonnes)	
Best section(s)	1-4 m wide pegmatite zones with contents of 0.005-0.012 % U and 0.0025-0.006 % Th; best spot: 0.14 % U, 0.90 % Th [1]
Extent of mineralisation	An outcrop of 50 m by 100 m, where a radioactive zone 10-20 m wide strikes NE, dipping 80 degrees NW [1]. In the surroundings, covering an area of 5 km by 20 km, GTK has found several indications of the same type of U (+Th) mineralisation in pegmatitic granite [2, 3].

Lodes

Exploration

Year of discovery	1974
Discovery	Scintillometry of specimens previously collected from the area; a pegmatitic granite from Puokio was found to be radioactive [1].
Case history	1974: detailed geological mapping and ground radiometrics; percussion drill sampling; diamond drilling.
Diamond drilling	GTK 1974: two drill holes
Drill core availability	GTK/Loppi: both cores
ElementsAnalysed	U, Th (gamma spectrometry)
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: P. Ervamaa

Ore

Ore minerals	Not determined
Accessory ore minerals	
Gangue	Feldspars, quartz, biotite
Composition of minerals	
Texture and fabrics of ore	
Composition of ore	
U/Th	2
Enriched elements	U, Th
Stable isotopes	
Pb isotopes	

Geology

Geological setting	
Host lithology	The outcrop is composed of enclaves of mica schist, meta-arkose and amphibolite, embedded in pink pegmatitic granite that intrudes these gneisses as a network of numerous veins. The radioactive pegmatites seem to follow a zone rich in amphibolite fragments [1].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model Intrusive/pegmatite

References

1 Ervamaa, P. 1975. Radiometriset tutkimukset Puolangan Puokiolla ja ympäristössä 1974. 4 p. Geological Survey of Finland, unpublished report M19/3441/75/2/10. (in Finnish)

2 Ervamaa, P. 1976. Selostus Puolangan eteläosassa 1975-76 suoritetuista uraanietsinnöistä. 4 p. Geological Survey of Finland, unpublished report M60/3441/76/2/10. (in Finnish)

3 Ervamaa, P. 1978. Selostus uraanitutkimuksista karttalehdillä 3441 (Puokiovaara) ja 3442 (Puolanka) vuonna 1977. 3 p. Geological Survey of Finland, unpublished report M60/3441/77/1/10. (in Finnish)

Deposit

Name **Aakenusvaara**

FinU_ID	55
ID of Malmikanta	
Last updated	10. 7.2000
Link to Fingold	
Red Book geologic setting	Metamorphic ? Sandstone ?
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	Kittilä greenstone area of the Central Lapland Greenstone Belt

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	2741 07 A
Coordinates	X (KKJ) 7522180 Latitude 67.78553
	Y (KKJ) 2520170 Longitude 24.47357
Municipality	Kittilä
Village	
Nearest town	34 km NW of Kittilä
Access	400 m off gravel road

Resources/Mining

Reservation	GTK 1981
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Drilled prospect
Economic evaluation	Uneconomic: small size and low grade [1]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	91 radioactive erratic boulders detected; of these, about 25 % contain 0.11-0.2 % U. In trenches, bedrock samples did not exceed 0.1 % U. In drill cores the contents were still poorer, for instance 8 m at 0.005 % U [1].
Extent of mineralisation	5 m by 30 m with lower grade continuations of radioactive interbeds of biotite schist towards SE and NW along the strike of the sedimentary

	sequence [1].
Lodes	One uraniferous lode with surface dimensions 5 m by 30 m, manifested by trenching and drilling. The lode is formed by widely spaced interbeds of uraniferous biotite schist. A "sulphide pocket" 2 m by 5 m was found in the trenches next to the uraniferous lode on its western side, composed of a network of quartz+carbonate+sulphides, showing anomalous Cu contents (up to 2.5 % Cu) and enhanced Au contents (up to 1.2 ppm Au) [1].

Exploration

Year of discovery	1981
Discovery	Regional ground radiometric survey of "Kumpu" conglomerates by GTK: discovery of uraniferous biotite schist pebbles in the conglomerate. Subsequent search for the provenance of this type of mineralised rock revealed a cluster of boulders of uraniferous biotite schist some 5 km to the NW. The boulders were traced to their source in bedrock in 1981 [1].
Case history	Outokumpu 1963-67, 1973: regional ground radiometrics based on the analogy with uraniferous quartzites. A few spots of radioactive quartzite and conglomerate were found, with U contents up to 0.1 %, including one fist-sized, well rounded boulder of sericite quartzite with 4.9 % U. In 1973 three boulders were found in the western part of Aakenusvaara, with 0.05-0.35 % U. GTK 1981-1982: regional & detailed ground radiometrics, including mapping of radioactive erratics; detailed magnetic and electromagnetic ground survey; trenching (600 m); detailed geological mapping; pedogeochemical sampling; microscopic petrography & autoradiography (with 3D models of specimens); diamond drilling [1].
Diamond drilling	GTK 1981-82: three drill cores (286 m)
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	U, Th (MCA); U (INAA); Cu, Co, Zn, Pb, Ag, Ni, Au (AAS) [1]
Radiometric response	In this terrain of rugged topography and relatively thin overburden combination of ground radiometrics with trenching proved to be efficient [1].
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Train of uraniferous boulders about 70 m by 300 m with glacial transport to the NE, relating to the younger of two local till sheets [1]
Geochemical dispersion	
Geologist(s)	GTK: K. Pääkkönen

Ore

Ore minerals	Uraninite, pitchblende [1]
Accessory ore minerals	Unidentified secondary uranium minerals; molybdenite, ilmenite, pigmentous opaque [1]
Gangue	Chlorite, biotite

Composition of minerals	
Texture and fabrics of ore	Roundish uraninite both as dissemination and as chains of grains. Microfractures in the rock are filled by pitchblende, secondary uranium minerals and iron hydroxides [1].
Composition of ore	No thorium
U/Th	
Enriched elements	U, Mo; Cu, Au
Stable isotopes	
Pb isotopes	

Geology

Geological setting	The deposit occurs in Pittarova Formation metasediments and metavolcanics of the Savukoski Group (>2050 Ma), about 1.5 km SE of the Saattopora gold mine (see [4]). About 1.5 km SE is the margin of the Levi Formation coarse clastics, part of the Kumpu Group (<1930 Ma, possibly <1885 Ma), the host of the conglomerate with pebbles derived from the Aakenusvaara deposit. The Kumpu Group has a discordant contact with the older sequences; at Aakenusvaara, this contact is related to a major tectonic line extending to the WNW within the Savukoski Group rocks through the Aakenusvaara deposit and the Saattopora mine to Pahtavuoma and possibly further to the Laavirova deposit [2, 3].
Host lithology	Biotite schist, composed of a mass of unoriented flakes of biotite where ore minerals form pigmentous streaks parallel to bedding. The biotite schist occurs as 1-100 mm thick interbeds in biotite-chlorite-albite schist. Together with albite schists, marl schists, greywacky quartzites, graphite schists, and greenstones it forms the host sequence which is overturned, with northerly dip varying from 60 to 80 degrees. The sequence is densely cut by networks of various veins: carbonate-albite-quartz-sulphides; quartz-biotite; quartz-chlorite; carbonate-pyrrhotite [1].
Intrusions	A thin sill of metadiabase was found in the greenstones [1]

Metamorphism/Deformation/Alteration

Metamorphic history	Greenschist conditions regional metamorphism [1]
Metamorphic index minerals	
Deformation history	Intense folding during the main deformation stage before the deposition of the Kumpu Group sediments; repetition by folding has increased the mineralised body [1; 3, 4]. The various vein phases in the host sequence are fracture fillings related to brittle deformation by two local directions of shearing or fracture cleavage [1].
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	A protection area of the Natura programme is located 1-2 km NE of the deposit (http://www.vyh.fi/luosuo/n2000/lap/kittila.htm)
Watersheds	

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	Syngenetic (Savukoski Group, >2050 Ma)? [1]: Adsorption of uranium from primary pore fluids into the precursor of what now is the biotite schist; this view is supported by the presence of uraniferous biotite schist pebbles in the overlying Kumpu Group conglomerates.
Genetic reasoning	
Tentative FinU model	?

References

1 Pääkkönen, K. 1989. Uraanimalmitutkimukset Aakenusvaaran länsiosassa Kittilässä 1981-82. 22 p. Geological Survey of Finland, unpublished report M19/2741/-89/1/60. (in Finnish)

2 Lehtonen, M., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Väänänen, J. 1998. Stratigraphical map of the Kittilä greenstone area. Espoo: Geological Survey of Finland.

3 Lehtonen, M., Airo, M.-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia: Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland: a report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.

4 Eilu, P. 1999. FINGOLD - a public database on gold deposits in Finland. Tiivistelmä: FINGOLD - julkinen tietokanta Suomen kultaesiintymistä. Geological Survey of Finland, Report of Investigation 146. 224 p.

Deposit

Name **Kuohunki-U**

FinU_ID	56	U- deposit?	☑
ID of Malmikanta		U as by-product?	☐
Last updated	11. 7.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Intrusive deposit?		
Eon or Era	Archaean		
Geological domain	Karelian		
Geological province	Achaean basement close to the Palaeoproterozoic Peräpohja schist belt		

Location

Map sheet	3613 05 A			
Coordinates	X (KKJ)	7351000	Latitude	66.24997
	Y (KKJ)	3470800	Longitude	26.34669
Municipality	Rovaniemen mlk			
Village				
Nearest town	54 km SE of Rovaniemi			
Access	Within 1 km of forest road			

Resources/Mining

Reservation	
Exploration license number	2997/1, 3640/1, 7045/
Mining concession number	
Holder of mineral rights	Outokumpu Mining Oy
Previous holders	GTK 1980-82, 1984-88
Status of development	Drilled prospect
Economic evaluation	Diamond drillings and pneumatic drillings have revealed only minor showings in bedrock; the results of the exploration work done so far suggest widely scattered small mineralisations of uranium in bedrock [1-4].
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	0.2 % U in erratic boulders, reflecting the contents of the mineralised parts of the blocks. In addition, up to 0.5 % Mo and 10 % P2O5 have

	been analysed in some of the boulder samples [1, 2]. Contents of 0.09-2.64 % U and 0.02-0.14 % Th in the best samples from boulders found by Outokumpu [5]. In the third boulder cluster, contents up to 2.2 % U were detected [4]. Drill core sections: 1-3 m at 0.017-0.067 % U, including 1 m at 0.14 % U [3].
Extent of mineralisation	Hundreds of radioactive erratic boulders in the Kuohunki area within a distance of 500-1000 m from the basal margin of the Palaeoproterozoic Peräpohja schist belt in the NW. More of these boulders are known to occur both to the NE and to the SW of Kuohunki, in an area at least 10 km long, following the strike of the Palaeoproterozoic/Archaean margin [1-4].
Lodes	Three separate clusters of radioactive erratic boulders have been located at Kuohunki, three km apart of each other. No distinct lodes in bedrock have been discovered [1-4].

Exploration

Year of discovery	1973
Discovery	Layman sample received by Outokumpu in 1973
Case history	Outokumpu 1973-77: regional and detailed radiometric boulder tracing - hundreds of radioactive erratic blocks were located; regional and detailed geochemical surveys; aeroradiometric survey (by Suomen Malmi); geological mapping; Rn survey; diamond drilling. Transfer of the research material to GTK in 1978 [1]. GTK 1978-1980: detailed radiometric boulder tracing; detailed pedo- and litogeochemical survey (percussion and pneumatic drillings); detailed ground magnetic and electromagnetic survey; diamond drilling [1, 3]. GTK 1982-85: detailed radiometric boulder tracing - the third boulder train delineated; detailed pedogeochemical sampling and trenching combined with the study of glacial geology (in co-operation with the University of Oulu); seismic profile survey; diamond drilling [4, 6].
Diamond drilling	Outokumpu: six drill holes (213 m); GTK: eight drill cores (667 m)
Drill core availability	GTK/Loppi: all GTK cores from Kuohunki-U
ElementsAnalysed	
Radiometric response	
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Widely dispersed radioactive erratic boulders, with three main clusters including several subclusters and trains [1, 3, 4, 6]
Geochemical dispersion	Uranium was also found to have enriched in peat [1]
Geologist(s)	Outokumpu: R. Sarikkola, J. Reino GTK: H. Pyy, K. Pääkkönen

Ore

Ore minerals	Uraninite [5]

Accessory ore minerals	Molybdenite, pyrite [4]
Gangue	Biotite, quartz, apatite, feldspars, garnet
Composition of minerals	
Texture and fabrics of ore	[5]: Uraninite occurs as disseminated euhedral grains, 0.05-1.0 mm in diameter. Secondary uranium phases occur in radial microcracks around and between uraninites; part of these occur with mica. Also pseudomorphs of secondary minerals after uraninite were found.
Composition of ore	U/Th in high grade samples 11-18 [5]. Biotite-apatite gneiss forms the best ore type, consisting of (90 %) biotite and apatite, with high contents of U and Mo. In these samples, TiO2 contents are high (1.1-3.1 % [4].
U/Th	14
Enriched elements	U, Th, Mo, P, Ti
Stable isotopes	
Pb isotopes	[5]: uraninite, minimum age 2113+-59 Ma

Geology

Geological setting	Poorly exposed Archaean terrain SE of the NE striking layered mafic intrusions and quartzites of the Palaeoproterozoic Peräpohja schist belt, covered by a usually <10 m thick set of till deposits and peat bogs. The rocks in the Archaean are migmatitic granite gneisses, with a great portion of biotitic paragneisses, granites, and pegmatites (1-4].
Host lithology	Radioactive boulders consisting of pegmatite, granite, granite gneiss, biotite gneiss, and biotite-apatite gneiss; of these, the biotite gneiss and the biotite-apatite gneiss constitute the best ore type (U+-Mo+-P). In the few outcrops and in drill cores, these host rocks have been found only as minor lenses and seams among the granite gneisses, granites, and pegmatites [1-4]. Sulphide-bearing erratics also found in the area are weakly uraniferous [4], which - with the source of these boulders possibly within the zone of layered intrusions - suggests stratigraphically more wide-spread mineralisation of uranium in this area.
Intrusions	Palaeoproterozoic metadiabase has been found to cut across the Archaean rocks [1]. A major dyke of metadiabase striking NNW is within a distance of 3-6 km to the SW of the Kuohunki-U showings [7].

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	Unconformity-type mechanism of uranium mineralisation has been suggested [2]. The date from the uraninite refers to a Palaeoproterozoic event related to the emplacement of metadiabase dykes or gabbro sills of the Peräpohja schist belt [7].
Genetic reasoning	
Tentative FinU model	Intrusive/migmatite neosome/pegmatite?

References

1 Pyy, H. 1981. Uraanimalmitutkimukset Rovaniemen maalaiskunnan Kuohungissa vuosina 1978 - 1980. 18 p. Geological Survey of Finland, unpublished report M19/3613/-81/1/60. (in Finnish)

2 Anon. 1981. IUREP (International Uranium Resources Evaluation Project) orientation phase mission report: Finland. OECD Nuclear Energy Agency. 104 p.

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7 Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Bedrock map of Finland 1:1 000 000. Espoo: Geological Survey of Finland.

Deposit

Name **Konttiaho**

FinU_ID	57
ID of Malmikanta	349
Last updated	17. 7.2000
Link to Fingold	http://www.gsf.fi/explor/gold/konttiaho.htm
Red Book geologic setting	
Eon or Era	
Geological domain	
Geological province	

- U- deposit? ☐
- U as by-product? ☑
- Th- deposit? ☐

Location

Map sheet	4611 10 C			
Coordinates	X (KKJ)	7343500	Latitude	66.18131
	Y (KKJ)	4457800	Longitude	29.06029
Municipality				
Village				
Nearest town				
Access				

Resources/Mining

Reservation

Exploration license number

Mining concession number

Holder of mineral rights

Previous holders

Status of development

Economic evaluation

Red Book class

Mining operations

Ore (million tonnes; in situ)

Contained U (tonnes; in situ)

% U

% Th

U production (tonnes)

Best section(s)

Extent of mineralisation

Lodes

Exploration

Year of discovery

Discovery

Case history

Diamond drilling

Drill core availability

ElementsAnalysed

Radiometric response

Magnetic Response

Electromagnetic response

Other geophysics

Glacigenic dispersion

Geochemical dispersion

Geologist(s)

Ore

Ore minerals

Accessory ore minerals

Gangue

Composition of minerals

Texture and fabrics of ore

Composition of ore

U/Th

Enriched elements

Stable isotopes

Pb isotopes

Geology

Geological setting

Host lithology

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model

References

Deposit

Name **Sivakkaharju**

FinU_ID	58	U- deposit?	☐
ID of Malmikanta	340	U as by-product?	☑
Last updated	17. 7.2000	Th- deposit?	☐
Link to Fingold	http://www.gsf.fi/explor/gold/sivakkaharju.htm		

Red Book geologic setting

Eon or Era

Geological domain

Geological province

Location

Map sheet	4611 10 C			
Coordinates	X (KKJ) 7344600		Latitude	66.19107
	Y (KKJ) 4457000		Longitude	29.04218

Municipality

Village

Nearest town

Access

Resources/Mining

Reservation

Exploration license number

Mining concession number

Holder of mineral rights

Previous holders

Status of development

Economic evaluation

Red Book class

Mining operations

Ore (million tonnes; in situ)

Contained U (tonnes; in situ)

% U

% Th

U production (tonnes)

Best section(s)

Extent of mineralisation

Lodes

Exploration

Year of discovery

Discovery

Case history

Diamond drilling

Drill core availability

ElementsAnalysed

Radiometric response

Magnetic Response

Electromagnetic response

Other geophysics

Glacigenic dispersion

Geochemical dispersion

Geologist(s)

Ore

Ore minerals

Accessory ore minerals

Gangue

Composition of minerals

Texture and fabrics of ore

Composition of ore

U/Th

Enriched elements

Stable isotopes

Pb isotopes

Geology

Geological setting

Host lithology

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model

References

Deposit

Name **Juomasuo**

FinU_ID	59
ID of Malmikanta	350
Last updated	17. 7.2000
Link to Fingold	http://www.gsf.fi/explor/gold/juomasuo.htm
Red Book geologic setting	
Eon or Era	
Geological domain	
Geological province	

- U- deposit? ☐
- U as by-product? ☑
- Th- deposit? ☐

Location

Map sheet	4613 02 B			
Coordinates	X (KKJ)	7355400	Latitude	66.28882
	Y (KKJ)	4464230	Longitude	29.19953
Municipality				
Village				
Nearest town				
Access				

Resources/Mining

Reservation

Exploration license number

Mining concession number

Holder of mineral rights

Previous holders

Status of development

Economic evaluation

Red Book class

Mining operations

Ore (million tonnes; in situ)

Contained U (tonnes; in situ)

% U

% Th

U production (tonnes)

Best section(s)

Extent of mineralisation

Lodes

Exploration

Year of discovery

Discovery

Case history

Diamond drilling

Drill core availability

ElementsAnalysed

Radiometric response

Magnetic Response

Electromagnetic response

Other geophysics

Glacigenic dispersion

Geochemical dispersion

Geologist(s)

Ore

Ore minerals

Accessory ore minerals

Gangue

Composition of minerals

Texture and fabrics of ore

Composition of ore

U/Th

Enriched elements

Stable isotopes

Pb isotopes

Geology

Geological setting

Host lithology

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards — Low-grade radioactive waste in the tailings area [1].

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model

References

1 Anon. 1999. Finland. In: Environmental activities in uranium mining and milling. Paris: OECD, 88-89.

Deposit

Name **Pohjaslampi**

FinU_ID	60
ID of Malmikanta	590
Last updated	17. 7.2000
Link to Fingold	http://www.gsf.fi/explor/gold/pohjaslampi.htm
Red Book geologic setting	
Eon or Era	
Geological domain	
Geological province	

U- deposit? ☐

U as by-product? ☑

Th- deposit? ☐

Location

Map sheet	4613 02 A			
Coordinates	X (KKJ)	7353400	Latitude	66.27091
	Y (KKJ)	4464500	Longitude	29.20611
Municipality				
Village				
Nearest town				
Access				

Resources/Mining

Reservation

Exploration license number

Mining concession number

Holder of mineral rights

Previous holders

Status of development

Economic evaluation

Red Book class

Mining operations

Ore (million tonnes; in situ)

Contained U (tonnes; in situ)

% U

% Th

U production (tonnes)

Best section(s)

Extent of mineralisation

Lodes

Exploration

Year of discovery

Discovery

Case history

Diamond drilling

Drill core availability

ElementsAnalysed

Radiometric response

Magnetic Response

Electromagnetic response

Other geophysics

Glacigenic dispersion

Geochemical dispersion

Geologist(s)

Ore

Ore minerals

Accessory ore minerals

Gangue

Composition of minerals

Texture and fabrics of ore

Composition of ore

U/Th

Enriched elements

Stable isotopes

Pb isotopes

Geology

Geological setting

Host lithology

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model

References

Deposit

Name **Hangaslampi**

FinU_ID	61
ID of Malmikanta	
Last updated	17. 7.2000
Link to Fingold	http://www.gsf.fi/explor/gold/hangaslampi.htm
Red Book geologic setting	
Eon or Era	
Geological domain	
Geological province	

U- deposit? ☐

U as by-product? ☑

Th- deposit? ☐

Location

Map sheet	4613 02 A			
Coordinates	X (KKJ) 7354500		Latitude	66.28077
	Y (KKJ) 4464400		Longitude	29.20358
Municipality				
Village				
Nearest town				
Access				

Resources/Mining

Reservation

Exploration license number

Mining concession number

Holder of mineral rights

Previous holders

Status of development

Economic evaluation

Red Book class

Mining operations

Ore (million tonnes; in situ)

Contained U (tonnes; in situ)

% U

% Th

U production (tonnes)

Best section(s)

Extent of mineralisation

Lodes

Exploration

Year of discovery

Discovery

Case history

Diamond drilling

Drill core availability

ElementsAnalysed

Radiometric response

Magnetic Response

Electromagnetic response

Other geophysics

Glacigenic dispersion

Geochemical dispersion

Geologist(s)

Ore

Ore minerals

Accessory ore minerals

Gangue

Composition of minerals

Texture and fabrics of ore

Composition of ore

U/Th

Enriched elements

Stable isotopes

Pb isotopes

Geology

Geological setting

Host lithology

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing

Genetic reasoning

Tentative FinU model

References

Deposit

Name **Hepo**

FinU_ID	62
ID of Malmikanta	
Last updated	17. 7.2000
Link to Fingold	
Red Book geologic setting	Intrusive deposit
Eon or Era	Archaean
Geological domain	Karelian
Geological province	Archaean gneisses E of the Tipasjärvi greenstones: Archaean Kuhmo-Suomussalmi greenstone belt.

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	4324 03 C
Coordinates	X (KKJ) 7092230 Latitude 63.92902
	Y (KKJ) 4468120 Longitude 29.3468
Municipality	Kuhmo
Village	Vepsä
Nearest town	32 km SW of Kuhmo
Access	300 m from forest road

Resources/Mining

Reservation	Claim reservation in 2000
Exploration license number	3548/1
Mining concession number	
Holder of mineral rights	
Previous holders	GTK 1983-85
Status of development	Mapped prospect
Economic evaluation	No economic value [5]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.05
% Th	
U production (tonnes)	
Best section(s)	Best pocket 10 m by 20 m averaging 0.05 % U; best single samples reach 0.5-1.3 % U [5]
Extent of mineralisation	Uraniferous pockets within the migmatitic mica gneiss in an area of 50 m by 150 m, close to the contact of the local granite [5]. In a larger area of 1 km by 3 km, Hepo represents one of the many uraniferous

	showings [2-6].
Lodes	

Exploration

Year of discovery	1983
Discovery	Ground follow-up of aeroradiometric gamma anomalies by GTK [4, 5]
Case history	GTK 1982-85: ground follow-up of airborne radiometrics in the area; detailed groung spectrometry at Hepo; trenching, regional and detailed geological mapping; percussion drill lithogeochemical and pedogeochemical sampling [5].
Diamond drilling	
Drill core availability	
ElementsAnalysed	By GSP & INAA: U, Th; by XRF:; by AAS:
Radiometric response	U channel gamma anomaly on radiometric maps 40 m by 60 m caused by radioactive boulders and outcrops at Hepo [5].
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	Preglacial regolith was found to underlie till cover in one of the trenches [5]
Geochemical dispersion	Radioactive springs were found in the area; NE of Hepo these wetland radioactive occurences are zones 1-3 m wide and 50 m long, with their radiation equalling 150 Ur [5].
Geologist(s)	GTK: O. Äikäs [5]

Ore

Ore minerals	Uraninite [3, 5]
Accessory ore minerals	Molybdenite; galena; minor monazite, xenotime, zircon; rutile, ilmenite; rare pyrrhotite, pyrite, and chalcopyrite [3, 5]
Gangue	Quartz, biotite, feldspars, apatite, garnet [3, 5]
Composition of minerals	
Texture and fabrics of ore	Disseminated euhedral uraninite [0.1-1 mm in diameter], mostly as inclusions in quartz, biotite, plagioclase and garnet
Composition of ore	In radioactive samples U/Th from 3 to 10; in some samples Th is nil. Mo contents vary from 0.001 to 0.226 % [3, 5].
U/Th	
Enriched elements	U, Th, Mo, P
Stable isotopes	
Pb isotopes	Discordant minimum date from uraninite 2200 Ma [3]

Geology

Geological setting	A chain of discontinuous occurrences of paragneiss (mica gneiss and amphibolite) areas within the TTG-type granitoids and gneisses [1, 3]. At

	Hepo, amphibolite was found as a few metres wide zone at the contact of the paragneiss and the granite [3, 5]; most of the paragneiss is migmatitic mica gneiss with tonalitic leucosome veins [3, 5].
Host lithology	At Hepo uranium is hosted by pods and nests of pegmatoids in the mica gneiss, mainly coarse grained quartz-feldspar-biotite rock and quartz-biotite rock, within 50 m of the margin of the granite. Along and near this SE trending contact there are up to 0.5 m thick selvages of biotite and biotite-chlorite rock.
Intrusions	Reddish, gneissose granite ("Kapusta granite") is located in the NW part of the area at Hepo with a sharp contact with the gneisses. The radioelement contents of this granite are <5 ppm U, 20 ppm Th. Coarse-grained pegmatitic granites are common in the area as veins, pods, and dykes in other rocks. A set of 10-20 m wide metadiabase dykes strikes in the area from SE to NW; the metadiabase is suggested to be Palaeproterozoic in age [2, 3, 5].

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	Accessory garnet in amphibolite. Coarse-grained garnet in uraniferous quartzose pockets, with inclusions of uraninite [3]
Deformation history	Polyphase folding in the paragneisses possibly controls the emplacement of uraniferous quartzose pegmatoids; foliation in the granite [3]
Alteration of rocks	
Alteration of U/Th minerals	Galena in the fractures of uraninite grains. Clusters of rutile+ilmenite+galena indicate disruption of a primary U-Ti mineral phase, possibly brannerite. Monazite shows zonal alteration.

Environment

Population centre	
Protection areas	Protected mire 4 km to the SW (SSO110362); protected old forest 1 km to the SE (AMO110128).
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	Source of uranium in the precursors of the paragneisses, uranium mobilised and enriched by anatectic hydrothermal fluids in the migmatisation processes, final remobilisation by the emplacement of Palaeoproterozoic diabase [3].
Tentative FinU model	Intrusive/migmatite neosome/pegmatite/quartz vein

References

1 Niiniharju, S. 1980. Om arkeiska skiffrar och granit-gnejser i Vepsäområdet, Kuhmo, östra Finland. Unpublished master's thesis, Åbo Akademi, Department of Geology and Mineralogy. 71 s. (in Swedish)

2 Äikäs, O. 1986. Malmitutkimukset Kuhmon kunnassa valtausalueella "Kapusta 1" (kaivosrek.nro. 3548/2). 10 p. Geological Survey of Finland, unpublished report M06/4324/-86/1/60. (in Finnish)

3 Kuosmanen, E. 1989. uraanin esiintyminen Kuhmon Hepovaaralla. Unpublished master's thesis, University of Helsinki, Department of Geology and Mineralogy. 86 p. (in Finnish)

4 Äikäs, O. 1989. Aeroradiometristen gamma-anomalioiden maastotarkistukset: 4322+4324 Tipasjärvi. 2 p. Geological Survey of Finland, unpublished report M19/4322/-89/1/60. (in Finnish)

5 Äikäs, O. 1989. Malmitutkimukset Kuhmon kaupungissa valtausalueella "Hepo 1" (kaivosrek.nro 3548/1). 14 p. Geological Survey of Finland, unpublished report M06/4324/-89/1/60. (in Finnish)

6 Äikäs, O. 1989. Uraanitutkimukset Kuhmon Lötössä 1984-85. 34 p. Geological Survey of Finland, unpublished report M19/4324/-89/1/60. (in Finnish)

Deposit

Name **Löttö**

FinU_ID	63	U- deposit?	☑
ID of Malmikanta		U as by-product?	☐
Last updated	17. 7.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Intrusive deposit		
Eon or Era	Archaean		
Geological domain	Karelian		
Geological province	Archaean gneisses E of the Tipasjärvi greenstones: Archaean Kuhmo-Suomussalmi greenstone belt		

Location

Map sheet	4324 03 D			
Coordinates	X (KKJ) 7095300		Latitude	63.95655
	Y (KKJ) 4468040		Longitude	29.34453
Municipality	Kuhmo			
Village	Vepsä			
Nearest town	30 km SW of Kuhmo			
Access	100 m from forest road			

Resources/Mining

Reservation	GTK: claim reservation 1984-85. Claim reservation in 2000
Exploration license number	
Mining concession number	
Holder of mineral rights	
Previous holders	
Status of development	Drilled prospect
Economic evaluation	No economic value
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.1
% Th	
U production (tonnes)	
Best section(s)	Best samples from boulders 0.2-1.3 % U in a rock rich in biotite and apatite; however, this type of mineralised rock was not found in bedrock. Drill core from quartz-biotite rock: 1.35 m at 0.09 % U, 0.02 % Th, 0.03 % Mo [6].
Extent of mineralisation	At Löttö, unexposed uraniferous pockets in bedrock cover an area 50 m

	by 200 m on the basis of percussion and diamond drill samples. In a larger area of 1 km by 3 km, Löttö represents one of the many uraniferous showings [2-6].
Lodes	At the head of the boulder train there are several unexposed radioactive pockets in bedrock in an area of 100 m by 300 m. The best of the pockets is a lenticular body 2.5 m thick, 10 m wide and 25 m long, plunging east at 15-20 degrees, and grading 0.1 % U. The body is located at the surface of bedrock, partly within the preglacial regolith.

Exploration

Year of discovery	1984
Discovery	Uraniferous boulder found by GTK during ground follow-up of aeroradiometric gamma anomalies in 1983 [6]
Case history	Kajaani Oy: 1973-79: sulphide ore prospecting in the area, based on a chalcopyrite-bearing layman sample received in 1972. Three of these drilling sites are 300 m W of Löttö, and the trains of sulphide-bearing boulders and radioactive boulders overlap at Löttö [1, 6]. GTK 1983-85: ground radiometrics including detailed boulder tracing; pedogeochemical sampling by percussion drilling, diamond drilling in a grid of vertical shallow holes [6].
Diamond drilling	GTK 1985: 23 drill holes (260 m) [6]
Drill core availability	GTK/Loppi: all GTK drill cores
ElementsAnalysed	
Radiometric response	Reasonable radiometric response on U channel aeroradiometric map by the boulder train [4, 6]
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	50-75 m wide and 400 m long train of radioactive boulders in the direction of 305 degrees. The head of the train was traced into a peat bog; uraniferous pockets in bedrock were located 250 m NW from the head. Thickness of overburden NW of the head of the train is 4-6 m, of which peat forms the topmost 2-3 m. The rest is composed of till and regolith [6].
Geochemical dispersion	Pedogeochemical percussion drill sampling was used to locate the source of the boulders.
Geologist(s)	GTK: O. Äikäs [6]

Ore

Ore minerals	Uraninite
Accessory ore minerals	Molybdenite;galena; pyrrhotie, pyrite, chalcopyrite; ilmenite; unidentified secondary uranium minerals [6]
Gangue	Quartz, biotite, feldspars, hornblende, apatite, garnet [6]
Composition of minerals	
Texture and fabrics of ore	Disseminated euhedral uraninite up to 1 mm in diameter
Composition of ore	In radioactive rocks U/Th is from 3 to 10

U/Th	
Enriched elements	U, Th, Mo, P
Stable isotopes	
Pb isotopes	

Geology

Geological setting	A chain of discontinuous occurrences of paragneiss (mica gneiss and amphibolite) areas within the TTG-type granitoids and gneisses [1, 3]. At Löttö amphibolite and mica gneiss showing migmatitic banding and veining occur to the NE of the local body of granite. In a magnetic anomaly zone to the W of Löttö, Kajaani Oy intersected thin veins of iron sulphides in calc silicate rock and amphibolite lithologies by drilling [2, 3, 6].
Host lithology	In the Löttö boulders uranium is hosted by pods and nests of coarse-grained quartz rock, quartz biotite rock and quartzose pegmatite and medium-grained biotite-apatite-quartz rock, conformable with their wall rocks amphibolite and mica gneiss. In one of the pedogeochemical anomalies, quartz-biotite rock was found to host uranium in drill core. The uraniferous pockets of Löttö are located within the paragneisses no more than 50-100 m from the NW trending margin of the granite [6].
Intrusions	Reddish, gneissose granite ("Kapusta granite") is located in the area in a N-S directed irregular body, with gradual contacts with the gneisses. Coarse-grained pegmatitic granites are common in the area as veins, pods, and dykes in other rocks [2, 3].

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	Porphyroblasts of garnet occur in amphibolite and in mica gneiss [6]
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	Unidentified secondary minerals as pseudomorphs of uraninite [6]

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	
Tentative FinU model	Intrusive/migmatite neosome/pegmatite/quartz vein

References

1 Niiniharju, S. 1980. Om arkeiska skiffrar och granit-gnejser i Vepsäområdet, Kuhmo, östra Finland. Unpublished master's thesis, Åbo Akademi, Department of Geology and Mineralogy. 71 s. (in Swedish)

2 Äikäs, O. 1986. Malmitutkimukset Kuhmon kunnassa valtausalueella "Kapusta 1" (kaivosrek.nro. 3548/2). 10 p. Geological Survey of Finland, unpublished report M06/4324/-86/1/60. (in Finnish)

3 Kuosmanen, E. 1989. uraanin esiintyminen Kuhmon Hepovaaralla. Unpublished master's thesis, University of Helsinki, Department of Geology and Mineralogy. 86 p. (in Finnish)

4 Äikäs, O. 1989. Aeroradiometristen gamma-anomalioiden maastotarkistukset: 4322+4324 Tipasjärvi. 2 p. Geological Survey of Finland, unpublished report M19/4322/-89/1/60. (in Finnish)

5 Äikäs, O. 1989. Malmitutkimukset Kuhmon kaupungissa valtausalueella "Hepo 1" (kaivosrek.nro 3548/1). 14 p. Geological Survey of Finland, unpublished report M06/4324/-89/1/60. (in Finnish)

6 Äikäs, O. 1989. Uraanitutkimukset Kuhmon Lötössä 1984-85. 34 p. Geological Survey of Finland, unpublished report M19/4324/-89/1/60. (in Finnish)

Deposit

Name **Matari**

FinU_ID	65
ID of Malmikanta	
Last updated	19. 7.2000
Link to Fingold	
Red Book geologic setting	Surficial deposit
Eon or Era	Recent
Geological domain	Karelian
Geological province	Koli area

U- deposit? ☑

U as by-product? ☐

Th- deposit? ☐

Location

Map sheet	4242 02 B			
Coordinates	X (KKJ)	6968150	Latitude	62.81397
	Y (KKJ)	4450400	Longitude	29.02415
Municipality	Kontiolahti			
Village				
Nearest town	35 km NE of Joensuu			
Access	300 m from forest road			

Resources/Mining

Reservation	
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Mapped prospect
Economic evaluation	Uneconomic because of small size [5]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	8
% U	0.0144
% Th	
U production (tonnes)	
Best section(s)	5-6 % U in peat ash by the Matari spring, up to 0.2 % in peat ash from the mire Matarinsuo. In the peat of the NW and middle basins of the mire average contents of 0.0144 % U and 0.0088 % Cu were detected in dry peat [5].
Extent of mineralisation	50-100 m by 600 m with depths of the two basins 3-4 m and 2-7 m [4, 6]

Lodes

Exploration

Year of discovery	1983
Discovery	Radioactive spring located in the 1950s; uranium anomalies in orcanic stream sediment survey during exploration at Riutta [4, 5]; previous tests [1] & IAEA working group on uranium geology [2, 3]; peat sampling at Matari 1983 [5].
Case history	GTK 1983: R & D work started to study deposits of young uranium; peat sampling at Matari. 1984: regional ground water survey directed to the area, additional peat sampling. 1886: peat sampling and gamma spectrometry at Matari [4-7].
Diamond drilling	
Drill core availability	
ElementsAnalysed	By INAA: U; by MCA: U, Th; by AAS: Co, Cu, Mn, Pb, Mo, Fe, Ni,
Radiometric response	High counts of radioactivity around the Matari spring detected by portable counters [6]
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	Anomalous Rn in the spring water; 0.3 ppm U in the spring water and in the creek water upstream [5, 6]
Geologist(s)	GTK: O. Äikäs

Ore

Ore minerals	
Accessory ore minerals	
Gangue	
Composition of minerals	
Texture and fabrics of ore	Recent peat and muck
Composition of ore	Young uranium (in radioactive disequilibrium), no daughter elements; co-precipitated Cu; practically no Th [5, 6]
U/Th	
Enriched elements	U, Cu
Stable isotopes	
Pb isotopes	

Geology

Geological setting	A topographic low at the NE margin of a dome-like basement window collects uraniferous waters from Archaean and overlying Proterozoic bedrock. These waters are discharging through a peat bog deposited in shallow basins on top of a Quaternary sandur delta [6].

Host lithology

Intrusions

Metamorphism/Deformation/Alteration

Metamorphic history

Metamorphic index minerals

Deformation history

Alteration of rocks

Alteration of U/Th minerals

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards — A hiking route (UKK Route) goes by the radioactive spring

Geochemical hazards

Restoration

Conclusions

Timing	From the termination of the last glaciation about 11000 years ago to recent
Genetic reasoning	Uranium leached from bedrock and till are transported by groundwater and surface waters into the mire to be precipitated in the peat and muck [5-7].
Tentative FinU model	Surficial/peat

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Deposit

Name **Näärinki**

FinU_ID	69	U- deposit?	☑
ID of Malmikanta		U as by-product?	☐
Last updated	24. 7.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Phosphorite deposit		
Eon or Era	Palaeoproterozoic		
Geological domain	Svecofennian		
Geological province	Virtasalmi volcanic belt; tonalite migmatite zone of southern Finland		

Location

Map sheet	3231 11 A			
Coordinates	X (KKJ)	6870700	Latitude	61.94164
	Y (KKJ)	3531200	Longitude	27.59106
Municipality	Juva			
Village	Pohjois-Näärinki			
Nearest town	20 km NW of Juva			
Access	Forest roads to the area			

Resources/Mining

Reservation	
Exploration license number	2200/1-2, 419271-2
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	GTK 1970-75, 1987-1990
Status of development	Drilled prospect
Economic evaluation	No economic value as uranium deposits [3, 4]
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	0.01
% Th	
U production (tonnes)	
Best section(s)	Tutunen, drill core: one metre at 0.016 % U, 0.0009 % Th [3]; one metre at 0.026 % U, 13.55 % P2O5 [4]. Näärinki, drill core: one metre at 0.01 % U, <0.001 % Th. In boulders up to 0.1 % U, 15.5 % P2O5 [3].
Extent of mineralisation	Uraniferous outcrops in an area 1.5 km by 10 km, including numerous glacial erratics forming at least three separate boulder trains [3]. Additional finding of uraniferous outcrops presumably of the same type

	10 km NW of Tutunen [5].
Lodes	Two drilled prospects in the area, Tutunen (NW) and Näärinki (SE), 5 km apart. Both of these show scattered pockets, nests or interbeds of uraniferous phosphatic rocks [3, 4].

Exploration

Year of discovery	1987
Discovery	Diamond drilling in the Tutunen limestone deposit by GTK; radiometric logging of cores on the basis of previous knowledge on the occurrence of uraniferous boulders and outcrops in the Näärinki area [4].
Case history	Outokumpu 1959: radiometric boulder tracing at Näärinki (map sheet 3231 10) - one outcrop and a few boulders with weak radioactivity found. GTK: boulder tracing, geological mapping, trenching, ground geophysics and diamond drilling in the Näärinki area since 1962, based on magnetite-bearing layman samples. Until 1974, various types of sulphide ore boulders were found, including uraniferous phosphatic rocks [1, 2]. At Tutunen, minor showings of uranium were found in quartz rock in association of pockets of apatite; another cluster of uraniferous boulders and outcrops was found 5 km to the SE at Näärinki [2, 3]. 1986-87: re-tracing of sulphide ore boulders in the area - new boulders found within the Tutunen train, with higher contets of Zn. Ground geophysics and diamond drilling led to the discovery of limestone in drill cores causing a resuffle of drilling program to investigate the limestone deposit [4]. 1989: ground follow-up of aeroradiometric gamma anomalies in the area [5].
Diamond drilling	GTK: Tutunen 1970-74: 13 drill holes [3], 1987 11 holes [4]; 1974
Drill core availability	GTK/Loppi: all cores
ElementsAnalysed	By GSP: U, Th
Radiometric response	Poor response to aeroradiometric survey; in the 1989 follow-up minor radioactive spots in outcrops of quartz-feldspar gneiss were found about 10 km NW of the Tutunen prospect [5].
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: L.J. Pekkarinen, H. Makkonen [1-4]

Ore

Ore minerals	Uraninite, pitchblende, apatite, pyrrhotite
Accessory ore minerals	Chalcopyrite, sphalerite [1]
Gangue	Quartz, feldspars, diopside, biotite [1]
Composition of minerals	From apatite concentrate: 56 ppm U, 2.4 ppm Th and 230 ppm U, 2.8 ppm Th in apatite [6]
Texture and fabrics of ore	Uraninite as inclusions in apatite and in carbonate; grain size of apatite

	is 0.7 mm [4]. Apatite as bands in limestone and as nest-like pockets in quartz rock; distribution of uranium largely follows that of apatite.
Composition of ore	In four samples of quartz rock boulders: 0.027 % U, 0.0008 % Th; nine samples from diopside gneiss boulders: 0.02 % U, 0.0016 % Th [3].
U/Th	
Enriched elements	U, P
Stable isotopes	Carbon and oxygen isotopes from Tutunen carbonate rocks fit the range of Svecofennian values [7]
Pb isotopes	

Geology

Geological setting	A belt of metavolcanics comprising diopside amphibolite and hornblende gneiss, with minor quartz-feldspar gneiss. Situated 17 km NW of Tutunen, the Ankele limestone deposit is associated with this belt. Chemical sediments (chert, iron formation rocks) occur at the contact zone of the volcanics and the surrounding migmatitic mica gneisses [4].
Host lithology	Radioactive boulders and outcrops: phosphatic quartz rock (up to 0.085 % U), phosphatic quartz-feldspar gneiss and diopside gneiss (up to 0.026 % U) [1]. Tutunen [4]: Within the mica gneiss, a 200 m thick, 2 km long tabular body of limestone strikes from SE to NW, dipping steeply NE. At the SE end of the body, the hanging wall is composed of quartz rock 50 to 100 m thick, with interlayers of quartz-feldspar gneiss and mica gneiss. Phosphatic interbeds occur in limestone, in quartz rock and in mica gneiss; all phosphatic rocks are not uraniferous.
Intrusions	Granite and pegmatite veins and dykes cut the host rocks [4]

Metamorphism/Deformation/Alteration

Metamorphic history	Amphibolite to granulite facies regional metamorphism [4]
Metamorphic index minerals	Wollastonite in limestones [4]
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	Phosphorite-banded and phosphatic calcareous metasediments connected to felsic to intermediate volcanics, with syngenetic uranium mineralisation bound into phosphate. Mobilisation of phosphate and

	uranium, redeposition in quartz rocks intersecting the supracrustal rocks.
Tentative FinU model	Metamorphic phosphorite

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Deposit

Name **Malmberg-U**

FinU_ID	71	U- deposit?	☑
ID of Malmikanta	210	U as by-product?	☐
Last updated	27.12.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting			
Eon or Era			
Geological domain	Svecofennian		
Geological province	Granite migmatite belt of southern Finland; Uusimaa schist belt		

Location

Map sheet	2014 06 D			
Coordinates	X (KKJ)	6676770	Latitude	60.203
	Y (KKJ)	2478180	Longitude	23.60977
Municipality	Kisko			
Village	Leilä			
Nearest town	11 km SE of Kisko, 35 km SE of Salo			
Access	Forest road through the area			

Resources/Mining

Reservation	In quarantine: reservation expired 1998
Exploration license number	1160/1-9
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	Atomienergia Oy 1956-59
Status of development	Drilled prospect
Economic evaluation	
Red Book class	
Mining operations	Iron mining between 1670 and 1866
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	(Malmberg iron ore deposit: length 500 m, width 200 m, depth 50 m; vertical - from GTK MALMIKANTA)
Lodes	

Exploration

Year of discovery	1956
Discovery	Malmberg iron deposit was found in 1670 [1]
Case history	Atomienergia drilled a number of short diamond drill holes in the 1950s; Outokumpu carried out ground scintillometry on waste rock heaps of the ancient iron mine in 1962 [V. Hurskainen/OPÄ, pers. comm. 1981). Rautaruukki Oy 1979: ?
Diamond drilling	Atomienergia 1956-59?
Drill core availability	
ElementsAnalysed	
Radiometric response	Weak response on uranium channel aeroradiometric map, concealed by nearby areas of exposed bedrock.
Magnetic Response	Magnetic anomalies due to iron ores
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	

Ore

Ore minerals	Uraninite or pitchblende
Accessory ore minerals	Magnetite, chalcopyrite, scheelite, hematite, molybdenite [1, 4; GTK MALMIKANTA]
Gangue	Actinolite, diopside, hedenbergite, garnet, calcite [4, GTK MALMIKANTA]
Composition of minerals	
Texture and fabrics of ore	Magnetite-bearing calc-silicate rock with uraninite/pitchblende veins (V. Hurskainen/OPÄ, oral comm. 1981)
Composition of ore	
U/Th	
Enriched elements	U, Fe, Cu
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Volcanogenic and sedimentary gneisses of the Uusimaa belt host iron ores and complex sulphide deposits; iron ores are associated with calcareous metasediments [1]. Malmberg deposit is situated in a narrow zone of metasediments within the Orijärvi granodiorite [2, 3].
Host lithology	Magnetite bearing calc-silicate rock ("skarn iron ore") and quartz-feldspar schist ("leptite") [1, 4]. The iron ores has been mined out, with eight empty pits left in the area [4]. The remnants of waste rock heaps provided the uraniferous samples.

Intrusions	Granodiorite [Orijärvi granodiorite] and (younger) microcline granite intrude the gneisses [2, 3, 4]

Metamorphism/Deformation/Alteration

Metamorphic history	Hornblende-hornfels facies metamorphism in the area [4]
Metamorphic index minerals	Garnet
Deformation history	
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre

Protection areas

Watersheds

Radioactive hazards

Geochemical hazards

Restoration

Conclusions

Timing	Orijärvi granodiorite (1890 Ma) encloses the host metasediments.
Genetic reasoning	Information available too poor for classification; a special type of uranium mineralisation in the Svecofennian of southern Finland; what is the timing of uranium mineralisation in relation to the iron ores?
Tentative FinU model	

References

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Deposit

Name **Petrovaara-U**

FinU_ID	75
ID of Malmikanta	
Last updated	27.12.2000
Link to Fingold	
Red Book geologic setting	
Eon or Era	Palaeoproterozoic
Geological domain	Karelian
Geological province	

U- deposit? ☑
U as by-product? ☐
Th- deposit? ☐

Location

Map sheet	4311 12 A
Coordinates	X (KKJ) 7003050 Latitude 63.1281 Y (KKJ) 4452900 Longitude 29.06965
Municipality	Juuka
Village	Petrovaara
Nearest town	100 km NW of Joensuu, 19 km SW of Juuka
Access	600 m from gravel road

Resources/Mining

Reservation	In quarantine, claim reservation expired January, 2000
Exploration license number	
Mining concession number	
Holder of mineral rights	Open for acquisition
Previous holders	
Status of development	Drilled deposit
Economic evaluation	
Red Book class	
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	
% U	
% Th	
U production (tonnes)	
Best section(s)	Information only from glacial erratics, showing low (< 0.03 %) U contents in sulphide-bearing quartz-feldspar gneiss [2]
Extent of mineralisation	
Lodes	

Exploration

Year of discovery	
Discovery	Outokumpu Mining Oy in the late 1970s, probably during exploration work on the Petrovaara copper deposit [GTK MALMIKANTA ID 446] 1,5 km south of Petrovaara-U [2]
Case history	Outokumpu: geological mapping, litho- and pedogeochemical sampling, ground scintillometry & boulder tracing, trenching, drilling [3] GTK: reconnaissance scintillometry 1985 on the basis of [2].
Diamond drilling	Outokumpu: over 30 drill holes 1978-85 [3, 4], most in the Cu deposit
Drill core availability	
ElementsAnalysed	Cu [3, 4], U, Th [2]
Radiometric response	Aeroradiometric uranium channel anomaly as an indication of radioactive erratics
Magnetic Response	Magnetic anomalies in the quartzite area of the old map [1, 3]
Electromagnetic response	Electromagnetic anomalies in the quartzite area of the old map [1, 3]
Other geophysics	
Glacigenic dispersion	Radioactive erratic boulders form a train of 0.5 km long, striking 325 degrees [2]
Geochemical dispersion	
Geologist(s)	Outokumpu: H. Saarnio, M. Parkkinen GTK: O. Äikäs

Ore

Ore minerals	Uraninite [2]
Accessory ore minerals	Altered uraninite, U-Ti mineral phase. Chalcopyrite, pyrrhotite [2]
Gangue	Quartz, plagioclase, K-feldspar, mica, sulphides
Composition of minerals	
Texture and fabrics of ore	Disseminated fine-grained uraninite and U-Ti mineral phases and aggregates; weak impregnation of sulphides; sulphide veins brecciating the rock together with quartz veins; older breccia texture in the host gneiss. U-minerals as inclusions in sulphides. [2]
Composition of ore	In five boulder samples: < 0.03 % U, < 0.001 % Th, up to 0.375 % Cu, slightly elevated Co and Ni contents [2]
U/Th	
Enriched elements	U, Cu
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Close to the unconformity between Jatulian quartzite and Archaean basement [1]. Detailed mapping, geophysics, and diamond drilling indicate more complicated geology with amphibolites, black schists and

	calcareous rocks of the upper Jatulian on top of the quartzite [3].
Host lithology	Information available derives from a few radioactive erratics, in which uranium occurs in sulphide-bearing fine-grained quartz-feldspar gneiss [2]. These may originate from the Archaean basement or from volcanics an related metasediments of the upper Jatulian series of rocks.
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	Garnet-bearing mica schists in drill core sections [3]
Deformation history	
Alteration of rocks	Chloritic schists in drill core sections [3]
Alteration of U/Th minerals	Pseudomorphs of altered fine-grained uraninite [2]

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	
Genetic reasoning	Detailed information is lacking: uranium is not mentioned in the reports describing the copper deposit [3, 4]. Two possibilities: Archaean volcanics near the unconformity, or Palaeoproterozoic (upper Jatulian) volcanics, maybe related to the phosphorite type of deposits, although there is no confirmed information of elevated phosphate contents.
Tentative FinU model	Volcanic? Metaphosphorite?

References

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Deposit

Name **Sokli**

FinU_ID	76
ID of Malmikanta	281
Last updated	29.12.2000
Link to Fingold	
Red Book geologic setting	Intrusive & surficial & phosphorite
Eon or Era	Palaeozoic
Geological domain	Karelian
Geological province	Igneous alkaline rock province of the Kola Peninsula (Russia) [7]

U- deposit?	☐
U as by-product?	☑
Th- deposit?	☑

Location

Map sheet	4723 04 A			
Coordinates	X (KKJ)	7524000	Latitude	67.80122
	Y (KKJ)	4471000	Longitude	29.30861
Municipality	Savukoski			
Village				
Nearest town	85 km NE of Savukoski			
Access	Gravel road to the area			

Resources/Mining

Reservation	
Exploration license number	2019, 2041
Mining concession number	2019
Holder of mineral rights	Kemira Agro Oy 1993-
Previous holders	Rautaruukki Oy 1967-
Status of development	Deposit
Economic evaluation	The feasibility studies of the Sokli deposit have been based on the regolithic phosphorite ores as a source of P [7]. The estimates of the by-product uranium contained in hard rock of the deposit are speculative and derive from the discussions between the 1980 IUREP Mission and Rautaruukki Oy [4]
Red Book class	By-product/unconventional
Mining operations	
Ore (million tonnes; in situ)	
Contained U (tonnes; in situ)	2500
% U	0.01
% Th	
U production (tonnes)	
Best section(s)	
Extent of mineralisation	

Lodes

Exploration

Year of discovery	1967
Discovery	Ground follow-up of remote-sensing procedures of Rautaruukki Oy
Case history	Detailed exploration and feasibility studies to the stage of pilot plant operations by Rautaruukki Oy [6]. Concession presently held by Kemira Agro Oy.
Diamond drilling	Rautaruukki
Drill core availability	GTK/Loppi: 229 drill holes between 1967 and 1972
ElementsAnalysed	
Radiometric response	Gamma radiation logging shows the distribution of pyrochlore-bearing rocks in the core [6]
Magnetic Response	
Electromagnetic response	
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	Rautaruukki: H. Paarma, J. Nuutilainen, H. Vartiainen

Ore

Ore minerals	Pyrochlore [1, 3]
Accessory ore minerals	Apatite, limonite [1, 3]
Gangue	Carbonate, olivine, apatite, magnetite, phlogopite [6]
Composition of minerals	U and Th contents of pyrochlore vary in the deposit [1, 3, 4]. In regolith samples uraniferous pyrochlore, apatite, and limonite [3]
Texture and fabrics of ore	Disseminated pyrochlore in hard rocks, very fine-grained uraniferous matter in soft regolith samples [1, 3]
Composition of ore	
U/Th	
Enriched elements	Th, U, P
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Archaean gneisses, gneissic granitoids, amphibolites and ultramafic rocks are intruded by the carbonatite body, with a surface section of 18 km2. The area of the magmatic carbonatite core is 4.5 km2; it is surrounded by zones of metacarbonatie and fenite, and a set of carbonatite ring dykes. On top of the carbonatite, there are regolithic phosphorite deposits [7]
Host lithology	Uranium is in the pyrochlore, which occurs in the phoscorite and sövite of the magmatic core [3, 4].

Intrusions	Carbonatite ring dykes, lamprophyre dykes [7]

Metamorphism/Deformation/Alteration

Metamorphic history	
Metamorphic index minerals	
Deformation history	
Alteration of rocks	Deep leaching and weathering in the phoscoritic parts of the carbonatite [7]
Alteration of U/Th minerals	Pyrochlore: leaching of uranium [3]

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	
Restoration	

Conclusions

Timing	Palaeozoic (365 Ma) to recent (at least 60000 years for the regolith) [7]
Genetic reasoning	Primary magmatic carbonatite with U and Th contained in the pyrochlore. Uranium leached from pyrochlore may form secondary surficial enrichments in regolithic phosphorites.
Tentative FinU model	Intrusive & surficial

References

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Deposit

Name **Talvivaara**

FinU_ID	77	U- deposit?	☐
ID of Malmikanta	267	U as by-product?	☑
Last updated	29.12.2000	Th- deposit?	☐
Link to Fingold			
Red Book geologic setting	Black shale deposits		
Eon or Era	Palaeoproterozoic		
Geological domain	Karelian		
Geological province	Kainuu schist belt		

Location

Map sheet	3344 06 B			
Coordinates	X (KKJ)	7099650	Latitude	63.99313
	Y (KKJ)	3551900	Longitude	28.05692
Municipality	Sotkamo			
Village				
Nearest town	38 km SE of Kajaani			
Access	500 m from paved road, gravel road to the deposits			

Resources/Mining

Reservation	
Exploration license number	750/1, 1555/1, 2819/
Mining concession number	2819/. 2838/, 2839, 2863
Holder of mineral rights	Outokumpu Mining Oy 1986-
Previous holders	Suomen Mineraali Oy 1949-52, Suomen Malmi Oy 1961-62, GTK 1977-86
Status of development	Deposit
Economic evaluation	In situ resource evaluation by GTK (300 million tonnes of mineralised rock) [6], feasibility studies and further evaluation by Outokumpu [5]. The recovery of uranium from the mineralised rock has not been studied [2]
Red Book class	By-product/unconventional
Mining operations	Several test pits in the Kuusilampi lode by Outokumpu.
Ore (million tonnes; in situ)	300
Contained U (tonnes; in situ)	3000
% U	0.001
% Th	
U production (tonnes)	
Best section(s)	Average black schists in one of the test pits in the Kuusilampi lode: 0.35 % Ni, 0.14 % Cu, 0.60 % Zn, 0.03 % Co, 0.17 % Mn, 8.85 % Fe,

	7.52 % S, 8.86 % C [5]. U contents in the deposits up to 47 ppm [1, 4].
Extent of mineralisation	
Lodes	Kolmisoppi 80 (Mt) in the north, Kuusilampi (220 Mt) in the south, 5 km apart. Mean uranium content given in the GTK MALMIKANTA entry is 0.001 % U for each.

Exploration

Year of discovery	1977
Discovery	GTK started systematic study on the previously known sulphide-bearing schists at Talvivaara in 1977.
Case history	GTK 1977-: diamond drilling, ground magnetic and electromagnetic survey, evaluation. Outokumpu 1978-1983 pilot plant concentration tests at Outokumpu, 1989-1990 additional diamond drilling [5]
Diamond drilling	GTK 57 drill holes (12.8 km) within the deposit; Outokumpu 67 drill
Drill core availability	GTK/Loppi: 90 GTK drill holes listed from the area
ElementsAnalysed	
Radiometric response	Clear response on aeroradiometric U channel maps
Magnetic Response	Good response on magnetic methods due to pyrrhotite [6]
Electromagnetic response	High ratio of real and imaginary components shown by the Ni-rich black schists [6]
Other geophysics	
Glacigenic dispersion	
Geochemical dispersion	
Geologist(s)	GTK: P. Ervamaa, T. Heino

Ore

Ore minerals	Pyrite, pyrrhotite [6]
Accessory ore minerals	Chalcopyrite, sphalerite, alabandite, pentlandite, galena 86]
Gangue	Quartz, graphite, sericite, biotite, feldspar, garnet, apatite, rutile [6]
Composition of minerals	
Texture and fabrics of ore	Finely disseminated banded sulphides; coarser-grained brecciating sulphide veins [5, 6]
Composition of ore	Uranium occurs in thucolite [6] and as disseminated accessory uraninite. The thorium contents in a series of 20 samples are below 15 ppm [4].
U/Th	
Enriched elements	Ni, Cu, Zn, Mn, Fe, S, C, U [4, 6]
Stable isotopes	
Pb isotopes	

Geology

Geological setting	Western flank of the Nuasjärvi basin, a tight syncline filled with

	Kalevian mica schists and metaturbidites, flanked with Jatulian quartzites on both sides [1]. The host black shales belong to the Lower Kalevian metasediments characterized by metaturbidites in the area. Enveloped by mica schists, the black shales overlie the Jatulian quartzites [1, 6].
Host lithology	Ni-Cu-Zn rich parts of theTalvivaara black schists (shales; C > 1 % & S > 1 %) contain three groups of rocks: 1) low Ni-Mn black schists, with < 0.1 % Ni & < 0.8 % Mn; 2) Ni-rich black schists with > 0.1 % Ni, and 3) Mn-rich black schists with > 0.8 % Mn [6]. Intercalations of black calc-silicate rock are common [6].
Intrusions	

Metamorphism/Deformation/Alteration

Metamorphic history	Amphibolite facies regional metamorphism [6]
Metamorphic index minerals	
Deformation history	Isoclinal folding [6]
Alteration of rocks	
Alteration of U/Th minerals	

Environment

Population centre	
Protection areas	
Watersheds	
Radioactive hazards	
Geochemical hazards	Environmental studies conducted in the surroundings have revealed naturally enhanced contents of various metals in lakes and ground waters [7].
Restoration	

Conclusions

Timing	Based on correlation with the Jormua area, 1.97-1.96 Ga is suggested for the age of the deposition of the host black schists, followed by deformation and metamorphism during the Svecokarelian orogeny 1.9 to 1.8 Ga ago [6].
Genetic reasoning	
Tentative FinU model	Black shale

References

1 Havola, M. 1981. Sotkamo. Geological Map of Finland 1:100 000, Pre-Quaternary Rocks, sheet 3433. Geological Survey of Finland.

2 Anon. 1981. IUREP (International Uranium Resources Evaluation Project) orientation phase mission report: Finland. OECD Nuclear Energy Agency. 104 p.

3 Anon. 1982. IUREP (International Uranium Resources Evaluation Project) Orientation Phase mission. Summary Report: Finland. Paris: OECD Nuclear Energy Agency. 24 p.

4 Loukola-Ruskeeniemi, K. 1991. Suomen proterotsooisten mustaliuskeiden uraanipitoisuudesta. 2 p. Geological Survey of Finland, unpublished report M19/3344/-91/1/30. (in Finnish)

5 Pekkarinen, L. & Sandberg, E. 1996. Talvivaaran monimetalliesiintymä. Vuorimiesyhdistys, B 61, 13-14. (in Finnish)

6 Loukola-Ruskeeniemi, K. & Heino, T. 1996. Geochemistry and genesis of the black shale-hosted Ni-Cu-Zn deposit at Talvivaara, Finland. Economic Geology 91, 80-110.

7 Loukola-Ruskeeniemi, K., Kontinen, A. & Airo, M.-L. 1997. Kainuu district. Geological Survey of Finland, Guide 42, 57-64.