Vihanti

Alternative Names: Lampinsaari, Isoaho
Occurence type: deposit

Commodity	Rank	Total measure	Total production	Total resource	Importance
zinc	1	1478113,07 t	1445122,67 t	32990,4 t	Large deposit
copper	2	159839,62 t	128682,02 t	31157,6 t	Medium sized deposit
gold	3	3,27 t	3,27 t	0 t	Small deposit
lead	3	98327,27 t	98327,27 t	0 t	Medium sized deposit
silver	3	278,07 t	278,07 t	0 t	Small deposit
phosphorous pentoxide	4	83916 t	0 t	83916 t	Occurrence
uranium	4	725,2 t	0 t	725,2 t	Small deposit
sulphur	5	422643,88 t	422643,88 t	0 t	Medium sized deposit

Easting EUREF: 410557,757
Northing EUREF: 7143629,837
Easting YKJ: 3410694
Northing YKJ: 7146622

Discovery year: 1946
Discovered by: Geological Survey of Finland
Province: Vihanti-Pyhäsalmi (Zn, Cu)
District: Vihanti (Zn, Cu)
Comments: The first indications were mineralised samples from glacial erractics found by amateur prospectors in 1936 and 1939; these led the GTK to discover the ore by drilling into an area indicated by glacial erratic boulder survey and as an electric and magnetic anomaly.
References: 2, 7, 8, 19, 20, 24, 26, 28, 29, 30, 34, 35, 36, 37, 39, 40, 45, 46, 47, 48, 49, 50, 51, 54, 58, 62, 64, 65, 67, 69

Mineral deposit type

Group: Metallogenic deposit
Main type: VMS (mixed hydrothermal)
Sub type 1: Bimodal-felsic
References: 14, 21, 25, 27, 28, 38, 42

Dimension

Expression: geophysical anomaly
Form: concordant
Shape: irregular
Length (m): 1500
Width (m): 125
Thickness (m): NA
Depth (m): 1000
Area (ha): NA
Dip azim: 315
Dip: NA
Plunge azim: NA
Plunge dip: NA
Orientation method: NA
Dimension comments: 1-50 m thick, 50-200 m wide and 150-900 m long lodes: pyrite, zinc, chalcopyrite and Pb-Ag-Au lodes; the Zn and pyrite lodes are 10-20 m apart. Main ore bodies are Ristonaho, Välisaari and Lampinsaari; Ristonaho and Välisaari combined is 1100 m long, and both are 100 m wide and 10-60 thick. Isoaho is a plate extending from the level 350 m to the level 1000 m

(below surface). The main pyrite ore bodies are Hautaräme and Hautakangas. U-P ore is separate from the sulphide ores.

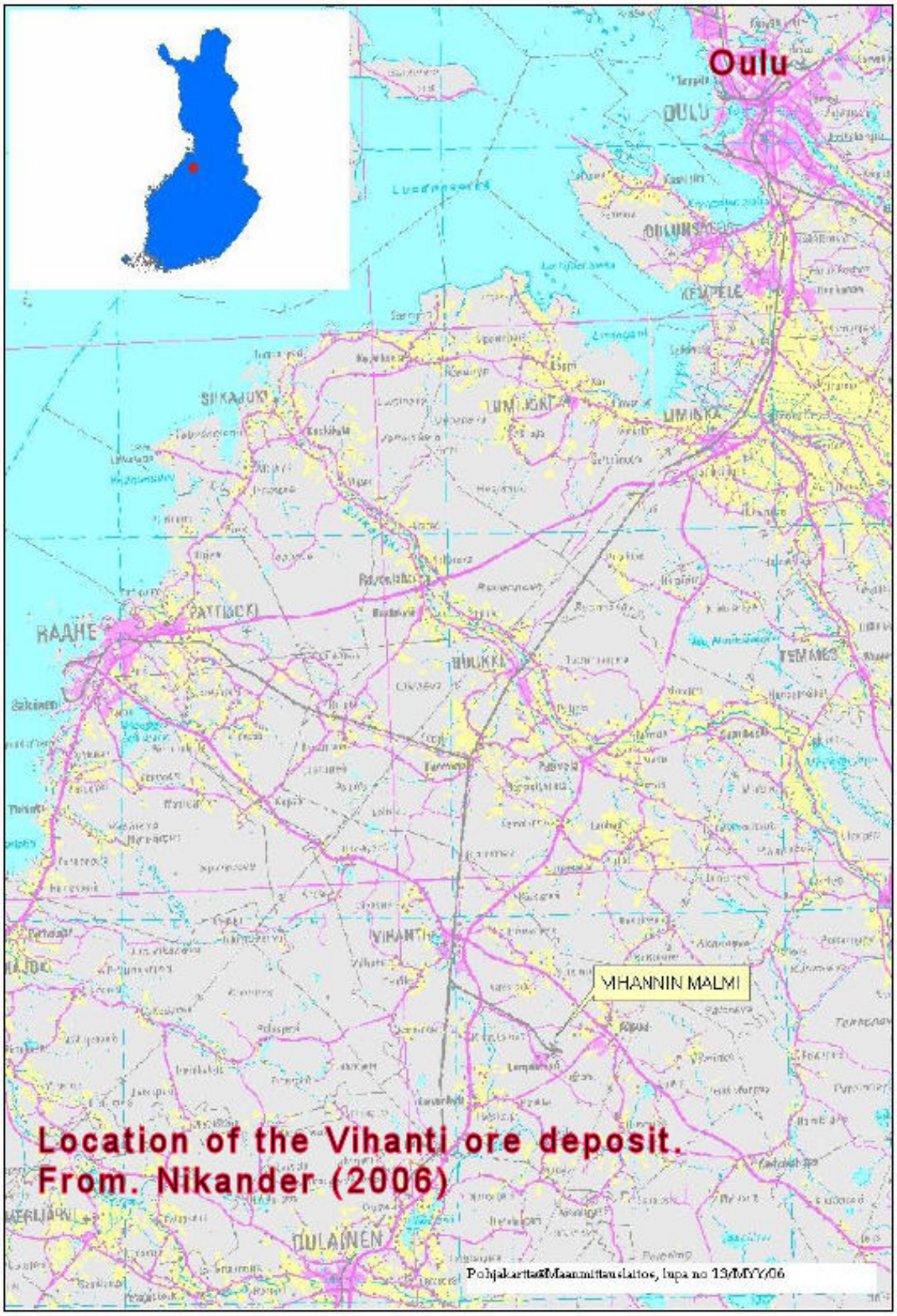
Holder history

Previous holders:

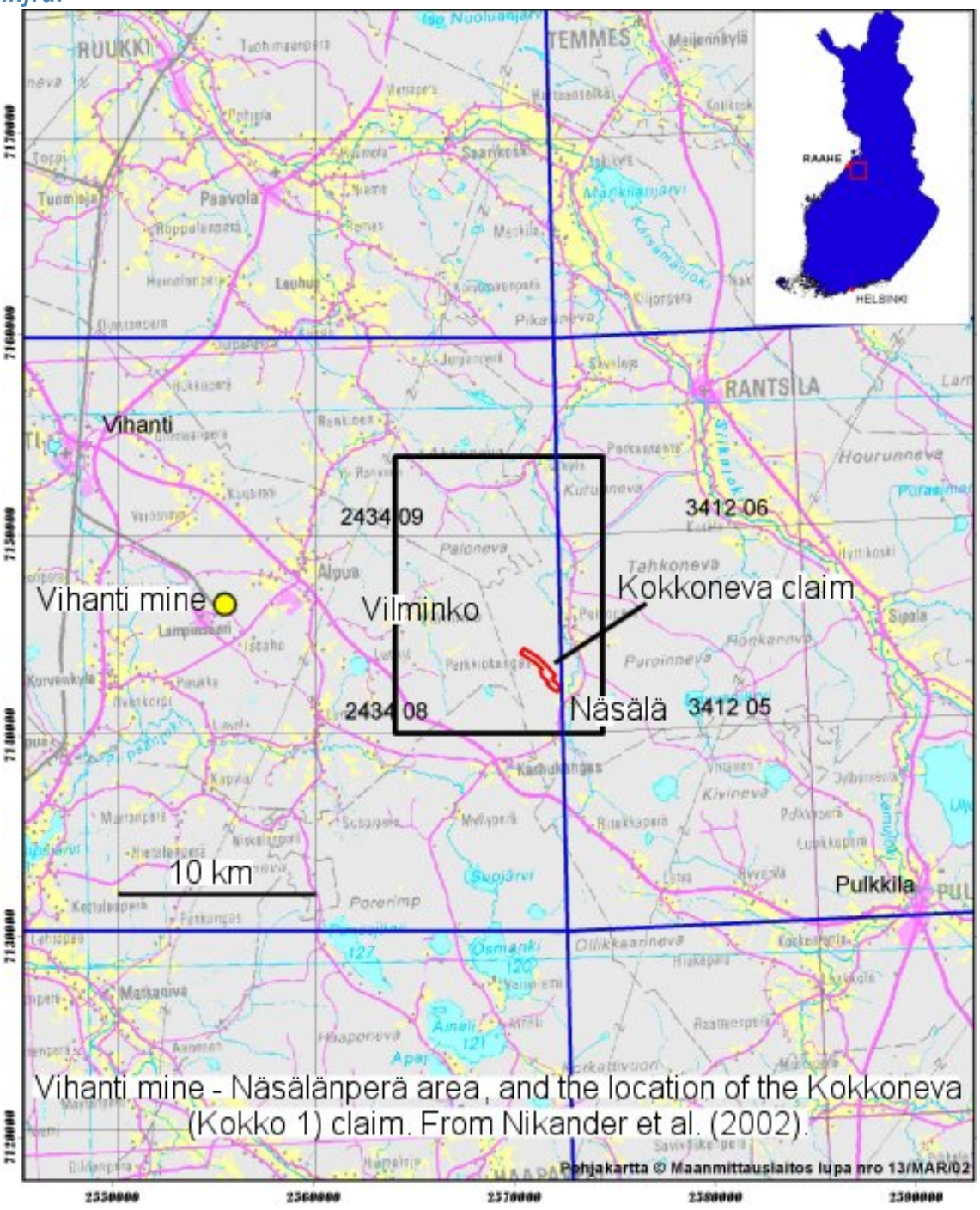
Company	Years	Holding type	Comments
Norrbotten Exploration AB	2019	Application for exploration permit	Norrbotten Exploration AB is owned by Arctic Minerals AB
Magnus Minerals Oy	2014-2016	Claim (old law)	NA
Oy SES Finland Ltd	2006	NA	NA
Outokumpu Oy	1952	Mining concession (old law)	NA
Outokumpu Oy	1951-2005	NA	NA
Geological Survey of Finland	1946-1950	NA	NA

Figures

Location of Vihanti-U SE of Vihanti ("VIHANNIN MALMI"):



Infra:



Vihanti mine - Näsälänperä area, and the location of the Kokkoneva (Kokko 1) claim. From Nikander et al. (2002).

EXPLORATION ACTIVITY

Arctic Minerals AB

Years	Activity type	Geologist	Exploration result	Ref
2018-2019	detailed geophysics	Risto Pietilä	geophysical anomaly	3, 4
	Reassessment of existing geophysical data: "interpretation shows a clear seismic anomaly located at a depth of approximately 1,000 meters to the southwest of the old mine and down-dip from the original orebody. The anomaly is consistent with the type to be expected by the presence of massive sulphides."			

Geological Survey of Finland

Years	Activity type	Geologist	Exploration result	Ref
1993-2006	core drilling	J. Nikander	key geological features	36, 37, 38, 39
	151 diamond drill holes in the Vihanti area. Of this, 20 diamond-drill holes, total 2638 m, in 2004-2005 and 12 drill holes, 2886 m, in 2006			

1992-2006	detailed geology	J. Kousa, J. Nikander, J. Luukas, E. Iisalo	NA	

1984-1984	regional geochemistry	Esko Iisalo	NA	9, 10, 11, 12, 17, 39, 60
	Regional till geochemical survey.			

1983-1983	regional geophysics	NA	key geological features	
	Low-altitude airborne magnetic, electromagnetic and radiometric survey			

University of Helsinki

Years	Activity type	Geologist	Exploration result	Ref
1978-1983	detailed geology	P. Rehtijärvi, P. Soljanto	mineral occurrences	31, 48, 49, 50, 51, 52, 53, 63
	Detailed mineralogical work on the Vihanti uranium-phosphorus mineralised rocks			

Outokumpu Oy

Years	Activity type	Geologist	Exploration result	Ref
1973-1992	ore deposit evaluation	R. Sarikkola, E. Rauhamäki, K. Pelkonen, O.-P. Isomäki	NA	14, 21, 31, 34, 46, 47

Geological Survey of Finland

Years	Activity type	Geologist	Exploration result	Ref
1970-2005	geological interpretation	Jarmo Nikander, Jukka Kousa, Jouni Luukas, Kirsti Loukola-Ruskeeniemi	key geological features	18, 19, 20, 24, 25, 26, 27, 28, 29, 36, 37, 38, 39, 60, 67, 69, 71

1970-2005	detailed geochemistry	Alf Björklund, L-M Kauranne, Esko Iisalo, K. Loukola-Ruskeeniemi	geochemical anomaly	5, 6, 9, 10, 11, 12, 17, 28
	A strong Au anomaly in till related to the ore, also where practically all zinc has been leached away from till. Only a low-contrast, incoherent, areally restricted Zn-Pb-Cu anomaly in till; rather, the Zn anomalies in till reflect the locations of granitic rocks in the region. An extensive Zn anomaly in dolomites and skarns and a similar Pb anomaly in all local rocks, except the black schists. The sequence of increasing lateral extent of the anomalies is: Cu, Mo, U, Ba, Tl, As, Hg, Zn, Ag,			

Outokumpu Oy

Years	Activity type	Geologist	Exploration result	Ref
1962-1968	detailed geochemistry	Heikki Wennervirta	geochemical anomaly	70
	Detailed lithogeochemical survey			

1951-1992	core drilling	Pentti Rouhunkoski	mineral reserve defined	4, 21, 54
	Extensive diamond drilling in 25 m profiles across the ore; by the end of 1966 total drilling was 120 km. Arctic Minerals reports (21 Feb 2019) "Towards the end of the mine life, Outokumpu drilled one hole from the bottom of the mine. This hole intersected several zones of semi-massive sulphide ore ... These intersections are located at a lateral distance estimated to be between 300 and 500 meters from the edge of the newly identified seismic anomaly"			

1951-1992	detailed geophysics	Pentti Rouhunkoski, R. Sarikkola, E. Rauhamäki, K. Pelkonen, O.-P. Isomäki	geophysical anomaly	1, 21, 30, 34, 54
	The pyrite lodes have a good response on slingram and gravimetry. The black schists have a strong response on both magnetic and electric methods.			

1951-1989	detailed geology	Pentti Rouhunkoski	key geological features	1, 5, 13, 14, 21, 31, 43, 54, 59, 70

1951-1989	percussion drilling	Pentti Rouhunkoski	geochemical anomaly	1, 5, 13, 14, 21, 31, 43, 54, 59, 70

1951-1992	ore beneficiation tests	P. Rouhunkoski, R. Sarikkola, E. Rauhamäki, K. Pelkonen, O.-P. Isomäki	positive feasibility study	1, 5, 7, 14, 43, 54, 58, 59, 62

1951-1989	regional geophysics	Pentti Rouhunkoski	key geological features	1, 5, 13, 14, 21, 31, 43, 54, 59, 70

Geological Survey of Finland

Years	Activity type	Geologist	Exploration result	Ref
1951-1955	regional geology	Ilmari Salli	key geological features	56, 57
	Regional bedrock mapping			

1946-1950	core drilling	Aimo Mikkola	mineral resource indicated	5, 16, 23, 28, 54, 57

	GTK to discover the ore by drilling into an area indicated by glacial erratic boulder survey and as an electric and magnetic anomaly; 40 diamond-drill holes, total 5979 m.	
	Intersections	
	HoleID	NA
	From-To	NA
	Length	1,2m
	uranium	0,15%
	phosphorous pentoxide	25,5%

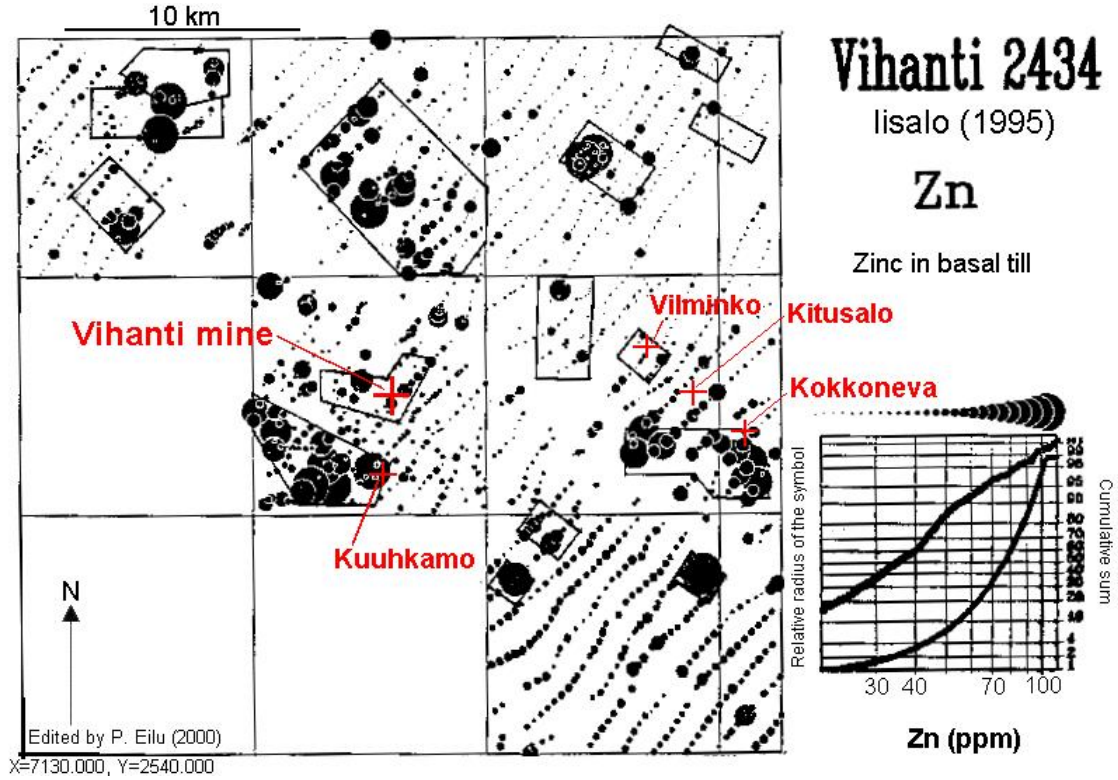
1936-1950	detailed geology	Aimo Mikkola	mineral occurrences	13, 16, 23, 32, 33, 54, 68
	Detailed bedrock mapping in the area			

1936-1950	detailed geophysics	Aimo Mikkola	geophysical anomaly	13, 16, 23, 32, 33, 54, 56, 57, 68
	ground electric, gravimetric and magnetic survey			

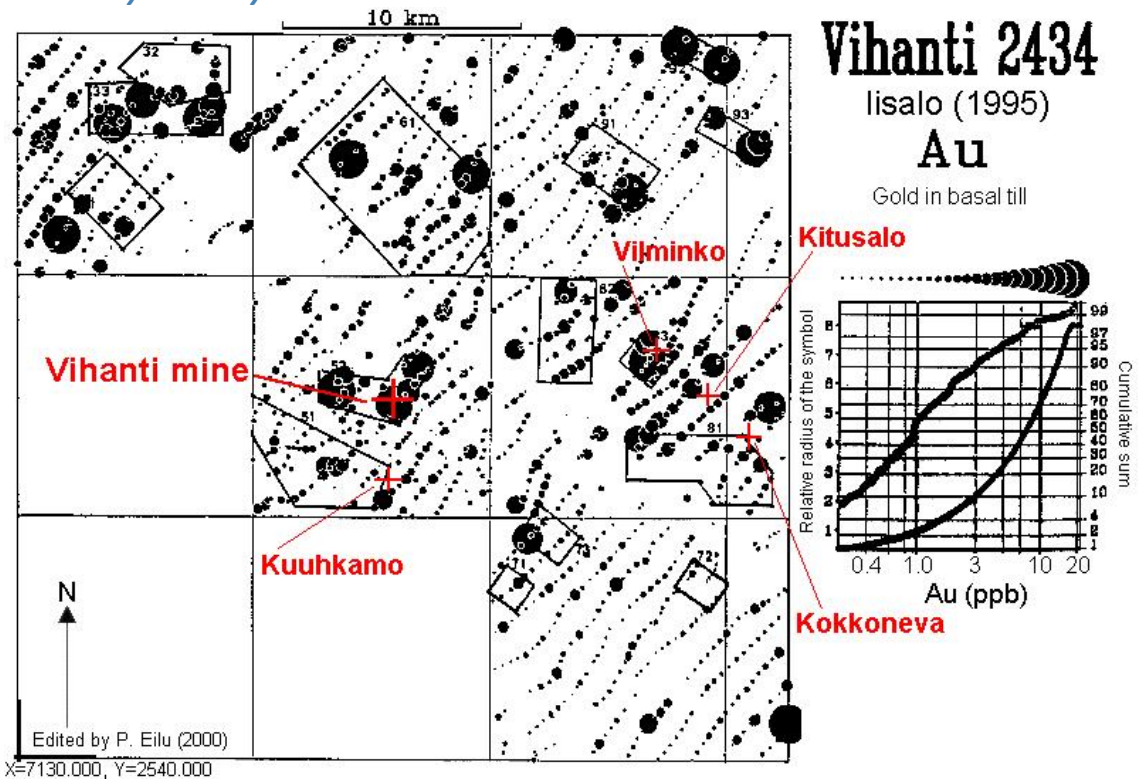
1936-1950	detailed geochemistry	Aimo Mikkola	geochemical anomaly	6, 10, 17
	Lithogeochemical and till-geochemical surveys			

Figures

Secondary anomaly:



Secondary anomaly:



RESOURCES AND RESERVES

Most recent

Type:	Company:	Year:	Date:	Calc Method:	Reference:
Resource	Outokumpu Oy	1992	NA	Non-compliant resource estimate	41
	Category:	**Indicated and inferred mineral resource**			
	Tonnage:	**9,164 Mt**			
	copper	0,34 %			
	zinc	0,36 %			
	Cutoff:	**NA**			

Type:	Company:	Year:	Date:	Calc Method:	Reference:
Resource	Outokumpu Oy	1992	NA	Non-compliant resource estimate	71
	Category:	**Inferred mineral resource**			
	Tonnage:	**2,59 Mt**			
	uranium	0,028 %			
	phosphorous pentoxide	3,24 %			
	Cutoff:	**NA**			

MINING

Vihanti

Alternative Names: Alpua, Ristonaho
Easting EUREF: 410557,757
Northing EUREF: 7143629,837
Status: Closed
Operating years: 1952-1992
Years in production: 41
Total ore mined: 27938832 t
References: 28, 41, 51, 61

Total production:

Product	Product measure
copper	128682,02 t
lead	98327,27 t
zinc	1445122,67 t
gold	3267,13 kg
silver	278,07 t
sulphur	422643,88 t

Other materials:

Material type	Material measure
Waste rock	2845360 t

Mining activity:

Year	Ore mined	Ore processed	Activity type	Production	Other material
1992	393161 t	393161 t	underground mining		
				zinc 13682 t copper 1203,07 t lead 1336,74 t gold 117,94 kg silver 8059,8 kg	Waste rock 3028 t
1991	1004322 t	1004322 t	NA		
				zinc 24003,29 t copper 3394,6 t lead 3113,39 t gold 351,51 kg silver 24103,72 kg	Waste rock 45267 t
1990	1056661 t	1056661 t	NA		
				zinc 30326,17 t copper 3381,31 t lead 3486,98 t gold 412,09 kg silver 27050,52 kg	Waste rock 31817 t
1989	1125670 t	1125670 t	NA		
				zinc 37259,67 t copper 3489,57 t lead 4840,38 t gold 551,57 kg silver 34895,77 kg	Waste rock 31917 t
1988	1098886 t	1098886 t	NA		

				zinc 38680,78 t copper 3626,32 t lead 3955,98 t gold 527,46 kg silver 30768,8 kg	Waste rock 60253 t
1987	1145369 t	1145369 t	NA		
				zinc 40316,98 t copper 3779,71 t lead 4123,32 t gold 549,77 kg silver 32070,33 kg	Waste rock 86861 t
1986	1130084 t	1130084 t	NA		
				zinc 42717,17 t copper 4181,31 t lead 3955,29 t gold 497,23 kg silver 29834,21 kg	Waste rock 153600 t
1985	1032318 t	1032318 t	NA		
				zinc 37782,83 t copper 3716,34 t lead 3922,8 t	Waste rock 143205 t
1984	1065760 t	1065760 t	NA		
				zinc 34956,92 t copper 3836,73 t lead 4049,88 t	Waste rock 132354 t
1983	1055993 t	1055993 t	NA		
				zinc 41606,12 t copper 3801,57 t lead 3590,37 t	Waste rock 81349 t
1982	963121 t	963121 t	NA		
				zinc 37754,34 t copper 2889,36 t lead 3274,61 t	Waste rock 78350 t
1981	956685 t	956685 t	NA		
				zinc 35493,01 t copper 2870,05 t lead 2870,05 t	Waste rock 87698 t
1980	928654 t	928654 t	NA		
				zinc 40675,04 t copper 4643,27 t lead 2878,82 t	Waste rock 78835 t
1979	936097 t	936097 t	NA		
				zinc 35758,9 t copper 5335,75 t lead 2901,9 t	Waste rock 137938 t
1978	846601 t	846601 t	NA		
				copper 5079,6 t zinc 30308,31 t sulphur 73654,28 t lead 2285,82 t	Waste rock 158838 t
1977	907741 t	907741 t	NA		
				copper 5083,34 t zinc 31952,48 t lead 2131,91 t	Waste rock 61535 t
1976	903734 t	903734 t	NA		
				copper 4518,67 t zinc 36601,22 t lead 2168,96 t	Waste rock 55266 t
1975	845060 t	845060 t	NA		

				copper 4056,28 t zinc 32872,83 t sulphur 40224,85 t lead 1569,49 t	Waste rock 63409 t
1974	732603 t	732603 t	NA		
				copper 3150,19 t zinc 35751,02 t sulphur 27179,57 t lead 1939,28 t	Waste rock 90348 t
1973	791639 t	791639 t	NA		
				copper 3562,37 t zinc 39265,29 t sulphur 34673,78 t lead 2374,91 t	Waste rock 75867 t
1972	831931 t	831931 t	NA		
				copper 3615,6 t zinc 36604,96 t sulphur 32029,34 t lead 2163,02 t	Waste rock 121018 t
1971	660573 t	660573 t	NA		
				copper 2972,57 t zinc 36661,8 t sulphur 39832,55 t lead 2019,22 t	Waste rock 138074 t
1970	710600 t	710600 t	NA		
				copper 2629,22 t zinc 37519,68 t sulphur 49813,06 t lead 2273,92 t	Waste rock 134322 t
1969	709331 t	709331 t	NA		
				copper 1276,79 t zinc 40219,06 t sulphur 50362,5 t lead 2796,86 t	Waste rock 75764 t
1968	706326 t	706326 t	NA		
				copper 3460,99 t zinc 38847,93 t sulphur 52621,28 t lead 1907,08 t	Waste rock 69039 t
1967	517504 t	517504 t	NA		
				copper 2742,77 t zinc 31153,74 t sulphur 22252,67 t lead 1623,57 t	Waste rock 63224 t
1966	435573 t	435573 t	NA		
				zinc 33103,54 t copper 2439,2 t lead 1960,07 t	Waste rock 51636 t
1965	487995 t	487995 t	NA		
				zinc 44017,14 t copper 2781,57 t lead 2586,37 t	Waste rock 43344 t
1964	466836 t	466836 t	NA		
				zinc 48504,26 t copper 3314,53 t lead 1867,34 t	Waste rock 36484 t
1963	464553 t	464553 t	NA		
				zinc 50125,26 t copper 3298,32 t lead 1765,3 t gold 139,36 kg silver 10452,44 kg	Waste rock 42228 t

1962	445189 t	445189 t	NA		
				zinc 49148,86 t copper 3962,18 t lead 1647,19 t gold 120,2 kg silver 9883,19 kg	Waste rock 33099 t
1961	437300 t	437300 t	NA		
				zinc 49283,71 t copper 4460,46 t lead 1792,93 t silver 9751,79 kg	Waste rock 36917 t
1960	438838 t	438838 t	NA		
				zinc 44717,59 t copper 3861,77 t lead 2281,95 t silver 11409,78 kg	Waste rock 28606 t
1959	405507 t	405507 t	NA		
				zinc 56770,98 t copper 3892,86 t lead 2595,24 t silver 10421,52 kg	Waste rock 45491 t
1958	403782 t	403782 t	NA		
				zinc 49019,13 t copper 2987,98 t lead 2664,96 t silver 11346,27 kg	Waste rock 44202 t
1957	402870 t	402870 t	NA		
				zinc 43026,51 t copper 2618,65 t lead 2658,94 t silver 12569,54 kg	Waste rock 48842 t
1956	305887 t	305887 t	NA		
				zinc 37685,27 t copper 1835,32 t lead 1804,73 t silver 9574,26 kg	Waste rock 35359 t
1955	175254 t	175254 t	NA		
				zinc 19751,12 t copper 858,74 t lead 1104,1 t silver 5485,45 kg	Waste rock 24443 t
1954	12824 t	12824 t	NA		
				zinc 1197,76 t copper 73,09 t lead 43,6 t silver 397,54 kg	Waste rock 65770 t
1953	0 t	0 t	NA		
					Waste rock 34563 t
1952	0 t	0 t	NA		
					Waste rock 15200 t

Figures


Vihanti mine site
Photo by permission of Outokumpu Oyj

GEOLOGY

Ore: Sulphide ore
Host rock: Quartz-Plagioclase Gneiss, Felsic volcanic rock, Calcite-Apatite Metacarbonate-rock, Skarn
Wall rock: Greywacke, Dolomitic marble, Cordierite Meta-felsic-rock

Sulphide ore (Ore)

Rock type: Ore
Proportion: major
Grain size: NA
Color: NA
References: 5, 13, 14, 18, 25, 28, 32, 38, 42, 43, 52, 54, 57, 59, 63, 67
Comments: Massive banded and non-banded, and disseminated sulphide ore with common sulphide±sulphosalt veins. The Zn and Cu lodes are chiefly in the diopside skarns and pyrite lodes in the 'arenaceous rocks' of the sequence .

Ore minerals:

Mineral	Proportion	Mineral texture
Antimony	minor	
Arsenopyrite	minor	
Bismuth	minor	
Boulangerite	minor	
Bournonite	minor	
Breithauptite	minor	
Chalcopyrite	major	Banded, Dissemination, Massive, Vein
	Grain size of ore minerals is 0.05-1 mm.	
Cubanite	minor	
Electrum	minor	
Gahnite	minor	
Galena	major	Banded, Dissemination, Massive, Vein
	Grain size of ore minerals is 0.05-1 mm.	
Gold	minor	
Gudmundite	minor	
Hessite	minor	
Magnetite	minor	
Molybdenite	minor	
Nickeline	minor	
Nisbite	minor	
Pyrargyrite	minor	
Pyrite	major	Banded, Dissemination, Massive, Vein
	Pyrite is commonly euhedral and forms porphyroblasts up to 10 cm in diameter (esp. in the pyrite lodes)	
Pyrrhotite	major	Massive, Banded, Dissemination, Vein
	Grain size of ore minerals is 0.05-1 mm.	
Silver	minor	
Sphalerite	major	Massive, Banded, Dissemination, Vein
	Grain size of ore minerals is 0.05-1 mm.	
Stannite	minor	
Tennantite	minor	
Tetrahedrite	minor	
Ullmannite	minor	
Uraninite	minor	
Valleriite	minor	

Other minerals:

Mineral	Proportion	Mineral texture
Baryte	present	
Diopside	present	
Fluorite	present	
Graphite	present	
Quartz	present	
Rutile	present	
Tourmaline	present	
Tremolite	present	

Structures
Veined

Textures
Massive
Banded

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA	-8	-630
Comments: Peak regional metamorphism at about 1876±2 Ma related to the intrusion of synorogenic, 1.89-1.87 Ga, granitoids.					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:		
Paleoproterozoic (2500-1600 Ma)	1860-2120	1979	Y		
Comments: The sulphides were formed at about 1900 Ma.					
Radiometric age:	**Method:**	**Age:**	**Error (Ma):**	**Mineral:**	**Reference:**
	Pb-Pb	1860		Microcline	54
	Pb-Pb	1918		Galena	66
	Pb-Pb	1925		Galena	66
	Pb-Pb	2070		Galena	54
	Pb-Pb	2120		Galena	54

Quartz-Plagioclase Gneiss (Host rock)

Rock type: Host rock
Proportion: present
Grain size: Medium grained 1 - 2 mm
Color: Grey
References: 38, 52, 53
Comments: Two variants, a pyritic zone and a pyrrhotite-dominant zone.

Ore minerals:

Mineral	Proportion	Mineral texture
Apatite	major	

	Fluorapatite, grain size characteristically 0.01-0.05 mm. Most of the uranium is contained in apatite in the phosphatic tuff, whereas about half of the uranium in phosphorite is in apatite. Fluorapatite with up to 0.126 % U.
Chalcopyrite	major
Galena	major
Pyrite	major
Pyrrhotite	major
Sphalerite	major
Uraninite	minor
	When as inclusion in apatite, uraninite is surrounded by a distinct yellowish halo in the host apatite.

Other minerals:

Mineral	Proportion	Mineral texture
Chlorite	minor	
Fluorite	minor	
Phlogopite	major	
Plagioclase	major	
	Andesine	
Quartz	major	
Rutile	minor	
Sericite	minor	

Textures
Granoblastic

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA		
Comments: U-Pb whole rock dating indicates metamorphism about 1880 Ma ago.					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:
Paleoproterozoic (2500-1600 Ma)	1600-2500		N

Felsic volcanic rock (Host rock)

Rock type: Host rock
Proportion: major
Grain size: NA
Color: NA
References: 14, 18, 25, 28, 42, 52, 54, 63, 67

Metamorphic description:
Ore minerals:

Mineral	Proportion	Mineral texture
Chalcopyrite	minor	
Galena	minor	
Pyrite	minor	
Pyrrhotite	minor	

Sphalerite	minor

Other minerals:

Mineral	Proportion	Mineral texture
Anthophyllite	minor	
Apatite	minor	
Biotite	major	
Calcite	present	
Chlorite	minor	
Cordierite	major	
Plagioclase	major	
Quartz	major	
Titanite	present	
Zircon	present	

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA	-8	-630

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:		
Paleoproterozoic (2500-1600 Ma)	1874-1922	1922	N		
Radiometric age:	**Method:**	**Age:**	**Error (Ma):**	**Mineral:**	**Reference:**
	U-Pb	1874	2	Monazite	
	U-Pb	1898	12	Zircon	
	U-Pb	1922	6	Zircon	

Calcite-Apatite Metacarbonate-rock (Host rock)

Rock type: Host rock
Proportion: present
Grain size: Medium grained 1 - 2 mm
Color: NA
References: 5, 40, 49, 51, 52, 53, 54, 67, 71
Comments: Bands and lenses less than 1 cm thick in dolomitic marble and skarn. The uraniferous phosphatic bodies occur between the hanging wall contact of the deposit and the sulphide ore lodes, mostly in the eastern part of the deposit, partly interfingering with the sulphide orebodies Hautakangas, Rämesaari and Isoaho.

Ore minerals:

Mineral	Proportion	Mineral texture
NA	minor	
	Non-homogeneous U-Pb or U-Ti minerals, possibly U-thucholite.	
Apatite	major	
	Fluorapatite, grain size characteristically 0.01-0.05 mm. Most of the uranium is contained in apatite in the phosphatic tuff, whereas about half of the uranium in phosphorite is in apatite. Fluorapatite with up to 0.126 % U.	
Graphite	minor	
Pyrite	minor	
Uraninite	minor	

	Inclusions and intergranular grains in phosphorite. Grain size generally 0.005 mm. When as inclusion in apatite, uraninite is surrounded by a distinct yellowish halo in the host apatite.

Other minerals:

Mineral	Proportion	Mineral texture
Calcite	major	
Phlogopite	minor	
Pyrrhotite	minor	
Quartz	minor	
Rutile	minor	

Textures
Granoblastic

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA		
Comments: U-Pb whole rock dating indicates metamorphism about 1880 Ma ago.					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:		
Paleoproterozoic (2500-1600 Ma)	1780-1780	1780	N		
Radiometric age:	**Method:**	**Age:**	**Error (Ma):**	**Mineral:**	**Reference:**
	U-Pb	1780			16, 23

Skarn (Host rock)

Rock type: Host rock
Proportion: minor
Grain size: NA
Color: NA
References: 5, 13, 14, 18, 25, 28, 32, 42, 52, 54, 63, 67
Comments: The Zn and Cu lodes are chiefly in the diopside skarns and pyrite lodes in the 'arenaceous rocks' of the sequence. Skarnified zones common at the contacts between dolomites and greywackes. Skarns are the most common immediate wallrocks and may, perhaps, show signs of Mg metasomatism in the form of phlogopite or cordierite formation.

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA	-8	-630
Comments: Tremolite skarn: tremolite-quartz-plagioclase-phlogopite-calcite-dolomite-pyrrhote-pyrite ± talc, tourmaline, scapolite, baryte, fluorite, corundum. Diopside skarn: dioside-quartz-plagioclase-phlogopite-calcite-dolomite-pyrrhote-pyrite ± talc, tourmaline, scapolite, baryte, fluorite, corundum.					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:
Paleoproterozoic (2500-1600 Ma)	1930-1960		N

Greywacke (Wall rock)

Rock type: Wall rock
Proportion: minor
Grain size: NA
Color: NA
References: 14, 18, 25, 28, 32, 42, 52, 54, 63, 67

Structures
Bedded

Textures
Clastic

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA	-8	-630
Comments: Greywacke (= felsic to intermediate volcanic rock) : quartz-biotite/phlogopite-plagioclase ± sulphides, hornblende, diopside, tremolite. Cordierite gneiss: quartz-phlogopite-plagioclase ± sulphides, K feldspar, sillimanite.					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:
Paleoproterozoic (2500-1600 Ma)	1930-1960		N

Dolomitic marble (Wall rock)

Rock type: Wall rock
Proportion: minor
Grain size: NA
Color: NA
References: 14, 18, 25, 28, 32, 42, 52, 54, 63, 67
Comments: Dolomites may be Mg-metasomatic derivates of sedimentary/biogenic limestones.

Other minerals:

Mineral	Proportion	Mineral texture
Dolomite	present	

Structures
Bedded

Metamorphic description:

Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA	-8	-630
Comments: Dolomite: Biotite-dolomite-calcite-diopside-tremolite-olivine-clinohumite-garnet-pyrrhotite.					

Geological age:

Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:
Paleoproterozoic (2500-1600 Ma)	1930-1960		N

Cordierite Meta-felsic-rock (Wall rock)

Rock type: Wall rock
Proportion: minor
Grain size: NA
Color: NA
References: 14, 18, 25, 28, 38, 42, 52, 54, 63, 67
Comments: Subvolcanic sill. Derived by cordierite±sillimanite±K-feldspar alteration form the subvolcanic quartz porphyry. Abundant in the W and upper parts and dominates in the hanging wall. Mg-Al-B-enriched rock.

Metamorphic description:

Other minerals:

Mineral	Proportion	Mineral texture
Cordierite	present	

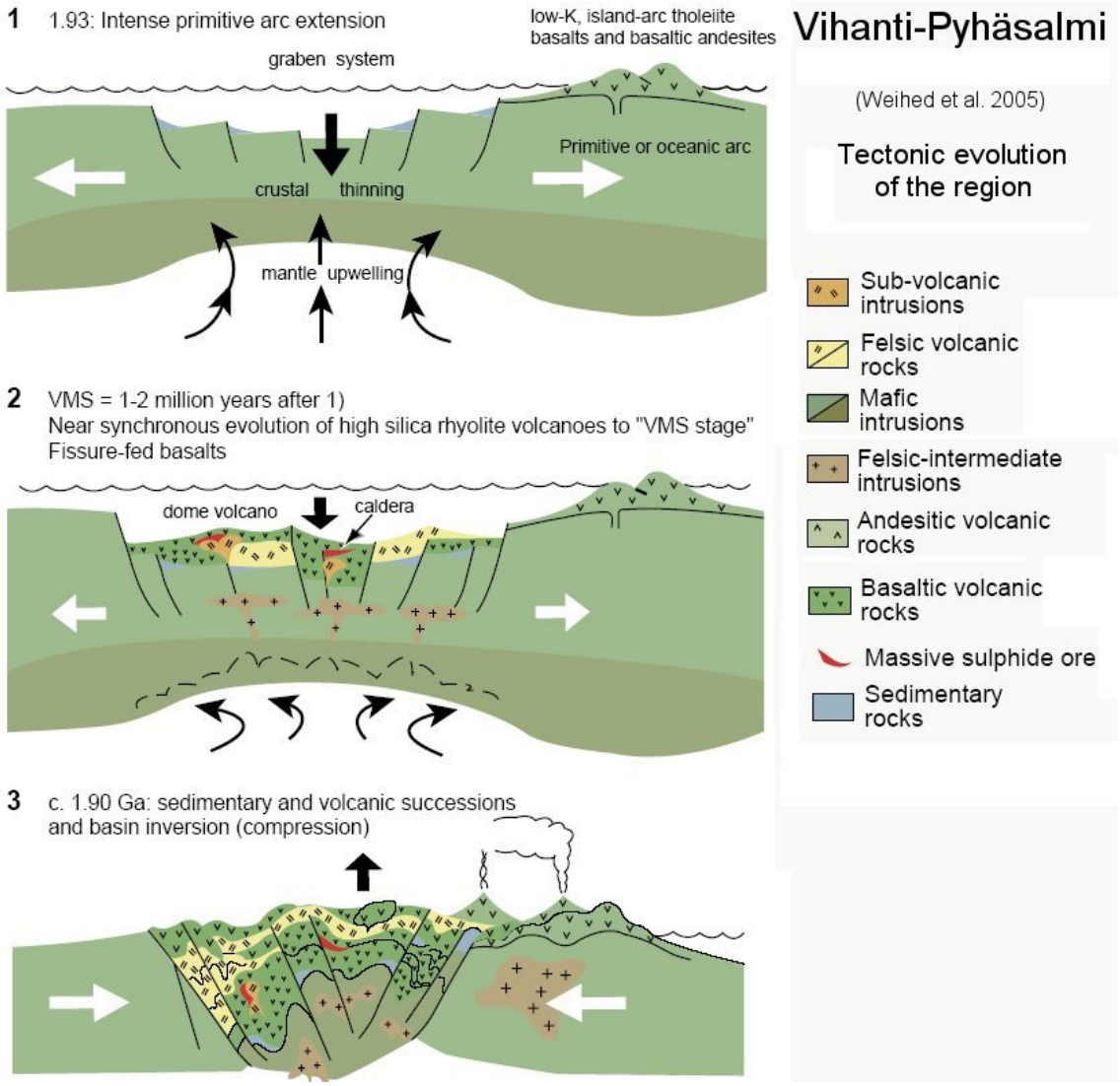
Type:	Facies:	Degree:	Relation to mineralization:	Min P- Max P (kbar)	MIn T- Max T (°C)
Regional	amphibolite metamorphic facies	high metamorphic grade	NA	-8	-630

Geological age:

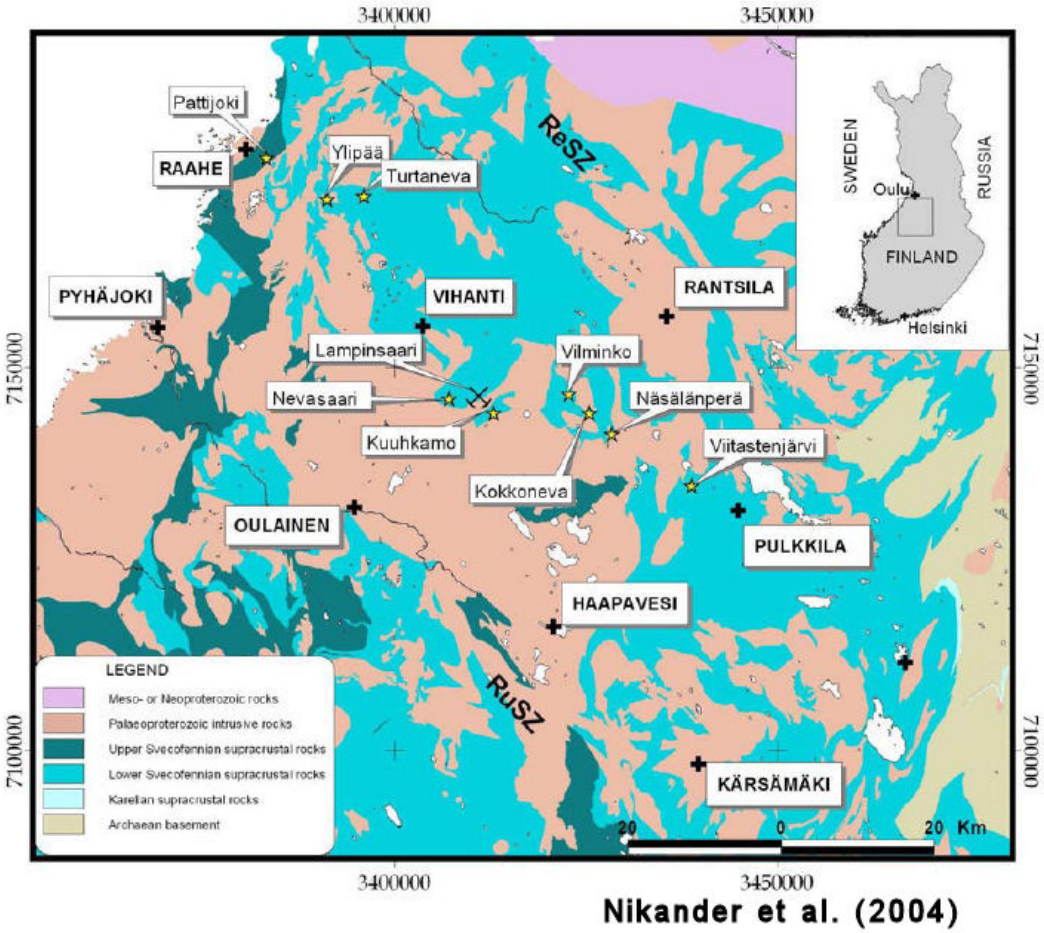
Geological era:	Max age - Minage (Ma):	Inferred age (Ma):	Age of mineralization:
Paleoproterozoic (2500-1600 Ma)	1930-1960		N

Figures

Schematic modelling:



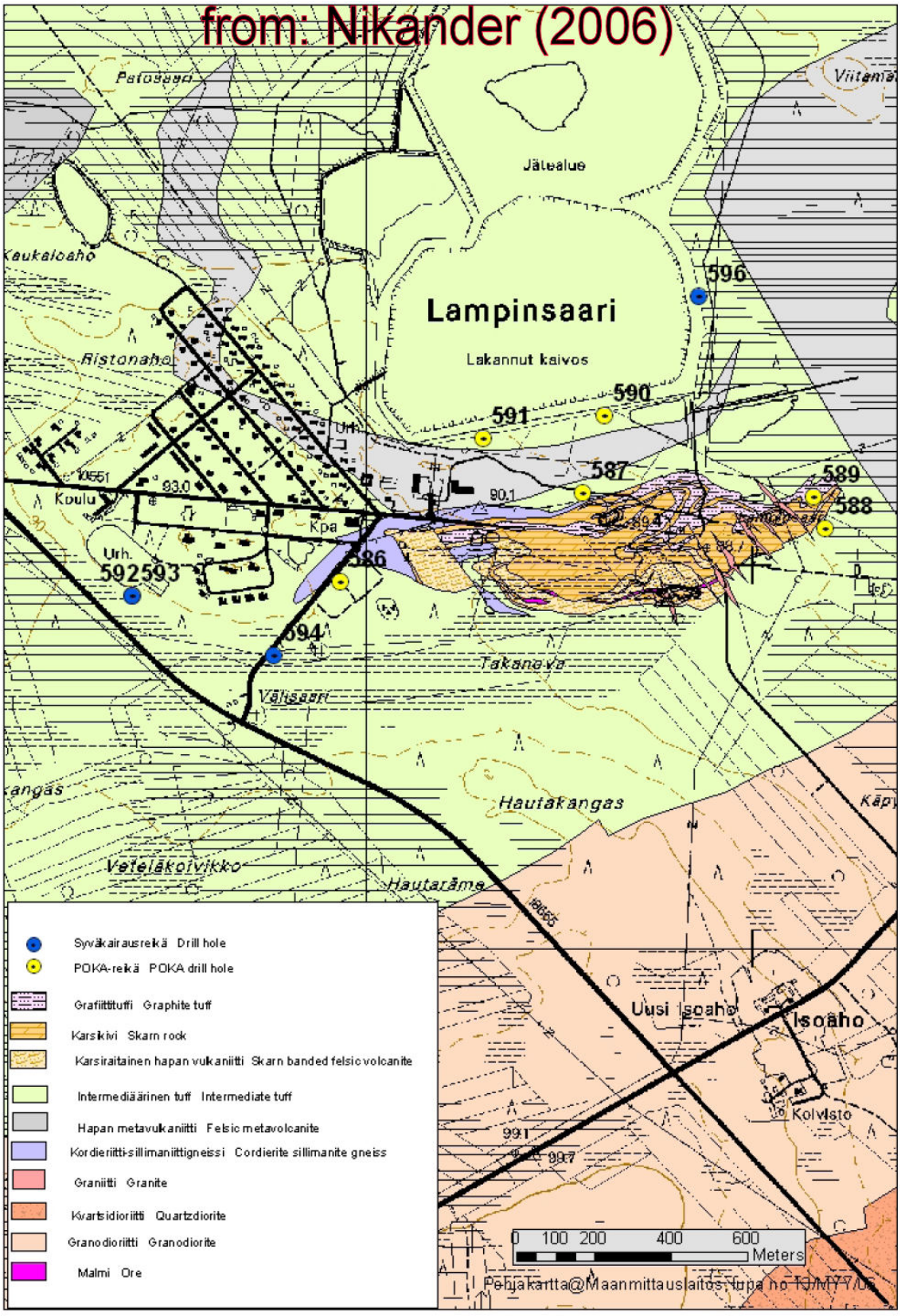
Sulphide occurrences in the Vihanti area (Vihanti-U = Lampinsaari):



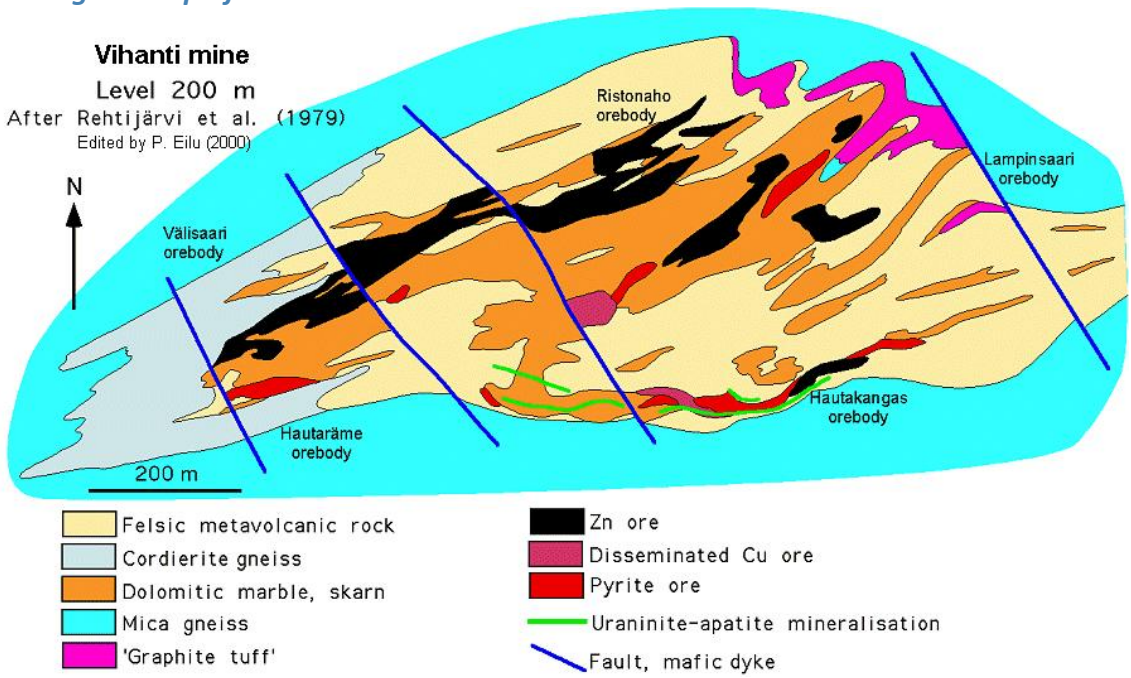
Kuva 1. Raahe-Laatokka –vyöhykkeen luoteisosan yleistetty geologia, tärkeimmät sulfidimalmiesiintymät ja malmitutkimuskohteet (modifioitu Lundqvist et al. 1996).
Fig. 1. Generalised lithological map of the Raahe-Ladoga zone with major zink ore deposits and prospects (modified Lundqvist et al. 1996).

Surface geology of the Vihanti ore deposit with map of the Lampinsaari village and the

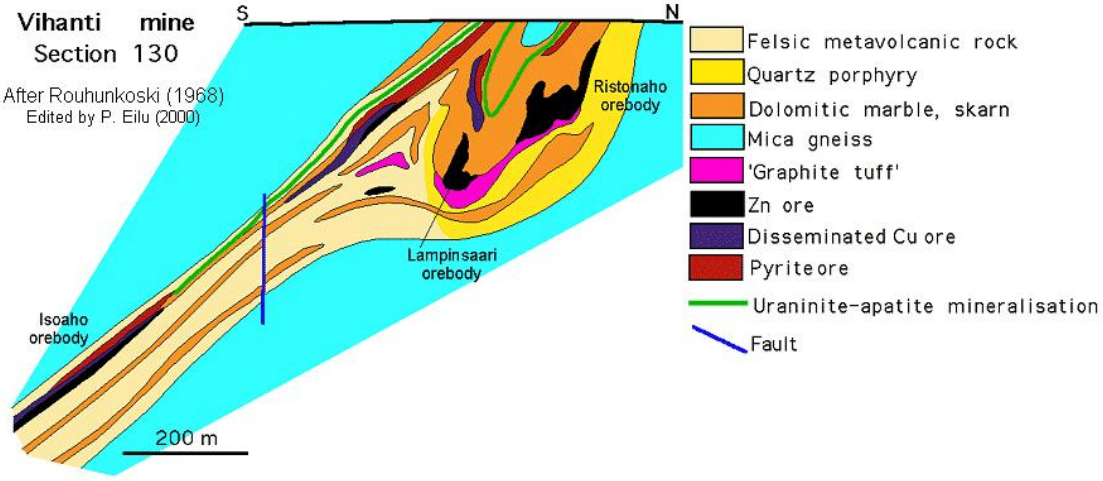
tailings area:



Geological map of Vihanti-U at +200 m level:

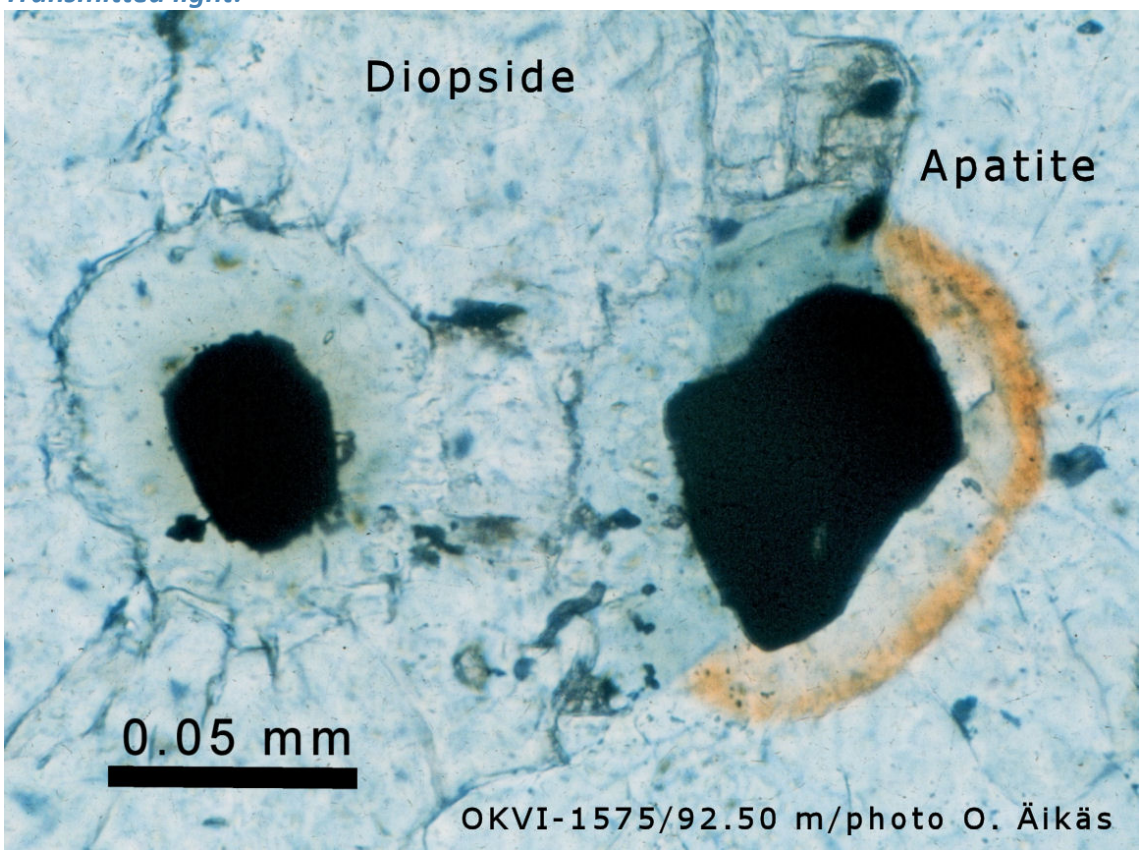


Vihanti-U cross section (CS 130 of the Vihanti mine):



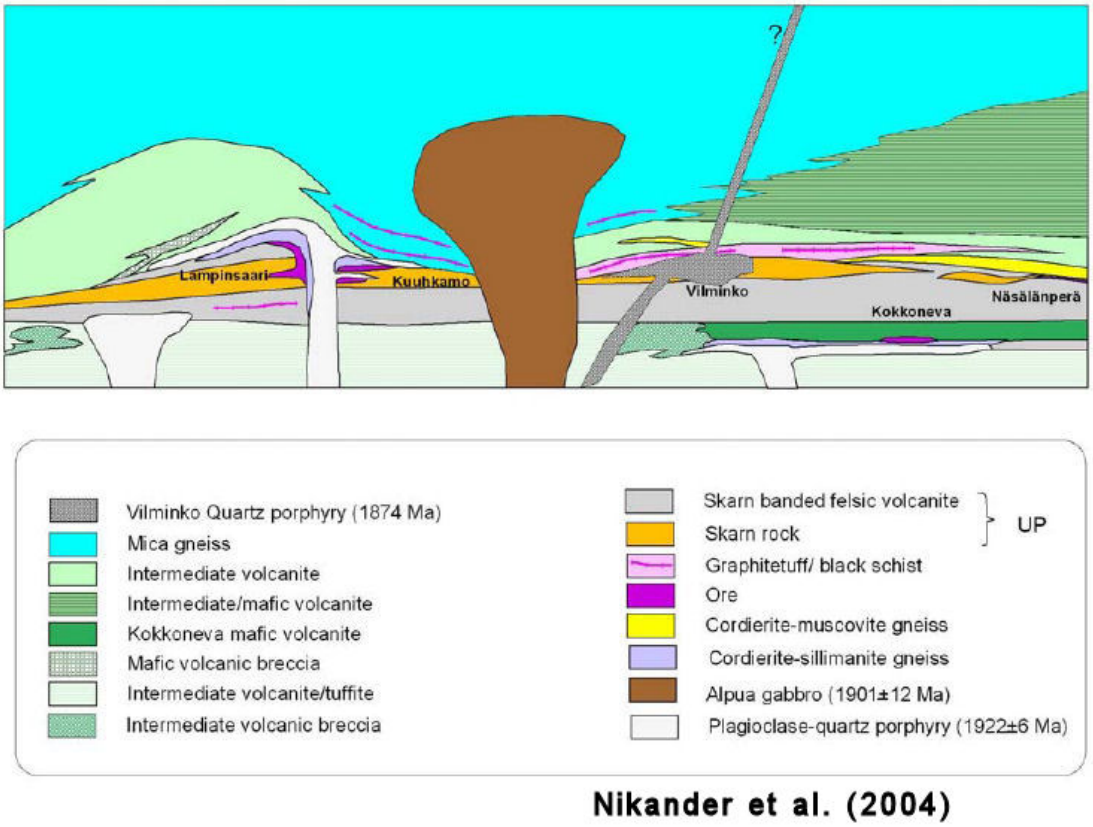
Uraninite grains in microscope, with a typical yellow radiation halo in the apatite.

Transmitted light:



Stratigraphy in the Lampinsaari-Vilminko area. The units marked 'UP' host the uraniferous

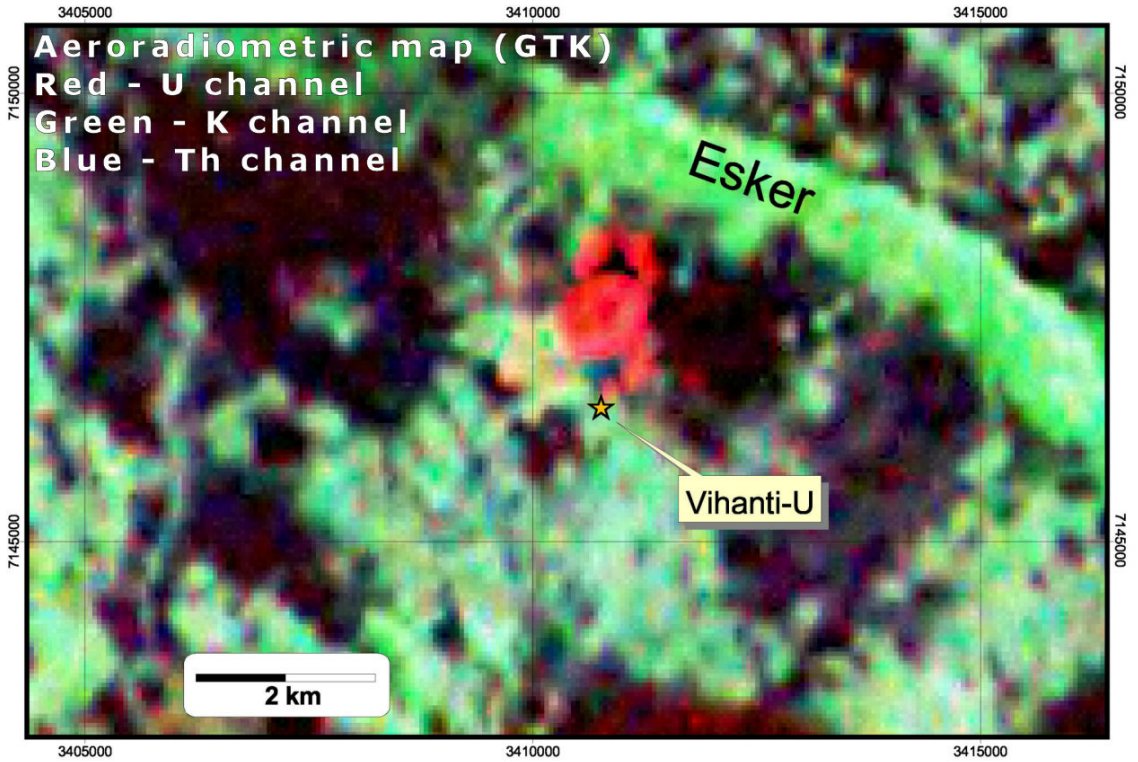
& phosphatic occurrences:



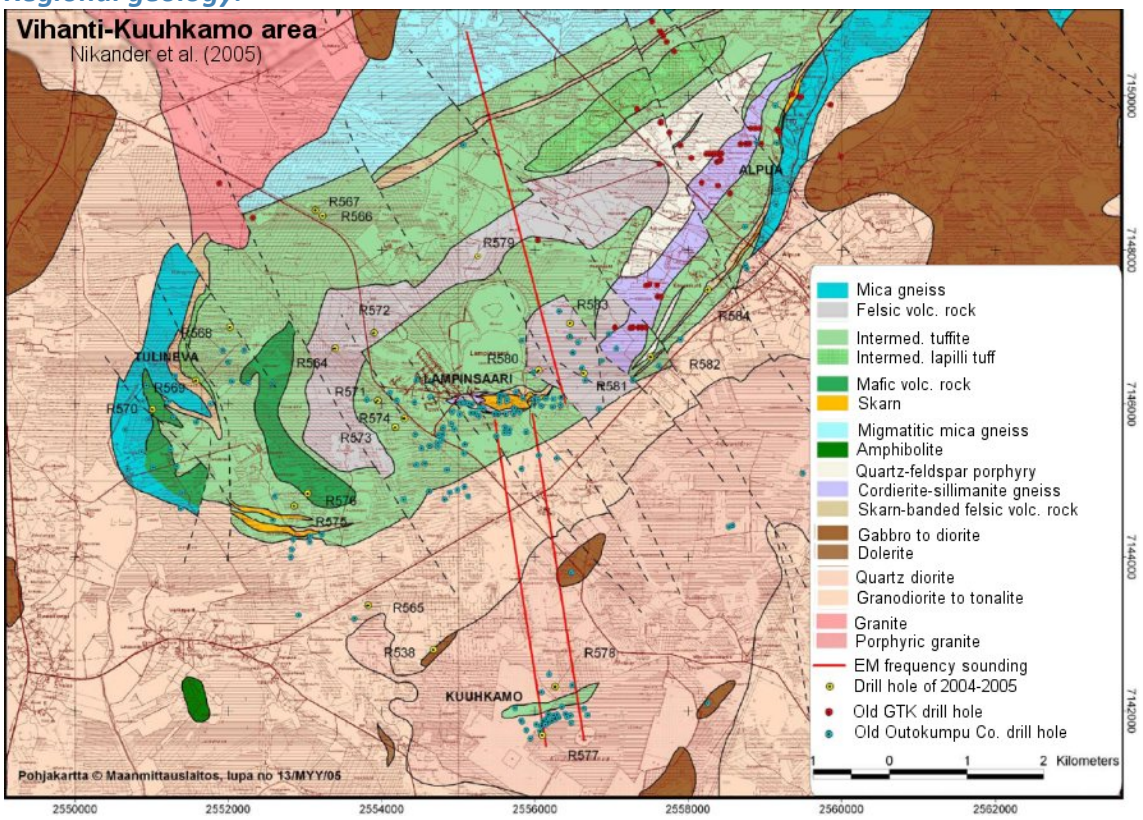
Kuva 3. Lampinsaaren – Vilmingon alueen stratigrafia.
Fig. 3. Stratigraphy of the Lampinsaari-Vilminko area.

Part of the aeroradiometric map from the GTK databases: a three-component image for U (red), Th (blue) and K (green) channels. The tailings area shows as a uranium channel

anomaly:



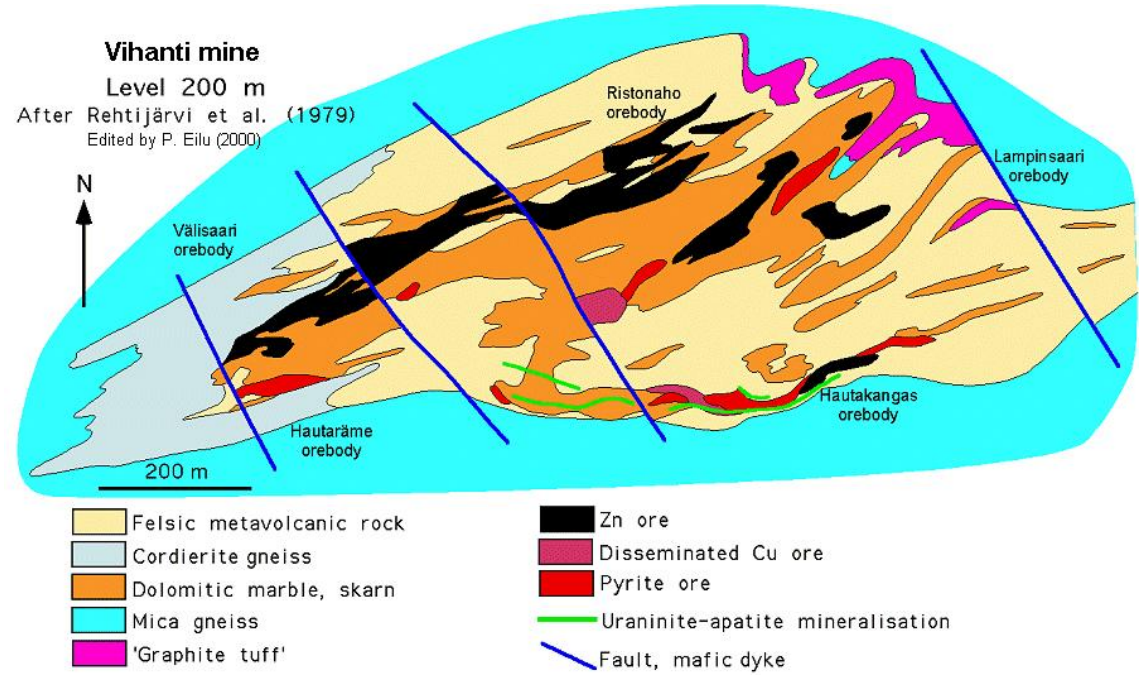
Regional geology:



Outcrop photo:

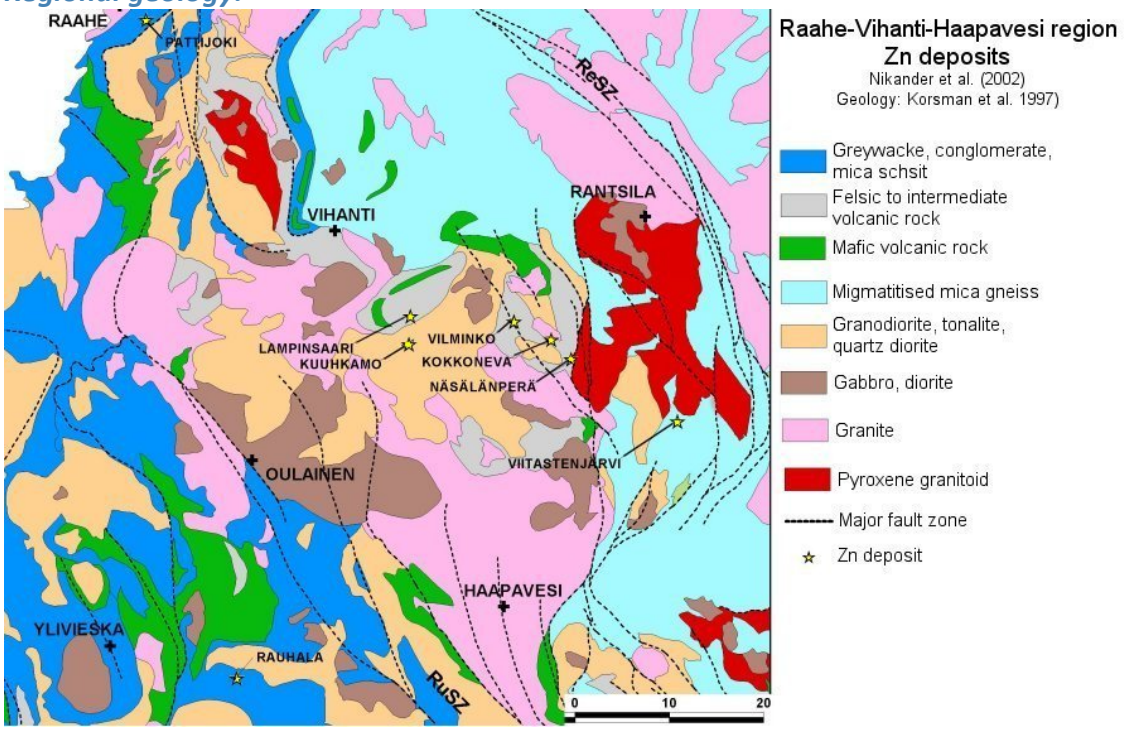
Skarn-banded intermediate metavolcanic rock. Vihanti mine, drill hole R1017, 55.60 m.
Width of drill core 2.2 cm. From Luukas et al. (2004).

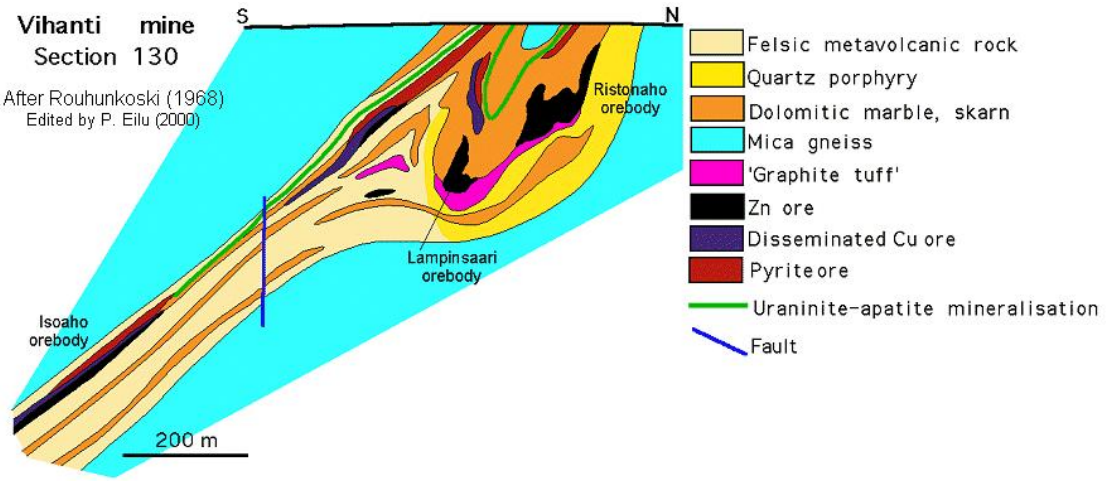
Plan view:

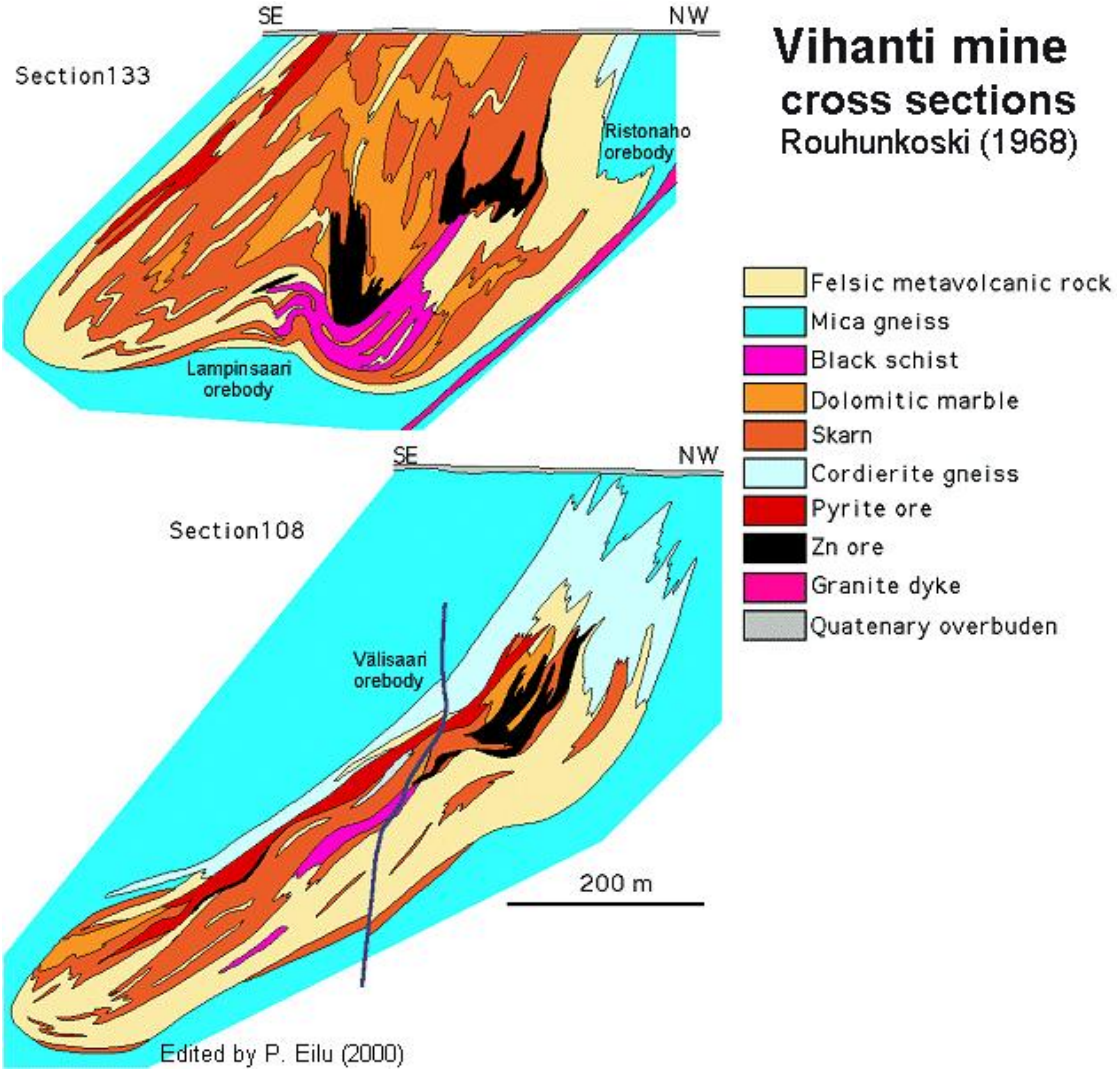


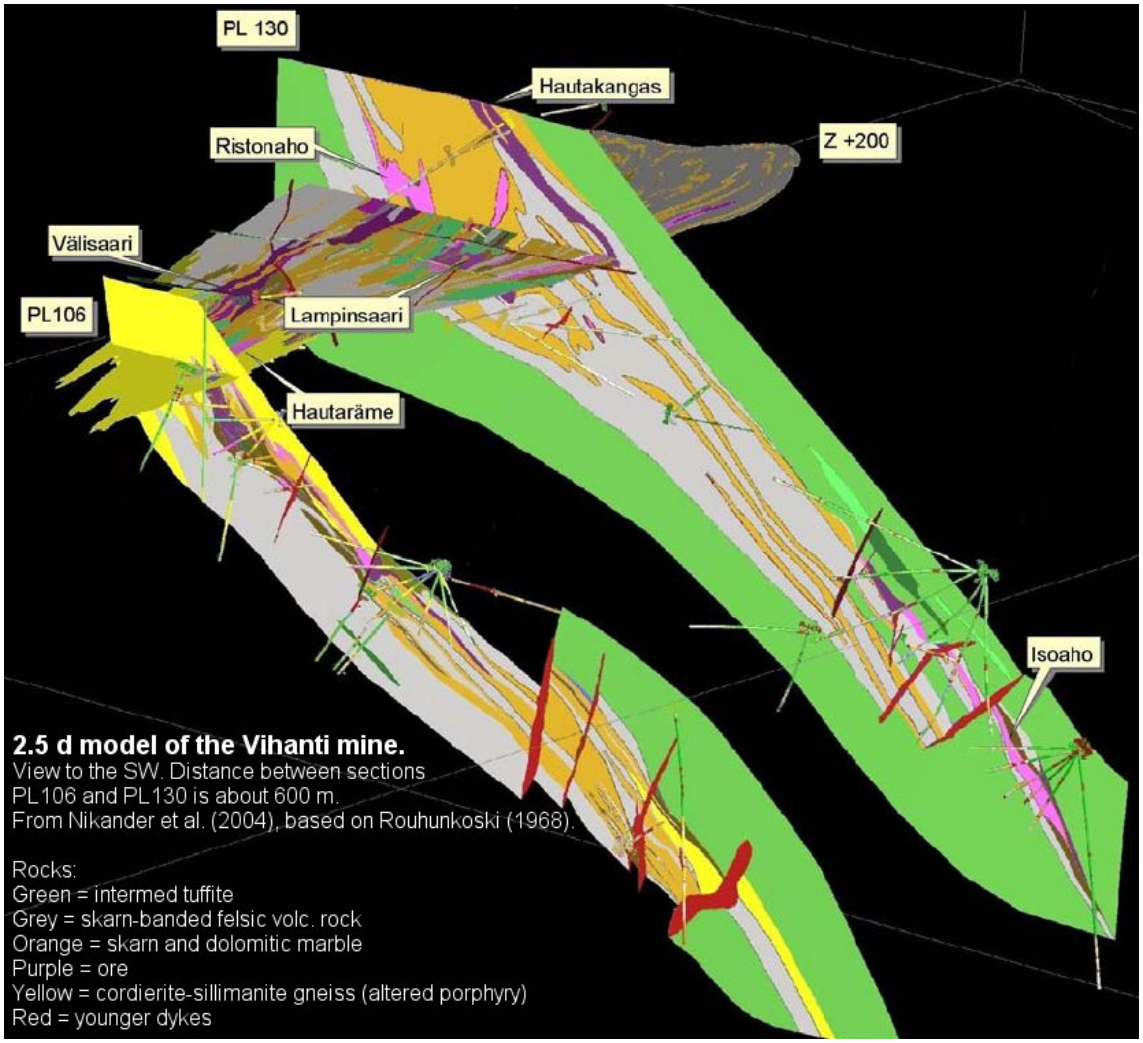
Massive sphalerite-galena ore at Vihanti. Field of view about 10 cm.
Photo Jari Väätäinen.

Regional geology:




Vihanti mine
Section 130
After Rouhunkoski (1968)
Edited by P. Eilu (2000)
S
N
Ristonaho orebody
Lampinsaari orebody
Isoaho orebody
200 m
Felsic metavolcanic rock
Quartz porphyry
Dolomitic marble, skarn
Mica gneiss
'Graphite tuff'
Zn ore
Disseminated Cu ore
Pyrite ore
Uraninite-apatite mineralisation
Fault


Vihanti mine
cross sections
Rouhunkoski (1968)
Section133
SE
NW
Ristonaho orebody
Lampinsaari orebody
Section108
SE
NW
Välisaari orebody
200 m
Edited by P. Eilu (2000)
Felsic metavolcanic rock
Mica gneiss
Black schist
Dolomitic marble
Skarn
Cordierite gneiss
Pyrite ore
Zn ore
Granite dyke
Quatenary overbuden


PL 130
Hautakangas
Ristonaho
Z +200
Välisaari
PL106
Lampinsaari
Hautaräme
Isoaho
2.5 d model of the Vihanti mine.
View to the SW. Distance between sections
PL106 and PL130 is about 600 m.
From Nikander et al. (2004), based on Rouhunkoski (1968).
Rocks:
Green = intermed tuffite
Grey = skarn-banded felsic volc. rock
Orange = skarn and dolomitic marble
Purple = ore
Yellow = cordierite-sillimanite gneiss (altered porphyry)
Red = younger dykes

REFERENCES

1. Anon. 1958. Selonteko hakemusten alaisten kaivospiirien Lampinsaari 9-16 alueilla suoritetuista tutkimuksista ja niiden tuloksista. Outokumpu Oy, Vihanti mine Report. (in Finnish)

2. Anon. 2005. Luonnon radioaktiivisia aineita sisältävät materiaalit. STUK tiedottaa 2/2005, 14 p. (in Finnish)*http://tupa.gtk.fi/karttasovellus/mdae/references/525_Vihanti/stuk.pdf*

3. Arctic Minerals 2019. Media release 26 March 2019
http://tupa.gtk.fi/karttasovellus/mdae/references/526_Kuuhkamo/526_ArcticMinerals005_20190326.pdf

4. Arctic Minerals AB 2019. Year-end report for the full year 2018. 21 February 2019
http://tupa.gtk.fi/karttasovellus/mdae/references/526_Kuuhkamo/526_ArcticMinerals003_20190221.pdf

5. Autere, I., Pelkonen, K. & Pulkkinen, K. 1991. Outokumpu Finnmines Oy:n Vihannin kaivos. Summary: Outokumpu Finnmines Oy's Vihanti zinc mine. Vuoriteollisuus 49, 81-88.

6. Björklund, A., Kontio, M. & Nikkarinen, M. 1976. Vihanti: the geochemical response of bedrock and ore in the overlying till. Journal of Geochemical Exploration 5, 370-373.

7. Hiltunen, P. & Tuovinen, O.H. 1983. Uraanimalmien rikkihappo- ja ferrisulfaattiliuotus laboratoriomittakaavassa. Tutkimusraportti, Helsingin yliopisto, Mikrobiologian laitos. 165 p. (in Finnish)

8. Huhtala, T., Mäkelä, T. & Rauhamäki, E. 1978. Vihannin - Pyhäsalmen alueen sinkkimalmien vulkaanis-stratigrafinen asema. In: Laatokan - Perämeren -malmivyöhyke : Geologijaoston järjestämä symposio Otaniemessä Teknillisen korkeakoulun kemian osaston I-salissa 16.2.1978. Espoo: Vuorimiesyhdistys ry., 111-120. (in Finnish)

9. Iisalo, E. 1995. Vihannin karttalehden 2434 vanhan moreeniaineiston uudelleen analysointi ICP:llä, tulosten vertailu ja anomaliat. Geological Survey of Finland, Report S/41/2434/95/1. 16 p. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/s41_2434_95_1.pdf

10. Iisalo, E. 2004. Geokemialliset malmiviitteet Vihannin alueella, Länsi-Suomessa. Geological Survey of Finland, Report M10.4/2004/2. 90-108 p. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/m10_4_2004_2.pdf

11. Iisalo, E. 2004. Moreeni-, rapakallio- ja kallionäytteiden geokemialliset erikoispiirteet Vihannin alueella, Länsi-Suomessa. Geological Survey of Finland, Report M10.4/2004/2. 73-89 p. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/m10_4_2004_2.pdf

12. Iisalo, E. 2004. Moreenin stratigrafia ja geokemia Raahe-Laatokka -vyöhykkeen luoteisosassa, Länsi-Suomessa. Geological Survey of Finland, Report M10.4/2004/2. 61-72 p. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/m10_4_2004_2.pdf

13. Isokangas, P. 1954. The Vihanti zinc deposit. In: Aurola, E. (ed.) The Mines and Quarries of Finland. Geological Survey of Finland, Geoteknillisiä julkaisuja 55, 29-32.
http://tupa.gtk.fi/julkaisu/geoteknillinen/gt_s_055_pages_029_032.pdf

14. Isomäki, O.-P. 1992. Vihannin sinkkikaivoksen toiminta päättyi. Summary: Outokumpu Finnmines

Oy's Vihanti zinc mine is closed. Geologi 44, 129-130.

15. Kaakinen, J. 2016. Öljyllä ja raskasmetalleilla pilaantuneita maita koskevan ympäristölainsäädännön ja lupamenettelyn edistäminen kemiallisella tutkimuksella. Oulun yliopisto, Oulu.*http://jultika.oulu.fi/files/isbn9789526211589.pdf*

16. Kahma, A. 1950. Yhteenveto geologisen tutkimuslaitoksen suorittamista tutkimuksista Lampinsaaren sinkkiesiintymällä Vihannissa. Geological Survey of Finland, Report M17/Vti-50/3. 9 p. (in Finnish)

17. Kauranne, L-M. 1979. Vihannin karttalehtialueen geokemiallisen kartoituksen tulokset. Summary: The results of the geochemical survey in the Vihanti map-sheet area. Explanation for geochemical maps, Sheet 2434. Geological Survey of Finland. 55 p.
http://tupa.gtk.fi/kartta/geokemiallinen_karttaselitys/gks_2434_s.pdf

18. Korsman, K. (ed.) & Glebovitsky, V. (ed.) 1999. Raahe-Ladoga Zone structure-lithology, metamorphism and metallogeny: a Finnish-Russian cooperation project 1996-1999. Map 2: Metamorphism of the Raahe-Ladoga Zone 1:1000000. Geological Survey of Finland.

19. Kousa, J., Huhma, H. & Vaasjoki, M. 2004. U-Pb -ajoitukset eräistä magmasyntyisistä kivistä Pohjois-Pohjanmaalta, Raahe-Laatokka -vyöhykkeen luoteisosasta. Geological Survey of Finland, Report M10.4/2004/2. 127-141. (in Finnish)*http://tupa.gtk.fi/raportti/arkisto/m10_4_2004_2.pdf*

20. 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.*http://tupa.gtk.fi/julkaisu/opas/op_041_pages_043_067.pdf*

21. Kuronen, U. 1988. Ajatuksia vuosina 1984-1987 Vihannin alueella suoritetuista tutkimuksista. Outokumpu Oy Exploration, Report 020/2434/UOK/88. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/020_2434_uok_88.pdf

22. Kuusisto, E. 1991. Metalli- ja rikkimalmikaivosten ja -louhosten jätealtaiden ja jätekasojen vaikutusta ympäristöön tutkivaan hankkeeseen liittyvä esiselvitys. Geologian tutkimuskeskus, Espoo. Julkaisematon raportti. 88 s.*https://tupa.gtk.fi/raportti/arkisto/s42_0000_1_1991.pdf*

23. Laatio, G. 1952. Vihanti. Geological Survey of Finland, Report Dc N:o 29. 4 p. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/dc_29.pdf

24. Lahtinen, R., Korja, A. & Nironen, M. 2001. Evolution and metallogeny if the Paleoproterozoic Svecofennian Orogen. In: Williams P.J. (ed.) 2001: A Hydrothermal Odyssey. May 17-19th, 2001,Townsville. Extended abstracts. EGRU and JCU. 110-111.

25. Lestinen, P. 1983. Sulphide deposits of central Finland. Outokumpu, Pyhäsalmi, Vihanti. X IGES - III SMGP Symposium, 1983. Excursion Guide. Espoo: Geological Survey of Finland. 9 p.

26. Loukola-Ruskeeniemi, K. 1991. Suomen proterotsooisten mustaliuskeiden uraanipitoisuudesta. 2 p. Geological Survey of Finland, Report M19/3344/-91/1/30. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/m19_3344_91_1_30.pdf

27. Loukola-Ruskeeniemi, K. 1999. Origin of black shales and the serpentinite-associated Cu-Zn-Co ores at Outokumpu, Finland. Econ. Geol. 94, 1007-1028.

28. Loukola-Ruskeeniemi, K., Kuronen, U. & Arkimaa, H. 1997. Geochemical comparison of metamorphosed black shales associated with the Vihanti zinc deposit and prospects in western Finland. Geological Survey of Finland, Special Paper 23, 5-13.
http://tupa.gtk.fi/julkaisu/specialpaper/sp_023_pages_005_013.pdf

29. Luukas, J., Kousa, J., Nikander, J. & Ruotsalainen, A. 2004. Raahe-Laatokka ¿vyöhykkeen luoteisosan kallioperä Länsi-Suomessa. Geological Survey of Finland, Report M10.4/2004/2. 6¿37.
http://tupa.gtk.fi/raportti/arkisto/m10_4_2004_2.pdf

30. Lång, K., Gaál, G. & Starostin, V. 1984. Structural and petrophysical features, some Precambrian stratabound base metal deposits of Finland (Outokumpu, Vihanti, Riikonkoski). In: 27th International Geological Congress = 27-j mezdunarodnyh geologiceskij kongress, Moskva, 4-14 avgusta: Tesizy = Abstracts. 6, 186-187.

31. Meriläinen, M. 1977. Vihannin sulfidimalmiesiintymään liittyvän uraani-fosforivyöhykkeen petrografiset, geokemialliset ja rikki-isotooppigeologiset pääpiirteet. MSc thesis, University of Helsinki, Department of Geology and Mineralogy. 48 p. (in Finnish).

32. Mikkola, A. 1947. Lampinsaaren kiisumalmin kairasydänten tutkiminen. Geological Survey of Finland, Report M17/Vti-47/1. 7 p. (in Finnish)

33. Mikkola, A. 1949. Vihannista lähetetyt kansannäytteet. 2 p. Geological Survey of Finland, Report M17/Vti-49/2. (in Finnish)

34. Mäkelä, M., Kuronen, U. & Mäki, T. 1987. Syvämalminetsintä ja geokemia. Geologi 39, 180-184. (in Finnish)

35. Mäki, T., Kousa, J. & Luukas, J. 2015. The Vihanti-Pyhäsalmi VMS belt. In: Maier, W.D., Lahtinen, R. & O'Brien, H. (eds) Mineral deposits of Finland. Amsterdam: Elsevier, 507-530.
http://www.sciencedirect.com/science/article/pii/B9780124104389000200

36. Nikander, J. & Luukas, J., Ruotsalainen, A. & Kousa, J. 2002. Kallioperä- ja malmitutkimukset Vihannin Vilmingon ja Rantsilan Pelkoperän välisellä alueella vuosina 1993-2002. Geological Survey of Finland, Report M 19/2434, 3412/2002/1/10. 71 p. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/m19_2434_3412_2002_1_10.pdf

37. Nikander, J. 2006. Vihannin Lampinsaaren kairaukset vuonna 2006 karttalehdellä 2434 05. Summary: Drillings in Lampinsaari in Vihanti in the year of 2006 on the map sheet 2434 05. Geological Survey of Finland, Report M19/2434/2006/1/10. 8 p. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/m19_2434_2006_1_10.pdf

38. Nikander, J., Luukas, J. & Ruotsalainen, A. 2004. Vihannin alueen massiivisten sulfidimalmiesiintymien geologia ja malminmuodostus Raahe-Laatokka ¿vyöhykkeellä Länsi-Suomessa. Geological Survey of Finland, Report M10.4/2004/2. 38¿60. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/m10_4_2004_2.pdf

39. Nikander, J., Luukas, J. & Ruotsalainen, A. 2005. Vihannin Lampinsaaren ympäristön ja Kuuhkamon kairaukset karttalehdellä 2434 05 vuosina 2005¿2005. Summary: Drillings in the Lampinsaari area and in Kuuhkamo in Vihanti on the map sheet 2434 05, during the years 2004¿2005. Geological Survey of Finland, Report M19/2434/2005/2/10. 14 p.
http://tupa.gtk.fi/raportti/arkisto/m19_2434_2005_2_10.pdf

40. OECD 1999. NEA/IAEA Report, Environmental activities in uranium mining and milling. Finland p. 88-89.*http://tupa.gtk.fi/karttasovellus/mdae/references/169_Luhti/169_766-environmental-activities.pdf*

41. Outokumpu Oy. 1992. Outokumpu Oy, internal report.

42. Papunen, H. (ed.) 1990. Sinkkiprojektin loppuraportti. University of Turku, Institute of Geology and Mineralogy, Publication 22. 143 p. (in Finnish)

43. Pelkonen, K. 1987. Hopeamineraalien esiintymisestä ja rikastettavuudesta Vihannin malmissa. Summary: Silver minerals in the Vihanti ore deposit and their behaviour in concentration process. In: ed. H. Kauppinen, R. Blomqvist, H. Laapas et al. Tuotantomineralogian seminaari 16.1.1986 TKK:n Vuoriteollisuusosastolla. Vuorimiesyhdistys Sarja B 38, 44-56.

44. Pohjavesialueet. Suomen ympäristökeskus. Vesi.fi-karttapalvelu. Viitattu 3.7.2023. *https://www.vesi.fi/karttapalvelu/*

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

46. Rauhamäki, E., Mäkelä, T. & Isomäki, O-P. 1980. Geology of the Vihanti mine. In: Häkli, T.A. (ed.) Precambrian Ores of Finland: Guide to Excursions 078 A+C, Part 2 (Finland). Espoo: Geological Survey of Finland, 14-24.

47. Rauhamäki, E., Mäkelä, T. & Isomäki, O.-P. 1978. Geology of the Vihanti mine. In: Metallogeny of the Baltic Shield, Helsinki symposium 1978, June 12-21, Finland : IGCP Project 74/1/91 "Metallogeny of the Precambrian". Excursion guide. Helsinki: The Academy of Finland, 35-56.

48. 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)

49. Rehtijärvi, P. & Äikäs, O. 1976. Uraanin ja fosforin jakautuminen eräissä Suomen uraani-fosforiesiintymien näytteissä. Helsingin yliopisto. Geologian laitos. Tiedonanto 2. 17 p. (in Finnish)

50. Rehtijärvi, P. & Äikäs, O. 1977. Fosfaatin värjäys ja autoradiografia apatiitti- ja uraanipitoisten geologisten näytteiden tutkimusmenetelmänä. Summary: Phosphate stain printing technique and autoradiography in the study of uranium- and apatite-bearing rock samples. Geologi 29 (2), 17-22.

51. Rehtijärvi, P. 1983. REE patterns for apatites from Proterozoic phosphatic metasediments, Finland. Bulletin of the Geological Society of Finland 55 (1), 77-82. *http://tupa.gtk.fi/julkaisu/sgs_bulletin/sgs_bt_055_1_pages_077_082.pdf*

52. Rehtijärvi, P. 1984. Distributions of phosphorus, sulphur and sulphur isotopes in a strata-bound base metal deposit, Kangasjärvi, Finland. Geological Survey of Finland, Report of Investigation 65. 16 p.*http://tupa.gtk.fi/julkaisu/tutkimusraportti/tr_065.pdf*

53. Rehtijärvi, P., Äikäs, O. & Mäkelä, M. 1979. A middle Precambrian uranium- and apatite-bearing horizon associated with the Vihanti zinc ore deposit, western Finland. Economic Geology 74, 1102-1117.

54. Rouhunkoski, P. 1968. On the geology and geochemistry of the Vihanti zinc ore deposit. Bulletin

de la Commission Geologique de Finlande 236. 121 p.*http://tupa.gtk.fi/julkaisu/bulletin/bt_236.pdf*

55. Räisänen, M. L., Beucher, A., Tornivaara, A. & Kauppila, P. 2015. Suljettujen ja hylättyjen metallikaivosalueiden nykytila ja arvio jätealueiden ympäristöriskipotentiaalista. Geologian tutkimuskeskus, arkistoraportti 46/2015, 129 s

56. Salli, I. 1958. Vihanti. Geological Map of Finland 1:100000. Pre-Quaternary Rocks, Sheet 2434. Geological Survey of Finland.*http://tupa.gtk.fi/kartta/kallioperakartta100/kp_2434.pdf*

57. Salli, I. 1965. Pre-Quaternary Rocks of the Pyhäjoki and Vihanti Map-Sheet areas. Geological Map of Finland 1:100000. Explanation to the Maps of Pre-Quaternary Rocks, Sheets 2432-2434. Geological Survey of Finland. 52 p.*http://tupa.gtk.fi/kartta/kallioperakartta100/kps_2432_2434.pdf*

58. Soljanto, P., Rehtijärvi, P. & Tuovinen, O. H. 1979. Uraanin erotus kvartsiiteista ja fosfaattisista metasedimenteistä bakteeriliuotuksen avulla. University of Helsinki, Department of Microbiology. Report 18. 44 p. (in Finnish).

59. Sotka, P. 1981. Vihanti: Välisaaren ja Isoahon malmimineraalien koostumuksesta. Outokumpu Oy Exploration, Report 070/Vihanti/PMS/1981. 2 p. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/070_2434_vihanti_pms_1981.pdf

60. Tontti, M., Koistinen, E. & Seppänen, H. 1981. Vihannin Zn-Cu-malmivyöhykkeen geomatemaattinen arviointi. Summary: Geomathematical evaluation of the Vihanti Zn-Cu ore zone. Geological Survey of Finland, Report of Investigation 54. 58 p.
http://tupa.gtk.fi/julkaisu/tutkimusraportti/tr_054.pdf

61. Tornivaara, A., Räisänen, M. L., Kovalainen, H. & Kauppi, S. 2018. Suljettujen ja hylättyjen kaivosten kaivannaisjätealueiden jatkokartoitus (KAJAK II). Suomen Ympäristökeskuksen raportteja 12/2018 *https://helda.helsinki.fi/handle/10138/235617*

62. Tuovinen, O. H., Hiltunen, P. & Vuorinen, A. 1983. Solubilization of phosphate, uranium and iron from apatite- and uranium-containing rock samples in synthetic and microbiologically produced acid leach solutions. European Journal of Applied Microbiology and Biotechnology (17), 327-333.

63. Törnroos, R. 1982. Sphalerite geobarometry of some metamorphosed sulphide ore deposits in Finland. Geological Survey of Finland, Bulletin 323. 42 p.
http://tupa.gtk.fi/julkaisu/bulletin/bt_323.pdf

64. Vaasjoki, M. & Sakko, M. 1988. The evolution of the Raahe-Ladoga zone in Finland: isotopic constraints. Geological Survey of Finland, Bulletin 343, 7-32.
http://tupa.gtk.fi/julkaisu/bulletin/bt_343_pages_007_032.pdf

65. Vaasjoki, M. & Sakko, M.1988. The evolution of the Raahe-Ladoga zone in Finland: isotopic constraints. Geological Survey of Finland, Bulletin 343, 7-32.
http://tupa.gtk.fi/julkaisu/bulletin/bt_343_pages_007_032.pdf

66. Vaasjoki, M. 1981. The lead isotopic compositions of some Finnish galenas. Geological Survey of Finland, Bulletin 316. 30 p.*http://tupa.gtk.fi/julkaisu/bulletin/bt_316.pdf*

67. Vaasjoki, M., Äikäs, O. & Rehtijärvi, P. 1980. The age of mid-Proterozoic phosphatic metasediments in Finland as indicated by radiometric U-Pb dates. Lithos 13, 257-262.

68. Vaasjoki, O. 1946. Vihannin näytteiden malmimineraalikokoomus. 3 p. Geological Survey of Finland, Report M17/Vti-46/3. (in Finnish)

69. Weihed, P. & Eilu, P. 2005. Fennoscandian Shield - Proterozoic VMS deposits. Ore Geology Reviews 27, 324-325.

70. Wennervirta, H. 1968. Litogeokemiallinen tutkimus, Vihannin malmikompleksi. Outokumpu Oy Exploration, Report 061/2434 05/604/HW/68. (in Finnish)
http://tupa.gtk.fi/raportti/arkisto/061_2434_hw_68.pdf

71. Äikäs, O. 1989. Phosphate resources in early Proterozoic supracrustal rocks, Finland, with reference to the Baltic Shield. In: Notholt, A. J. G., Sheldon, R. P. & Davidson, D. F. (eds.) Phosphate deposits of the world. Vol. 2: Phosphate rock resources. Cambridge: Cambridge University Press, 429-436.