

# Geochemical soil baselines of mineral potential areas and mining surroundings in Finland

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Programme for Sustainable Growth and Jobs

Leverage from  
the EU  
2014–2020



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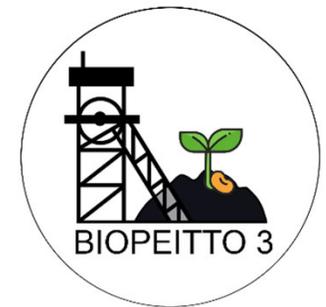


European Union  
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Development Fund

# Biopeitto 3 (Biocover 3)

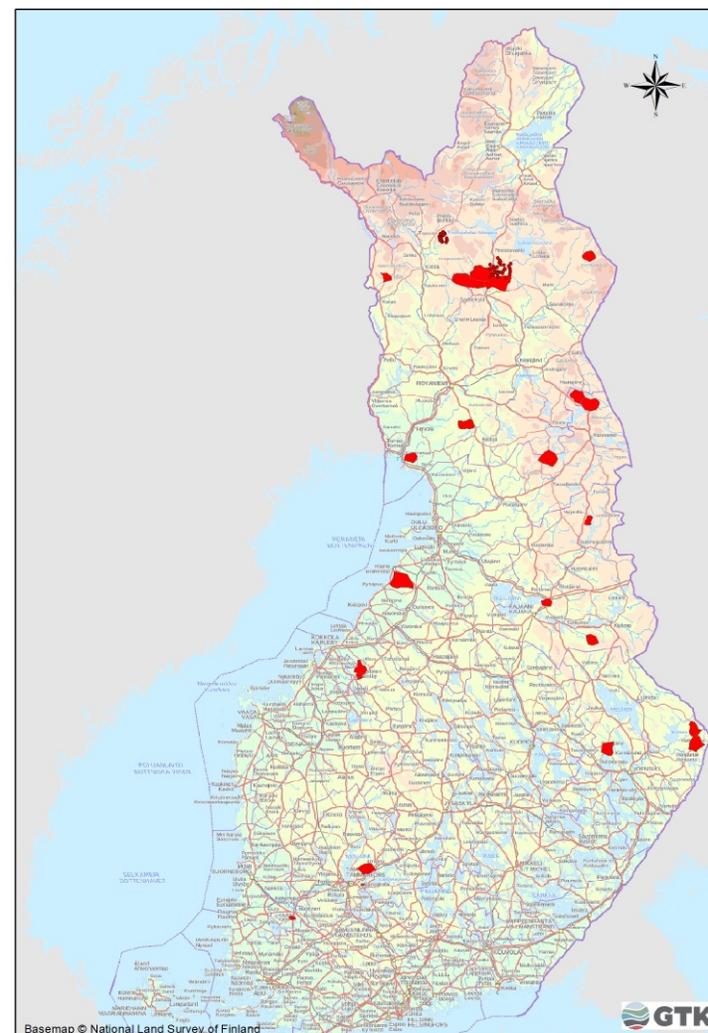
## Ecosystem recovery promoting biocovers for mining sites

- Co-funded project 1.1.2024–31.12.2026 (GTK, LUKE, EU + some mining companies) <https://www.luke.fi/en/projects/biopeitto3>
- Objectives:
  - Optimization of the cover structure
  - Cover structure modelling
  - The impact of biochar on the water economy of the cover
  - Support for the natural succession
  - **Microbes and geochemistry in mining environments**
  - Ecosystem restoration on a mining waste site
  - Geomorphological design of the cover structure
  - Synthesis and clarification of the regulatory approval process



# Geochemical soil baseline study in mining area surroundings and in mineral potential areas in Finland

- In 2016–2023, mineral potential areas and mining surroundings were included to geochemical background mapping carried out by GTK
  - 22 mineral deposits and mining surroundings
- Soil sampling focusing on glacial till, at minimum 60 soil samples per site of varying size
  - Anthropogenic influenced sites were avoided
  - 775 topsoil samples, 768 subsoil samples
  - Topsoil 0–25 cm, subsurface sediment (subsoil) 50–100 cm
- The near-total element concentrations (~43 elements)
  - Drying < 40°C, sieving < 2 mm
  - Aqua regia extraction (AR), ICP-AES, ICP-MS
  - Pt, Pd, Au (GFAAS), Hg analyser
  - pH, LOI (loss on ignition), soil carbon (C%)
- Since 2017, samples for soil microbe analyses were taken from each sampling point at the 10–15 cm depth (usually B-horizon)



# The Finnish national trigger values for arsenic and harmful metals in soil

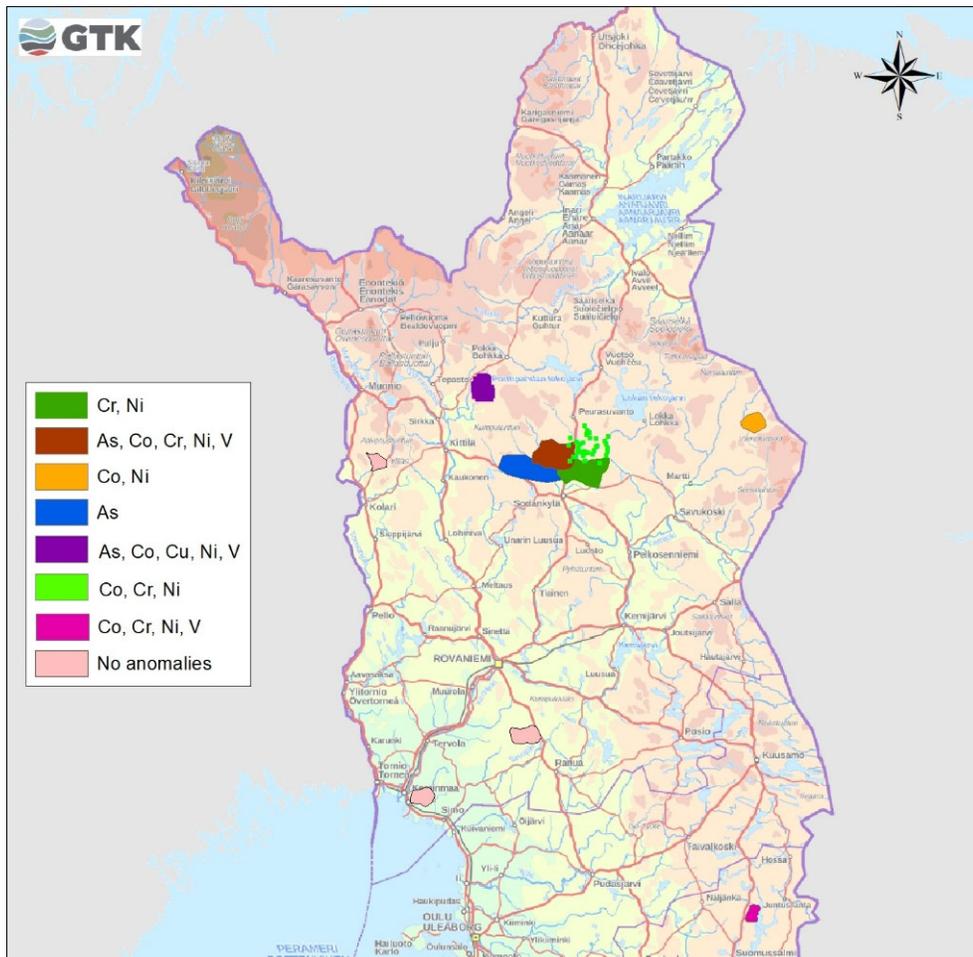


(Government Decree on the Assessment of Soil Contamination and Remediation Needs 214/2007)

Element	Threshold value	Lower guideline value	Upper guideline value
	mg/kg	mg/kg	mg/kg
Antimony (Sb)	2	10	50
Arsenic (As)	5	50	100
Mercury (Hg)	0,5	2	5
Cadmium (Cd)	1	10	20
Cobalt (Co)	20	100	250
Chromium (Cr)	100	200	300
Copper (Cu)	100	150	200
Lead (Pb)	60	200	750
Nickel (Ni)	50	100	150
Zinc (Zn)	200	250	400
Vanadium (V)	100	150	250

- The upper limit of regional geochemical baseline calculated for each study area

# Results



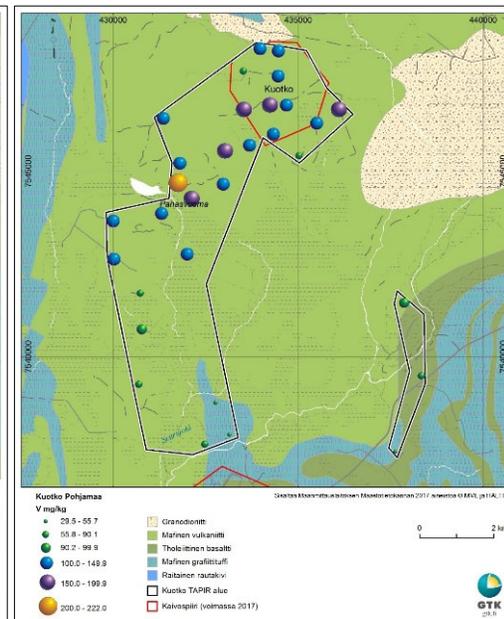
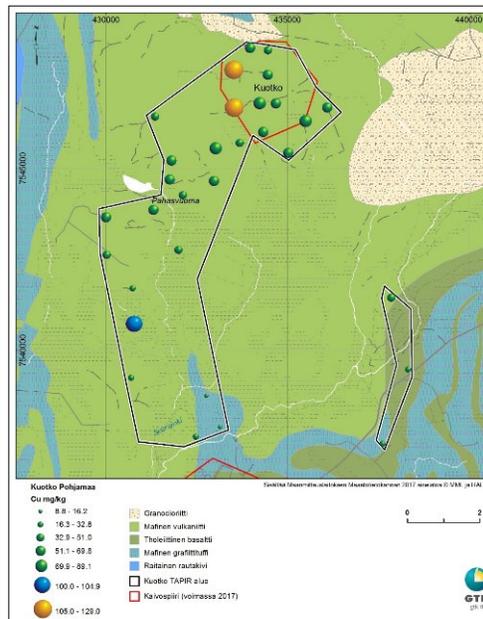
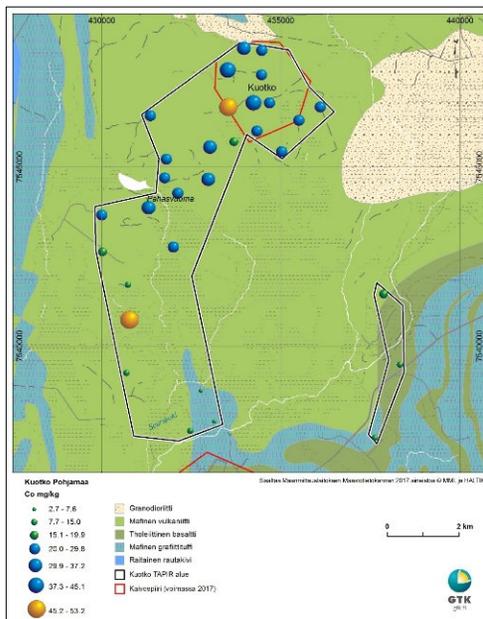
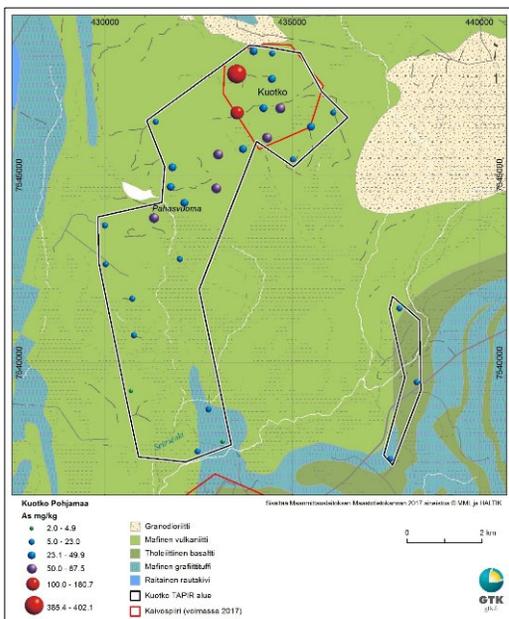
# Metallic mineral deposits or mines (Au)

Metallic mineral deposits or mines (Au)			
Study area	Elements and compounds in mineral deposit or mine	Elements above threshold value, <b>lower guideline value</b> or <b>upper guideline value</b>	Elements which regional baseline (SSTP) is above threshold value
Kuotko (Kittilä)	Au	<b>As, Co, Cu, Ni, V</b> , Pb	As, Co, Cu, Ni, V
Pahtavaara (Sodankylä)	Au	As, Co, <b>Cr</b> , Cu, <b>Ni</b> , V	As, Co, Cr, Ni, V
Ikkari (Sodankylä)	Au	Sb, As, Co, <b>Cr, Cu</b> , Ni, V	As
Laivakangas (Raahe)	Au	As	-
Rämepuro (Ilomantsi)	Au	As, <b>Cu, Ni</b>	As
Pampalo (Ilomantsi)	Au	<b>As</b>	As
Orivesi	Au	<b>As</b> , Co	As
Jokisivu (Huittinen)	Au	<b>As</b> , Co	As

# Kuotko mineral potential area, Kittilä



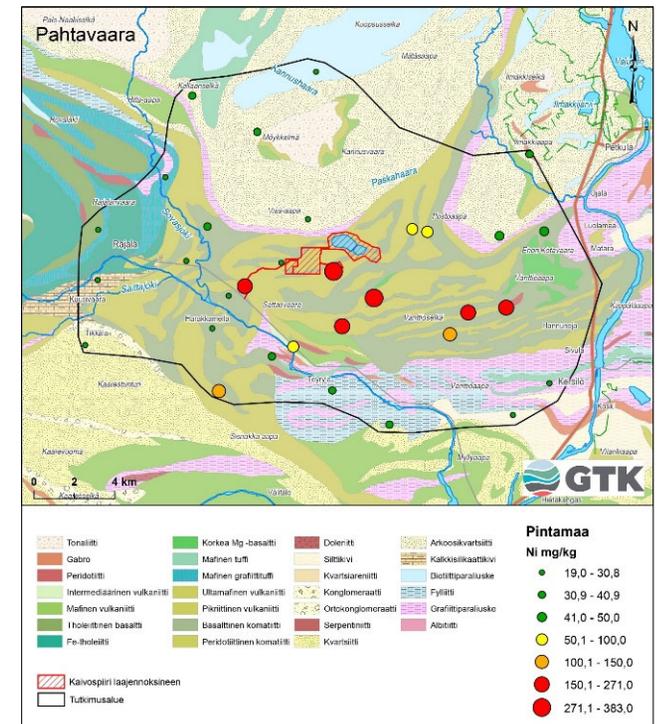
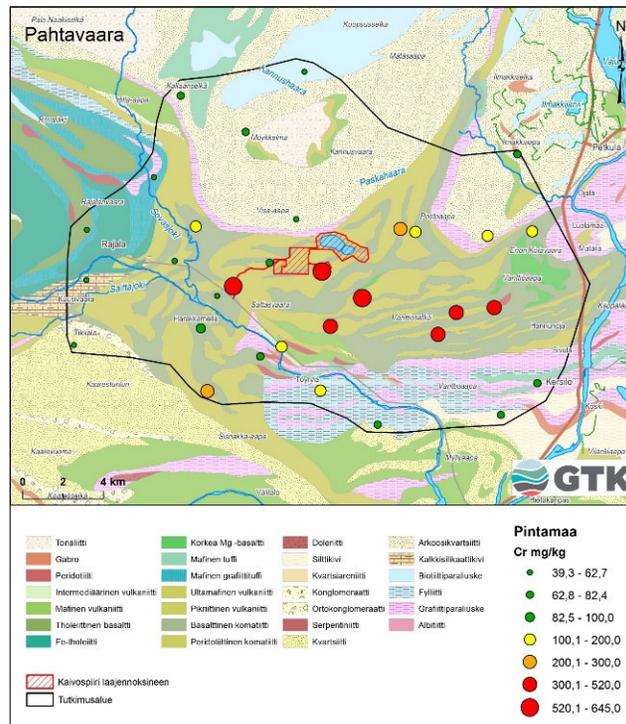
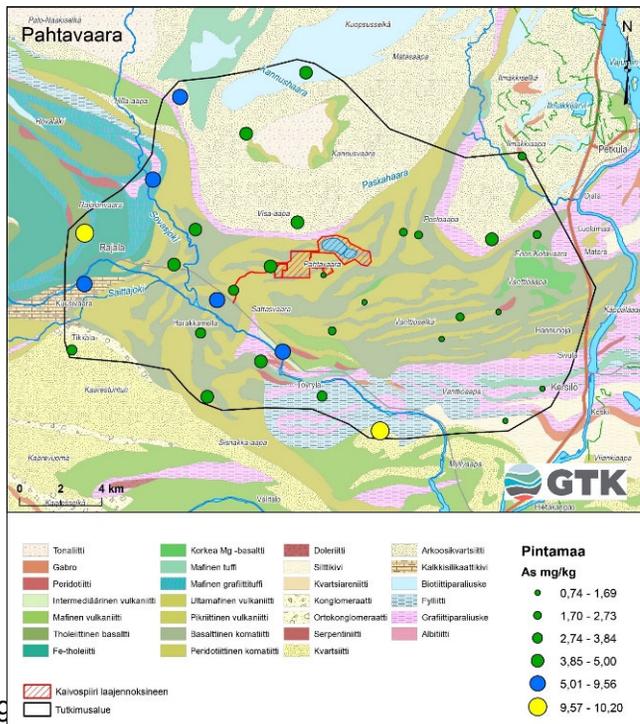
	Kuotko, Kittilä			Trigger values (Government decree VNa 214/2007)		
	Topsoil and subsoil n = 63		Regional Baseline SSTP	Threshold value	Lower guideline value	Upper guideline value
	Median	Maximum				
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
<b>Arsenic (As)</b>	<b>19,6</b>	<b>402</b>	<b>88</b>	5	50	100
<b>Cobalt (Co)</b>	18,6	<b>53,2</b>	<b>45</b>	20	100	250
<b>Copper (Co)</b>	42,5	<b>129</b>	<b>105</b>	100	200	300
<b>Nickel (Ni)</b>	30,1	<b>75,9</b>	<b>58</b>	50	100	150
<b>Vanadium (V)</b>	<b>103</b>	<b>222</b>	<b>200</b>	100	150	250



# Pahtavaara mining area surroundings, Sodankylä



	Pahtavaara, Sodankylä		Trigger values (Government decree VNa 214/2007)			
	Topsoil and subsoil n = 63		Regional Baseline SSTP	Threshold value	Lower guideline value	Upper guideline value
	Median	Maximum				
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
<b>Arsenic (As)</b>	4,2	<b>10,2</b>	<b>10</b>	5	50	100
<b>Cobalt (Co)</b>	10,7	<b>44,9</b>	<b>29</b>	20	100	250
<b>Chromium (Cr)</b>	79,9	<b>744</b>	<b>300</b>	100	200	300
<b>Nickel (Ni)</b>	40,4	<b>428</b>	<b>150</b>	50	100	150
<b>Vanadium (V)</b>	67,5	<b>114</b>	<b>108</b>	100	150	250



# Sulfide mineral deposits or mines

Sulfide mineral deposits or mines			
Study area	Elements and compounds in mineral deposit or mine	Elements above threshold value, <b>lower guideline value</b> or <b>upper guideline value</b>	Elements which regional baseline (SSTP) is above threshold value
Kevitsa (Sodankylä)	Ni, Cu, PGE	As, <b>Co</b> , <b>Cr</b> , <b>Ni</b>	Co, Cr, Ni
Sakatti (Sodankylä)	Ni, Pt, Cu	As, <b>Cr</b> , <b>Ni</b>	Cr, Ni
Hannukainen (Kolari)	Fe, Cu	-	-
Suhanko (Ranua)	PGE-minerals, Pd, Pt, Ni	-	-
Taivalhopea (Sotkamo)	Ag, Pb, Zn, Au	As	-
Kylylahti (Polvijärvi)	Co, Cu, Ni, Zn	-	-
Mieslahti, Paltamo (Kajaani)	Ni, As, Talk	As, Cr, <b>Ni</b>	Ni
Hangaslampi, Juomasuo (Kuusamo)	Co, Au, Cu	V	-
Maaninkavaara (Kuusamo)	Co, Au, Cu	-	-
Peura-aho, Hietaharju (Suomussalmi)	Ni, PGE	As, Co, <b>Cr</b> , <b>Ni</b> , <b>V</b>	Co, Cr, Ni, V

# Oxide ore deposits or mines and Sokli

Oxide ore deposits or mines			
Study area	Elements and compounds in mineral deposit or mine	Elements above threshold value, <b>lower guideline value</b> or <b>upper guideline value</b>	Elements which regional baseline (SSTP) is above threshold value
Kemi	Cr <sub>2</sub> O <sub>3</sub>	As, Co, Cr	-
Mustavaara (Taivalkoski)	V, Fe, Ti	Co, Cr, <b>Cu</b> , <b>Ni</b>	-

Sokli mineral deposit			
Study area	Elements and compounds in mineral deposit or mine	Elements above threshold value, <b>lower guideline value</b> or <b>upper guideline value</b>	Elements which regional baseline (SSTP) is above threshold value
Sokli (Savukoski)	PO <sub>4</sub> , Fe, (REE)	As, Co, Cr, <b>Ni</b> , Zn	Co, Ni

## Conclusions

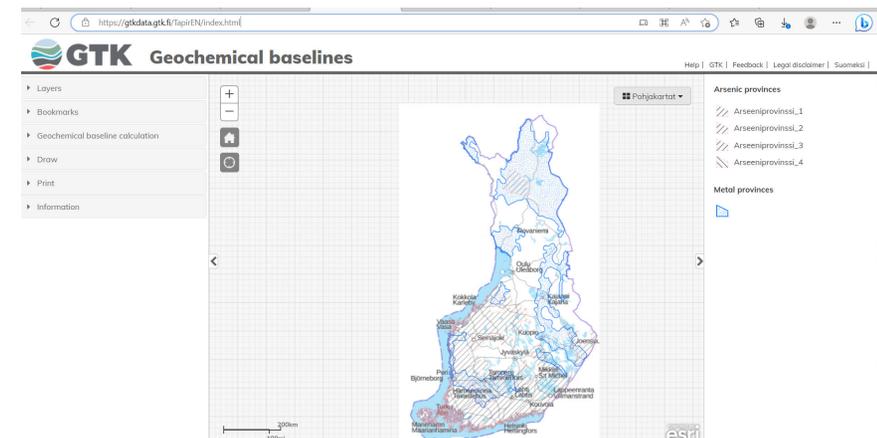
- In many investigated areas, the geogenic concentrations of potentially harmful elements (PHEs) in soil parent material exceeded the Finnish threshold values
  - In the eight study areas around *the metallic mineral deposits or mines* (Au), the threshold value of at least one PHE was exceeded
  - From ten *sulphide mineral deposits or mining surroundings* in seven areas, at least one PHE in soil parent material exceeded the Finnish threshold values
  - In the soil parent material of the two studied *oxide ore mining surroundings*, three or four PHEs exceeded the threshold values
  - In *the mineral potential area of phosphate, iron and REE*, five PHEs exceeded the threshold values in the soil parent material
- In nine mineral potential areas or mining site surroundings, the calculated geochemical baselines of soil parent material were below the Finnish threshold values
- In eight areas, the geochemical baseline was exceeded by arsenic or nickel, in five areas by cobalt, in four areas by chromium and in one area by vanadium

# Reporting

- Reports of each study area
  - 21 reports
  - In Finnish
  - Publicly available in GTK Hakku-service <https://hakku.gtk.fi/en>



- Map service: Geochemical baselines
  - <https://gtkdata.gtk.fi/TapirEN/index.html>
  - Short summary of soil geochemical baseline survey from each study area
  - In Finnish and in English



**The Keriva mining area surroundings in the Sodankylä municipality**  
 Sampling year: 2016

**Sample media:** Topsoil (0–25 cm): aqueous extractable concentrations of <2 mm grain-size fraction; gold (Au), platinum (Pt) and palladium (Pd) aqueous extractable concentrations from ground-<2 mm grain-size fraction

**Quaternary sediment type:** 26 topsoil samples of glacial till; 8 topsoil samples of sand or gravel

The soil geochemistry database of Geological Survey of Finland (GTK) was supplemented in 2016 with results of 34 topsoil and 34 subsoil samples from the Keriva mining area surroundings in the Sodankylä municipality. Altogether 26 topsoil and subsoil samples presented glacial till and eight topsoil and subsoil samples were taken from sand or gravel deposits. The topsoil samples have been taken from the upper 0–25 cm mineral soil layer beneath the humus layer. The subsoil samples have been taken from soil parent material at the depth of 40–90 cm. Aqueous extractable element concentrations were analysed from <2 mm grain-size fraction of all the samples. For gold, platinum and palladium determination the <2 mm grain-size sample material was ground.

**Statistics:** The regional upper limit of geochemical baseline variation (SSTP) is calculated based on the element concentrations uploaded in the Geochemical baseline database. Only the element concentrations of topsoil samples are uploaded in the Geochemical baseline database. Thus, the statistics and the SSTP-values have also been calculated separately for the Keriva mining area surroundings based on both sample depths.

**Median values, maximum values and the Upper limit of geochemical baseline variation (SSTP) on topsoil and subsoil in the Keriva study area, Sodankylä municipality and threshold and guideline values prescribed in the Government Decree on the Assessment of Soil Contamination and Remediation Needs (7/24/2007):** \* = the calculated SSTP-value is below the threshold value

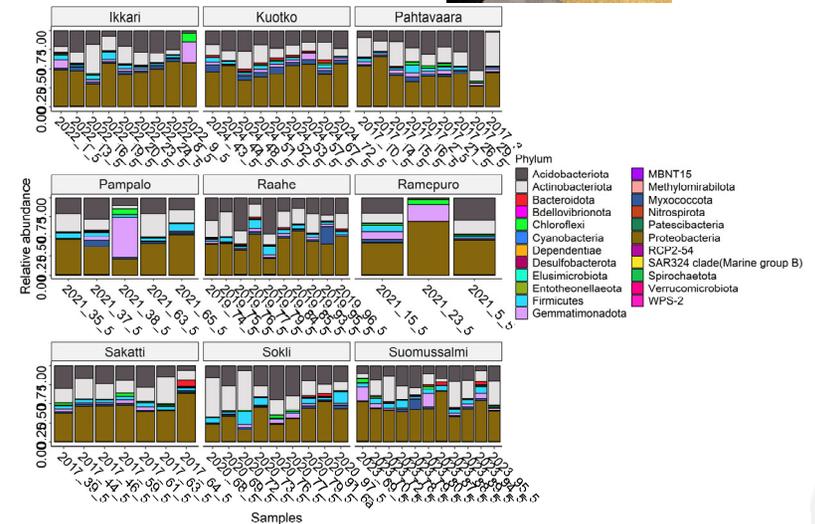
Median n = 48	Maximum		The Decree (7/24/2007)	
	Topsoil and subsoil	Topsoil	Threshold value	Upper guideline
	mg/kg	mg/kg	mg/kg	mg/kg
Antimony (Sb)	0.14	0.3	–	50
Arsenic (As)	1.0	6.0	–	10
Arsenic (As)	0.007	0.017	–	0.5
Cadmium (Cd)	0.02	0.05	–	0.1
Cobalt (Co)	8.2	38.3	24	20
Copper (Cu)	0.05	1.68	100	200
Copper (Cu)	17.0	71.2	100	100
Lead (Pb)	1.8	8.1	–	60
Nickel (Ni)	17.2	228	90	100
Nickel (Ni)	42.0	79.9	–	100
Zinc (Zn)	14.9	12.8	–	200

More information about the results of the pilot study on baseline variation in the mining area surroundings (includes the Keriva study area) is available in a report:  
 Hanikka, T., Pietilä, R., Räsänen, M.-L., Seppänen, T. & Tarvainen, T. 2017. Karooahoiduksen maaperän taustapitoisuus- ja pitoisuuskartat - 2016. Geologian tutkimuskeskus. Adnotointiposti 12/2017: 106 s. + 3 liitettä [http://www.gtk.fi/raportit/arkisto/12\\_2017.pdf](http://www.gtk.fi/raportit/arkisto/12_2017.pdf)

# Next steps



- More comprehensive interpretation and statistical analyses of results
- Acid generation potential
  - *Pro gradu* work containing selected samples will be finished this year
  - Environmental risk assessment
  - Overall potential of metal leaching
- Soil microbes
  - *Biopeitto 3 (Biocover 3)*: selected soil microbe samples have been sequenced and the interpretation of the results is going on



Thank you!

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