UNIVERSITY OF OULU

Trace element and isotope analyses of sulphide minerals in mineral deposit fingerprinting: A case study from Petäjäselkä Au occurrence, northern Finland

Atte Taivalkoski

University of Oulu

14.12.2021

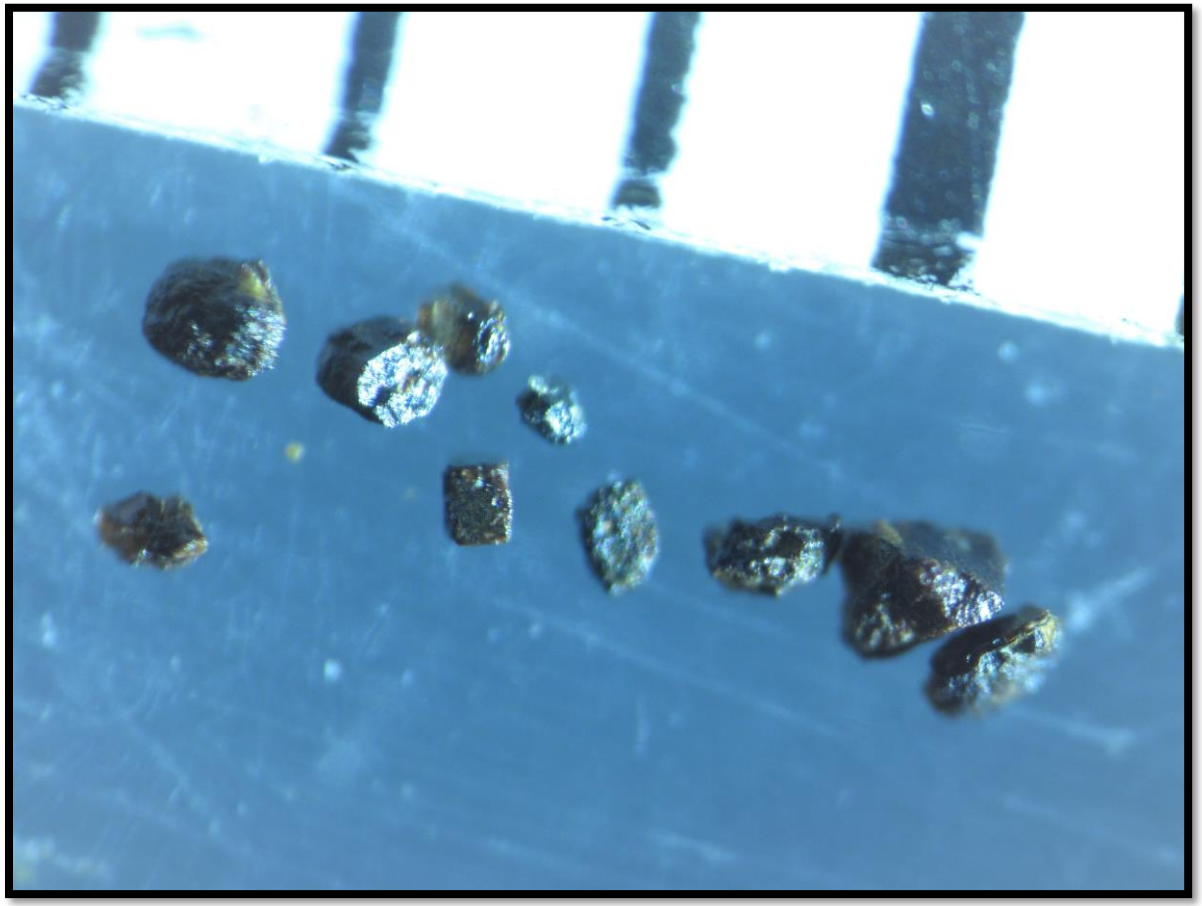
MinExTarget Workshop

eit RawMaterials
Connecting matters

MinExTarget

Content:

- MinExTarget project introduction
- What is Mineral fingeprinting
- Study Area (Petäjäselkä)
- Heavy mineral concentrate workflow
- Results so far
- Upcoming work



What is mineral fingerprinting?

-The concept is based on minerals having different geochemical signatures which is related to their different environment of crystallization.

-These unique traits can be studied through mineral trace elements and stable radiogenic isotopes with high capacity analyzing equipments (e.g.LA-SC/MC-ICP-MS)→ mineral deposit type can be potentially determined → important for vectoring different deposits.

-Associations of trace elements in several common ore-forming sulfides (e.g. pyrite, chalcopyrite, arsenopyrite etc.), oxides (e.g. magnetite, hematite) and other minerals (e.g. scheelite, tourmaline) fingerprint the type of mineral deposit in which these minerals were formed.

-Can more effectively predict localizations and types of mineral deposits compared to the bulk geochemical method.

Advanced analysis techniques

-The laser ablation inductively coupled plasma mass spectroscopy (LA-ICPMS) analytical method has been introduced to the trace element characterization of mineral grains quite recent decades→ Developed and improved constantly.

-Capable to measure not only trace elements but also stable and radiogenic isotope compositions in mineral grains with down to a few tens of micrometers in size (laser beam usually 40-250 micron).

-Application of automated mineral identification through modern electron-microscopy methods (INCA software on FE-SEM-EDS) supports fast detection and selection of mineral grains for the LA-ICPMS analyses.

Research Questions and goals

Is it possible to use heavy mineral grains (sulfides) found in till samples to fingerprint different deposit types and hydrothermal events related to mineralization?

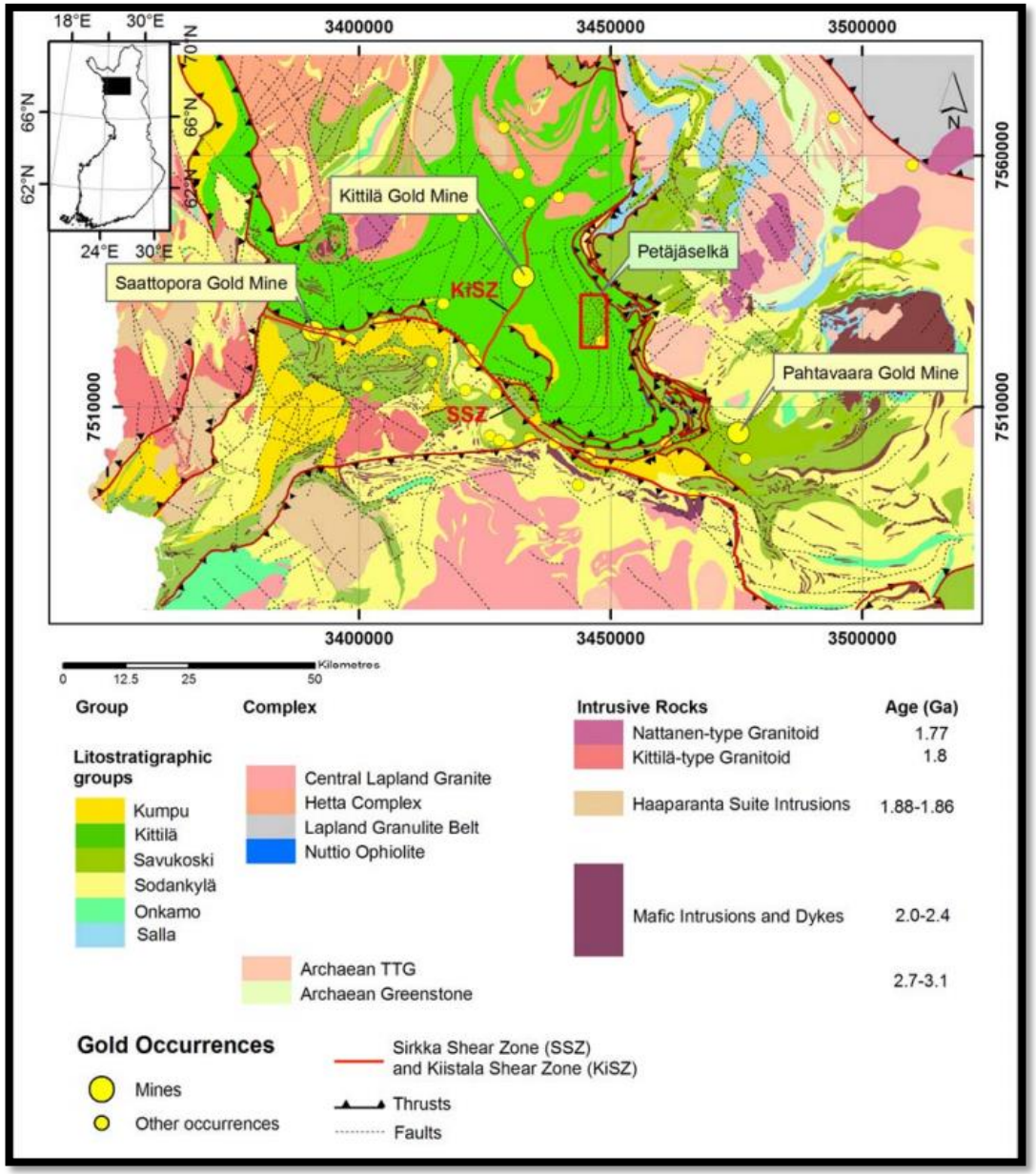
If yes, It would have huge benefits on greenfield exploration projects to gain valuable data on deposit type from early stages→ Environmental friendly and efficient way → Lower costs!

Petäjäselkä Bedrock geology

- Area is located in the northern part of Fennoscandian shield in the Central Lapland Belt (CLB).

- The CLB comprises Paleoproterozoic volcanic and sedimentary rocks (2.5-1.97 Ga) deposited on to the Archean basement.

- The CLB hosts numerous gold deposits (e.g. Saattopora, Pahtavaara and Suurikuusikko deposits).



Map copyright: Helena Hulkki, Heikki Salmirinne, Pertti Sarala ja Tuomo Karinen GTK in see ref.1.

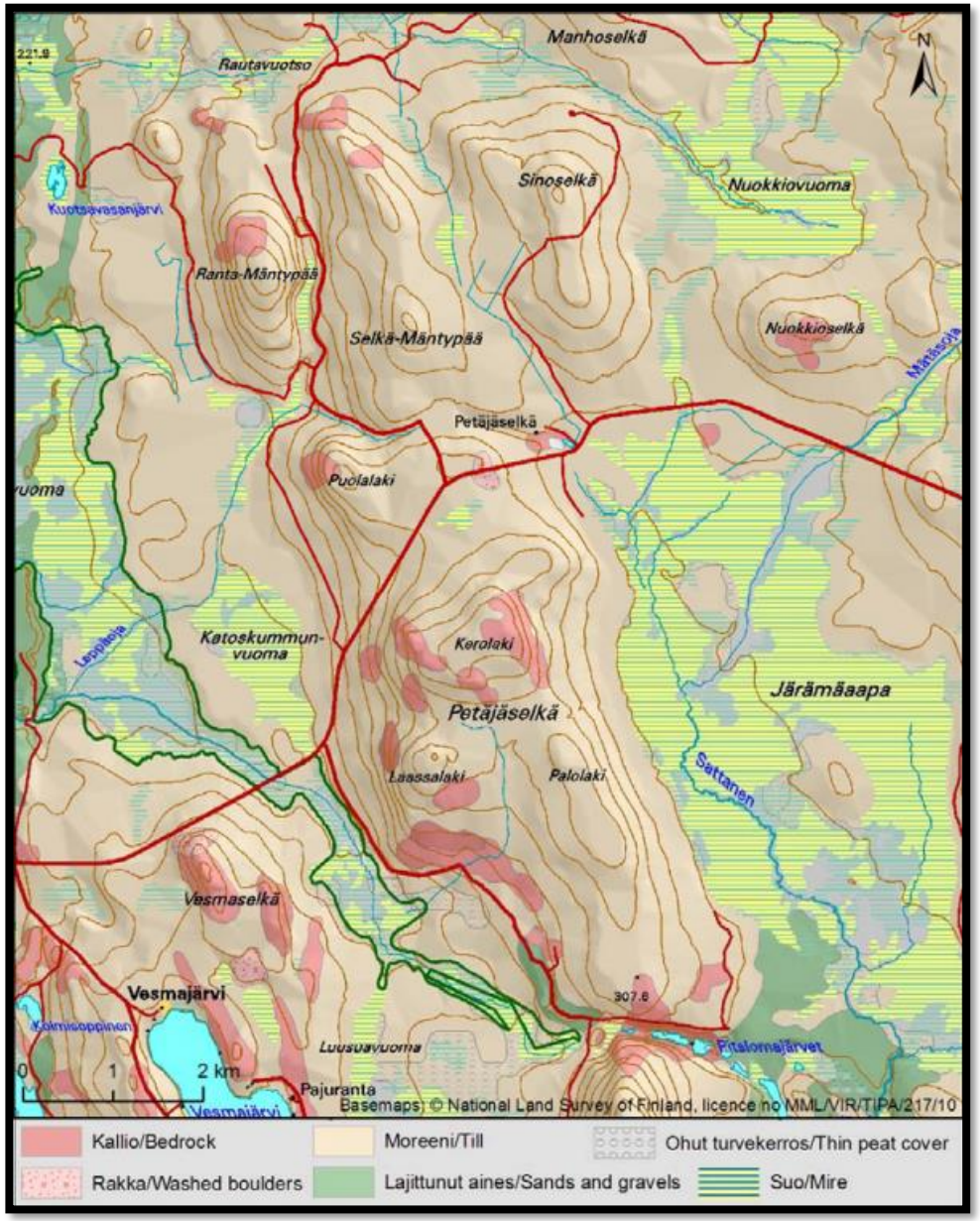
Quaternary geology

- The overburden is composed of glaciogenic till with varying thickness 1-3 m in hill areas and > 3 m in the low land areas.

- Pre-glacial weathered surface of bedrock is commonly observed between the fresh bedrock and till.

- Main ice-flow direction has been from the west to the east.

- Glacial transport distance for till is usually low, because the area has been situated in the ice-divide zone during the last deglaciation prevailing 10,000-11,000 years ago!



Map copyright: Helena Hulkki, Heikki Salmirinne, Pertti Sarala ja Tuomo Karinen GTK in see ref.1.

Why Petäjäselkä?

- Area has undergone extensive hydrothermal alteration (chlorite, carbonate, sericite) and high Au have been reported throughout the 52 km^2 area.

-Gold is enriched in the sulfide-carbonate-quartz-rich veinlets in these zones.

-Three Au-bearing targets (Kerolaki, Selkä-Mäntypää and Ranta-Mäntypää) were discovered in the GTK studies during the period 2002–2009.→Lot of data!

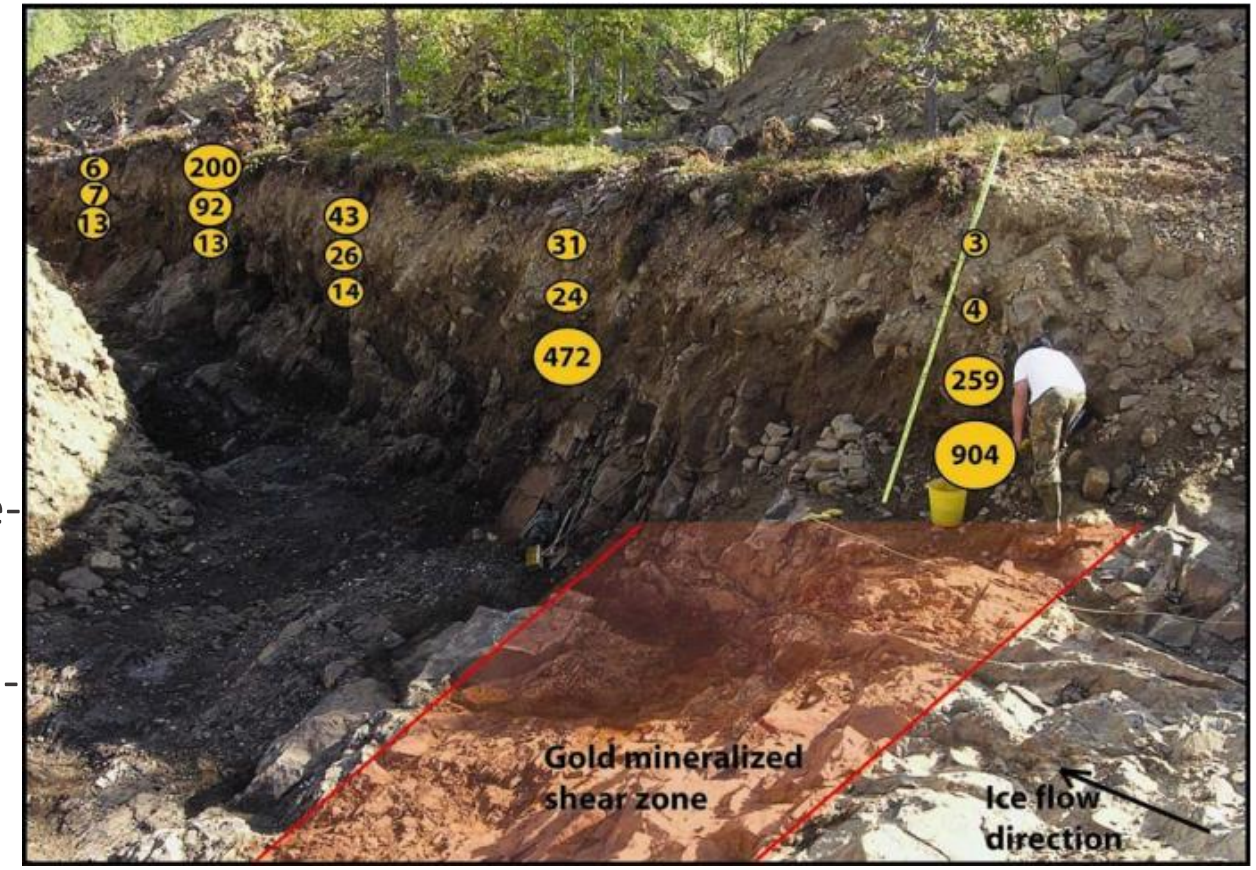
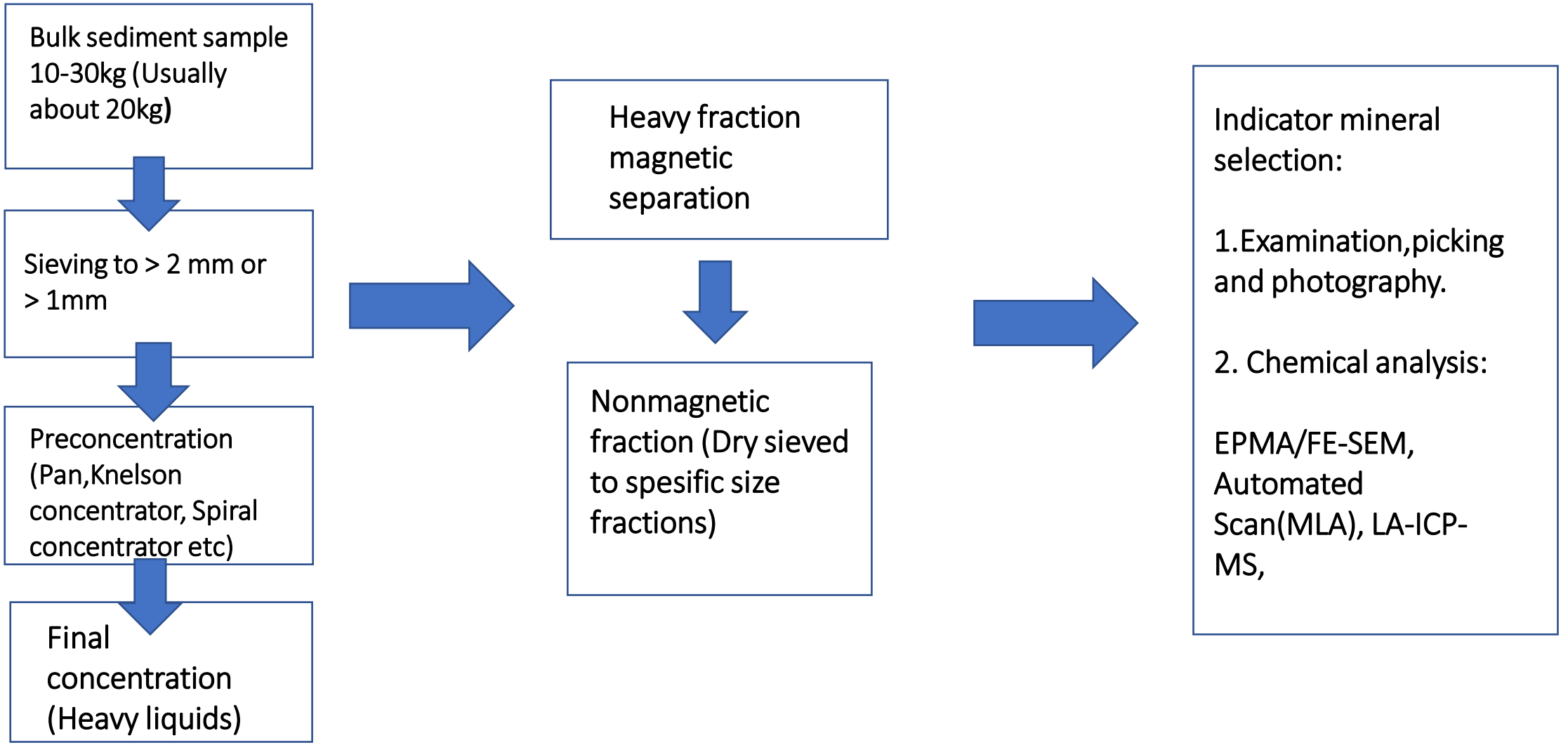


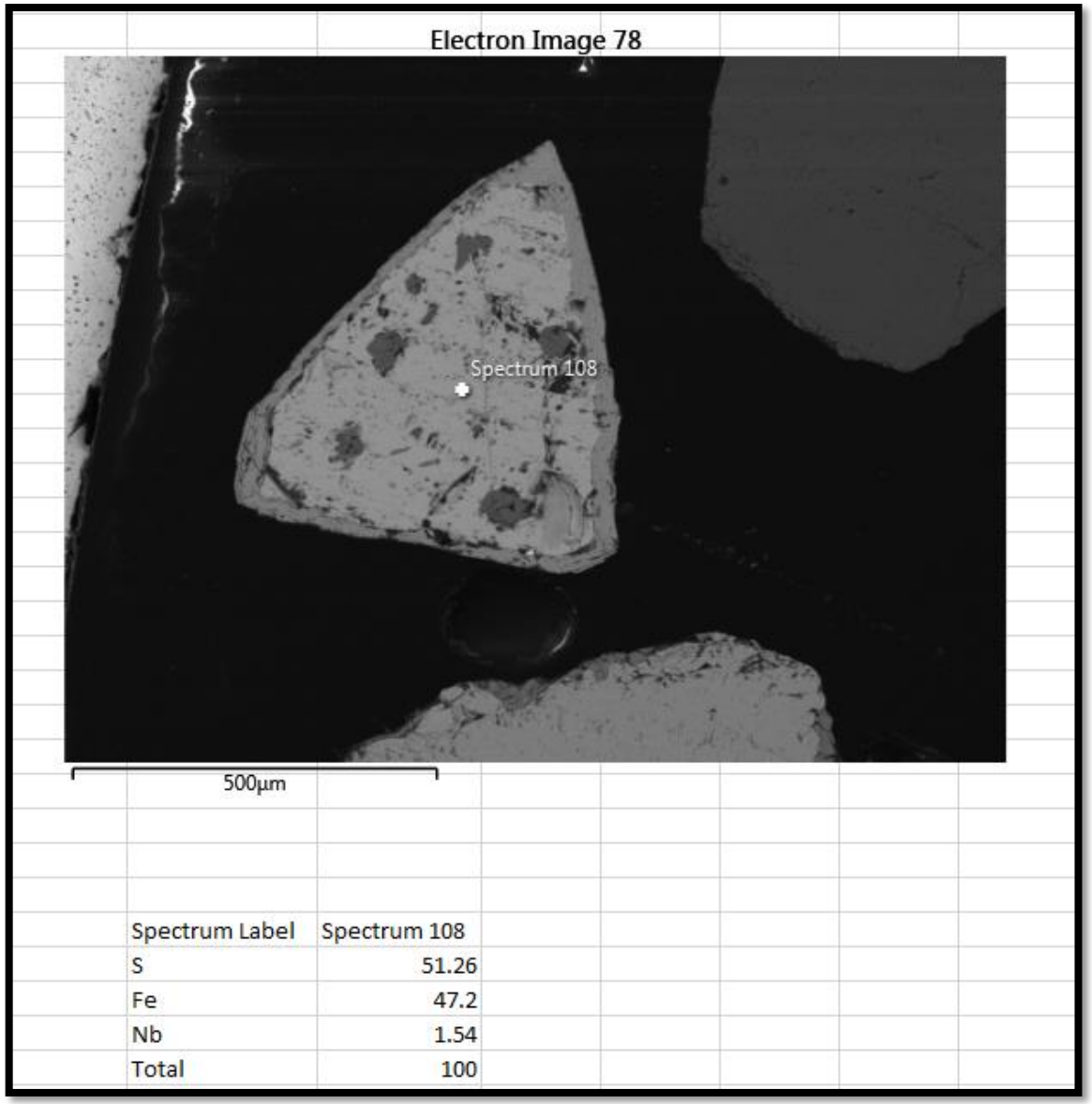
Photo copyright: Pertti Sarala, GTK. (Sarala & Ojala 2008)

Heavy mineral concentrate workflow



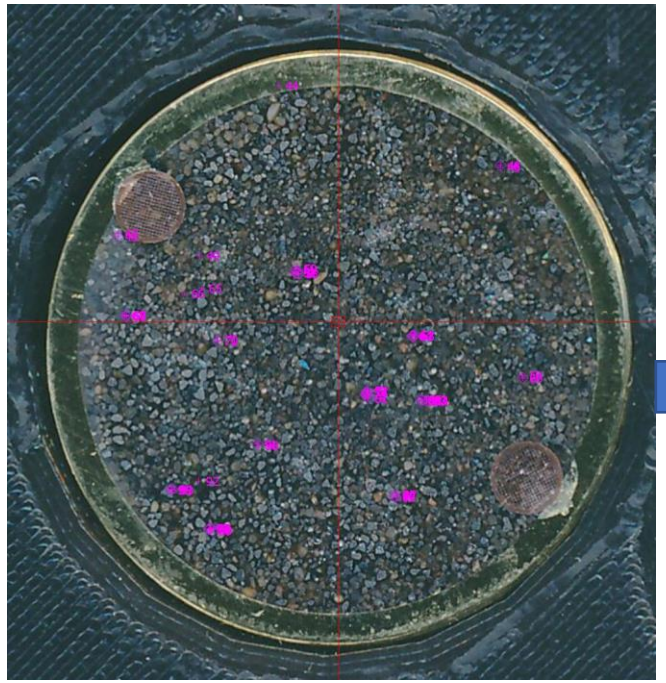
Results so far FE-SEM-EDS

- Under 125 µm material was scanned with FE-SEM-EDS automated scan→poor results→oxidized till
- Coarser fractions 125-500 µm microns and 0-2000 µm contained large goethisized grains with pyrite inclusions.
- Total of 80 grains (most of them pyrite) have been located in 21 samples.

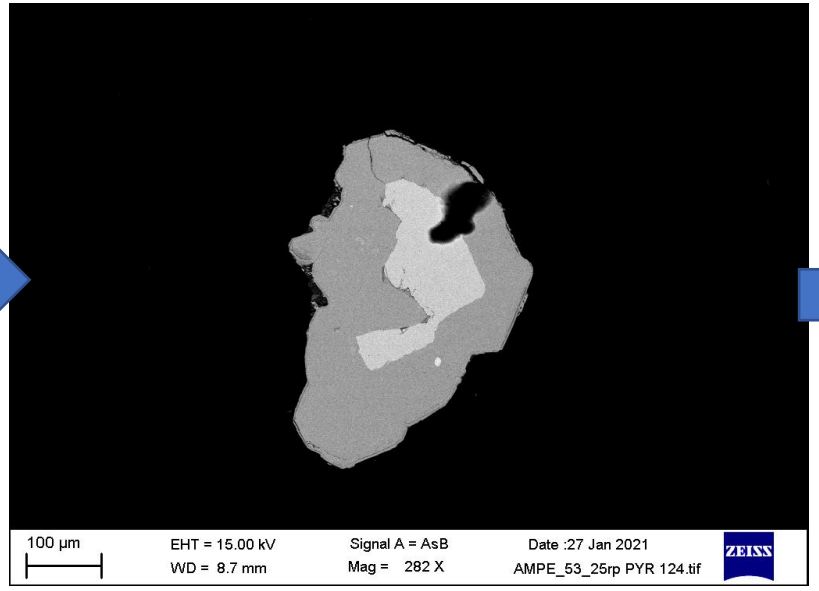


Spectrum Label	Spectrum 108
S	51.26
Fe	47.2
Nb	1.54
Total	100

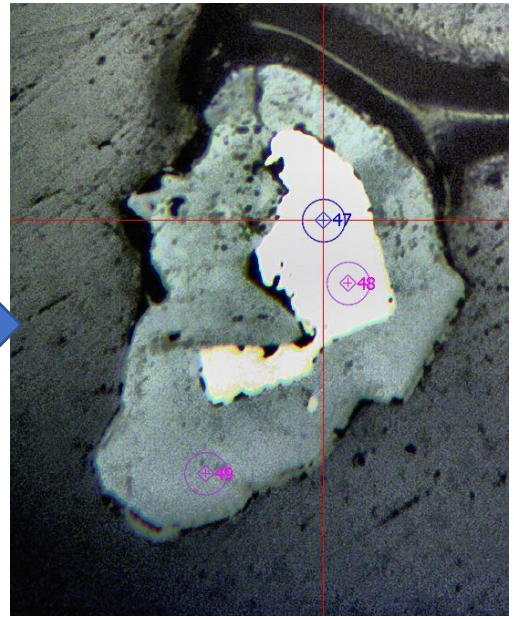
Results so far (LA-ICP-MS analysis)



Epoxy sample mounts with copper grids for grain coordinations.



FE-SEM BSE image of the grain



LA-ICP-MS picture with analyze spots

Main Pyrite trace-elements in HM samples (Median)

Kerolaki		Selkä-Mäntypää	
Co	2640 ppm	**Co**	1600 ppm
As	930 ppm	**As**	270 ppm
Ni	72 ppm	**Ni**	158 ppm
Se	26 ppm	**Se**	54 ppm
Ti	6 ppm	**Ti**	6 ppm

Main trace-elements in total (Median)

Pyrite inclusion		Oxidized rims	
Co	1500 ppm	Co	3043 ppm
As	375 ppm	Mn	434 ppm
Ni	140 ppm	Ni	343 ppm
Se	45 ppm	Cu	222 ppm
Ti	6 ppm	Se	28 ppm

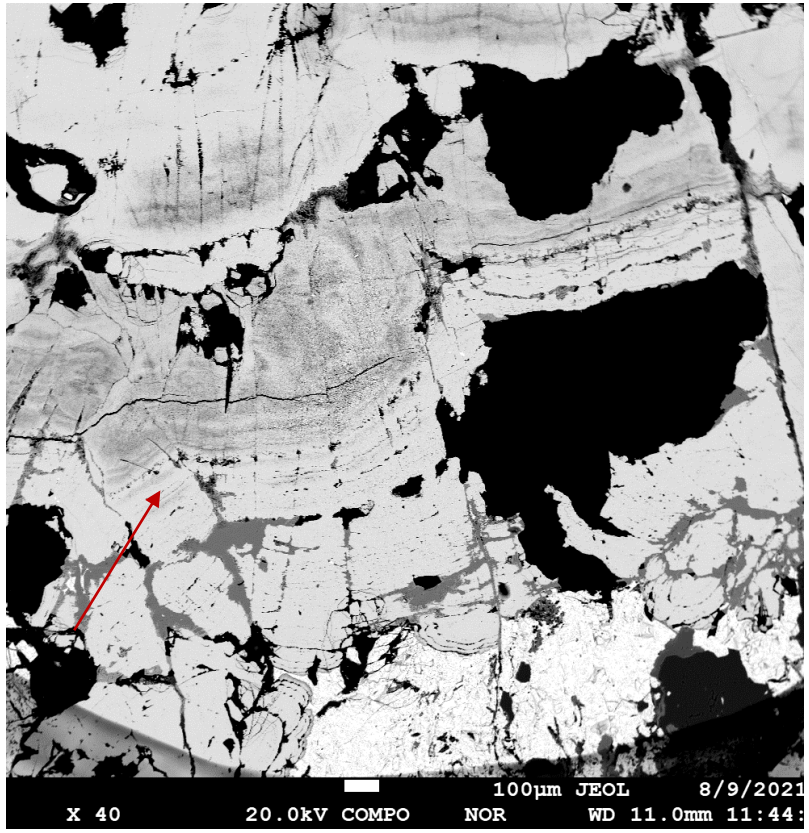
Bedrock samples (Source Characterization)

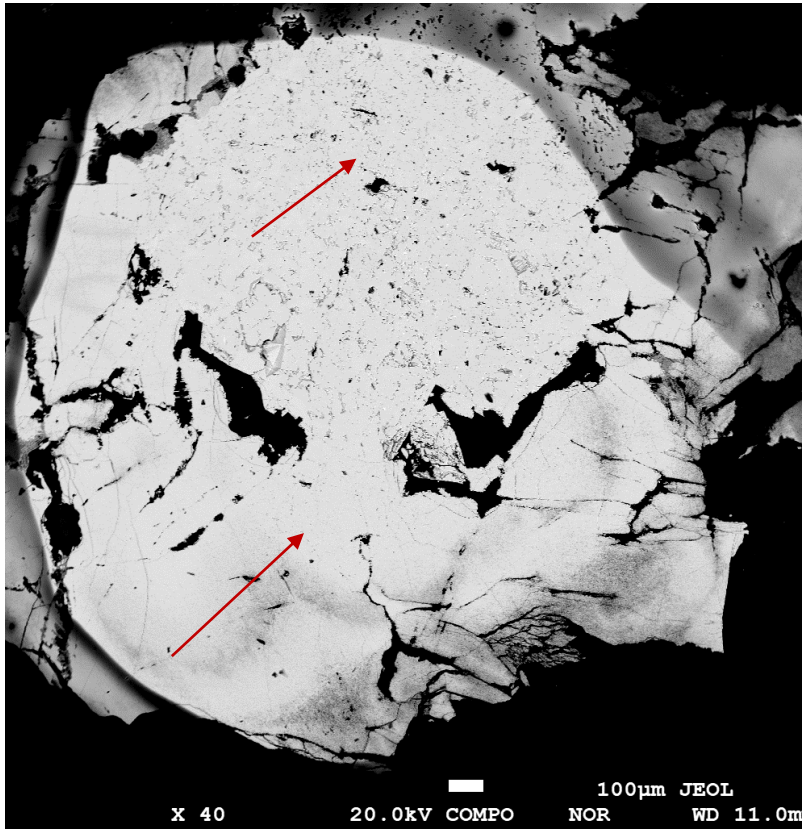
- 39 bedrock samples was carefully chosen from mineralized parts of four different drillcores → produced to thin sections.

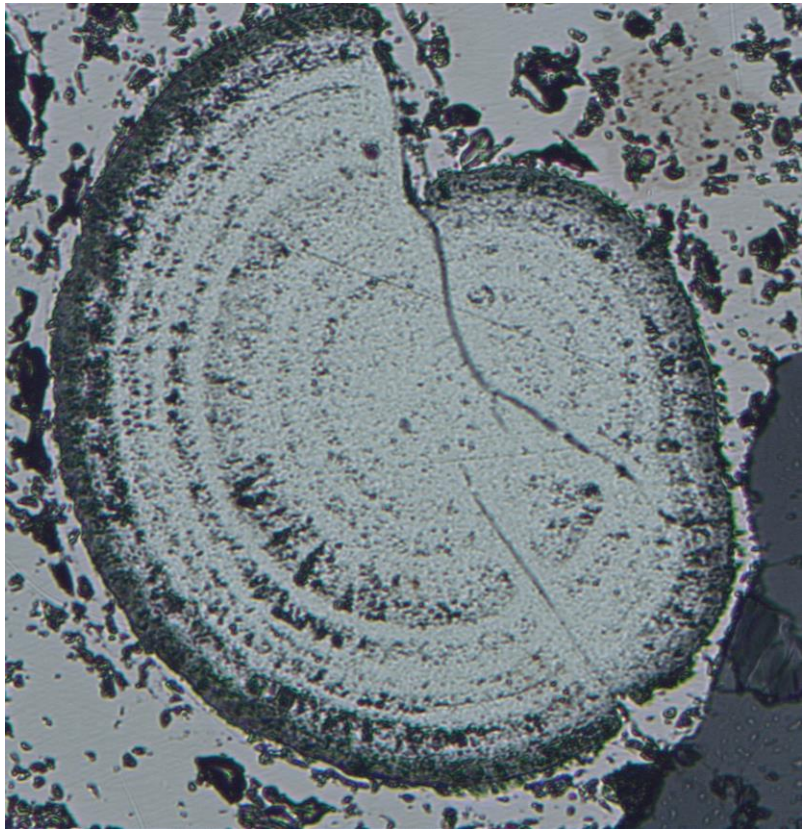
- 11 samples were chosen to further analysis after mineralogical study.

- Samples contained four different sulfides (arsenopyrite,pyrrhotite, pyrite and chalcopyrite) and some small gold particles (<50 microns) which were analysed by LA-ICP-MS for trace-elements and S isotopes.

- Three different pyrite textures was identified from the samples→





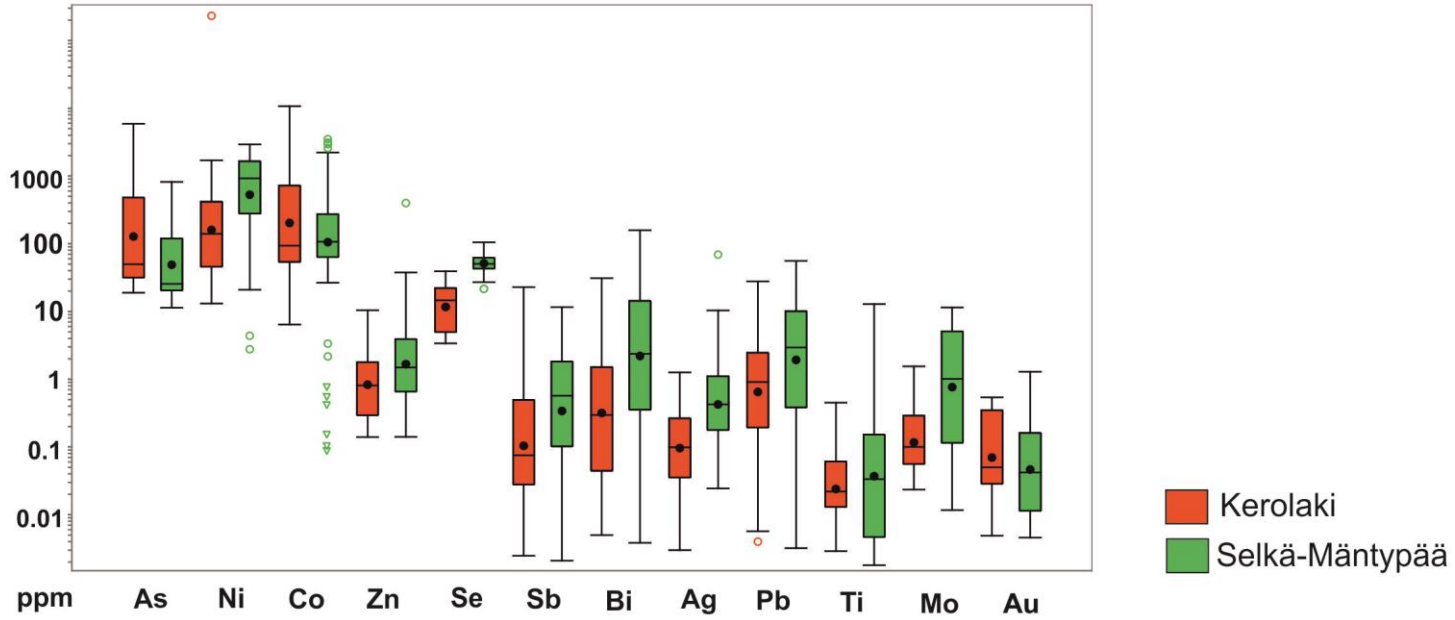


Pyrite textures

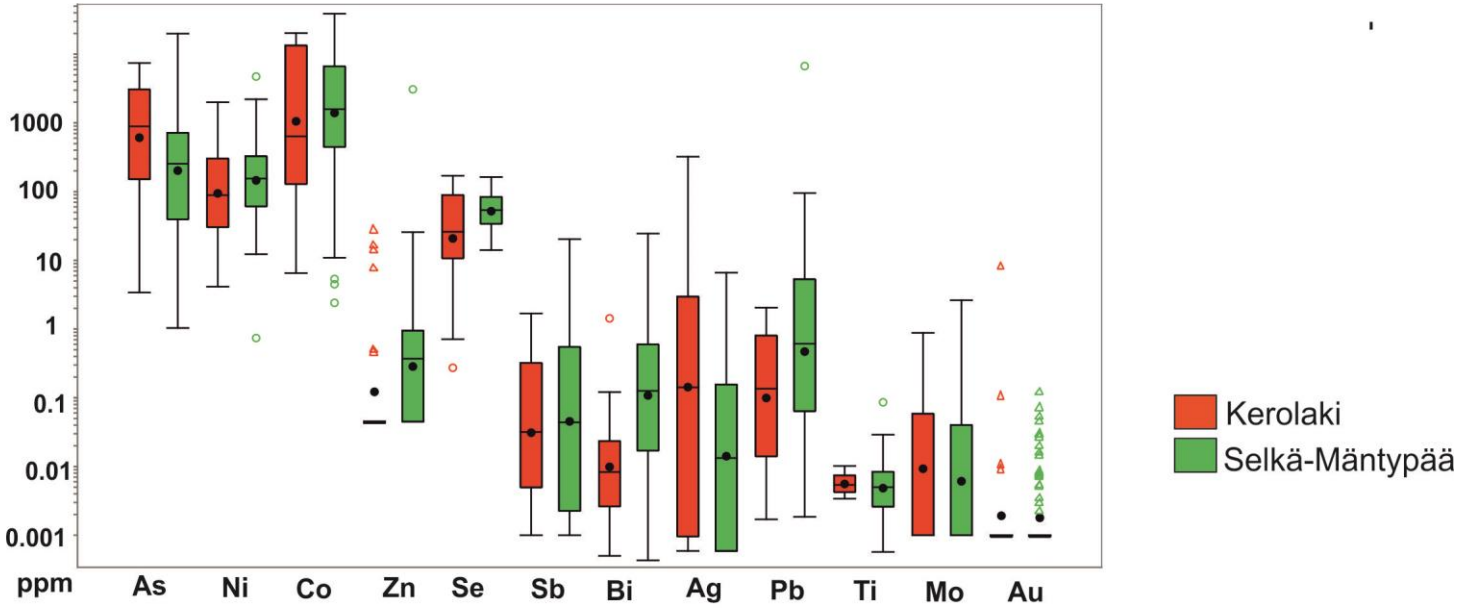
Main Pyrite trace-elements in Bedrock samples (Median)

Kerolaki		Selkä-Mäntypää	
Ni	139 ppm	Ni	923 ppm
Co	93 ppm	Co	106 ppm
As	49 ppm	As	25 ppm
Se	15 ppm	Se	50 ppm
Ti	6 ppm	Ti	6 ppm

Pyrite bedrock trace element box plot



Pyrite heavy mineral trace element box plot



Upcoming work

- Statistical pyrite texture comparison-
- Advanced statistical methods whole data→ PCA (Principal compoment analysis) SOM (self organising map)
- SEM-AM analyse work on selected thin sections (Under process)
- First manuscript will be submitted in early 2022.

References:

1. Hulkki, H., Salmirinne, H., Karinen, T., Nykänen, V. and Sarala, P. (2010). The Petäjäselkä gold prospect Ml 9/3721/201 0/62, GTK

2. Sarala, P. & Ojala, V.J. (2008). Implications of complex glacial deposits for till geochemical exploration: Examples from the central Fennoscandian ice sheet. In: Stefánsson, Ó. (ed.), Geochemistry Research Advances, Chapter 1. Nova Publishers, New York, pp. 1-29.

3. Taivalkoski, A., Sarala, P. & Hulkki, H. (2015). Gold exploration using heavy minerals in till and weathered bedrock in Petäjäselkä, northern Finland. *Geochemistry: Exploration, Environment, Analysis*, *15*(2-3), 205-221.

THANK YOU!