OULU MINING SCHOOL
UNIVERSITY OF OULU
10 years

crm
Conference on
Exploration and Exploitation
of Critical Raw Materials

Environmentally friendly surficial geochemical exploration techniques

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EGT-TWINN

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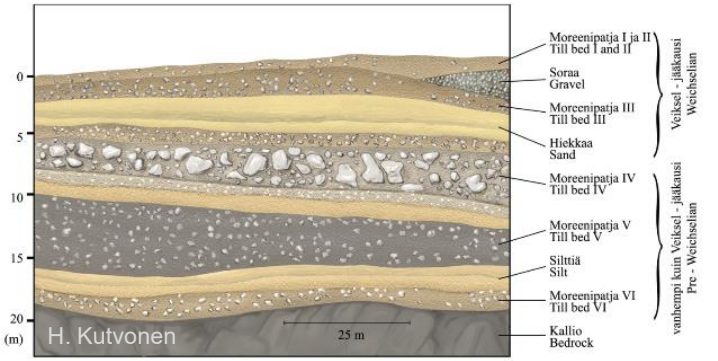
Introduction

- Many terrain types problematic for the conventional surficial exploration methods:
  - Thick transported cover
  - Sedimentary rocks above crystalline bedrock
  - Challenge terrain to move
  - Vulnerable and protected areas
  - Sensitive Arctic areas, etc.

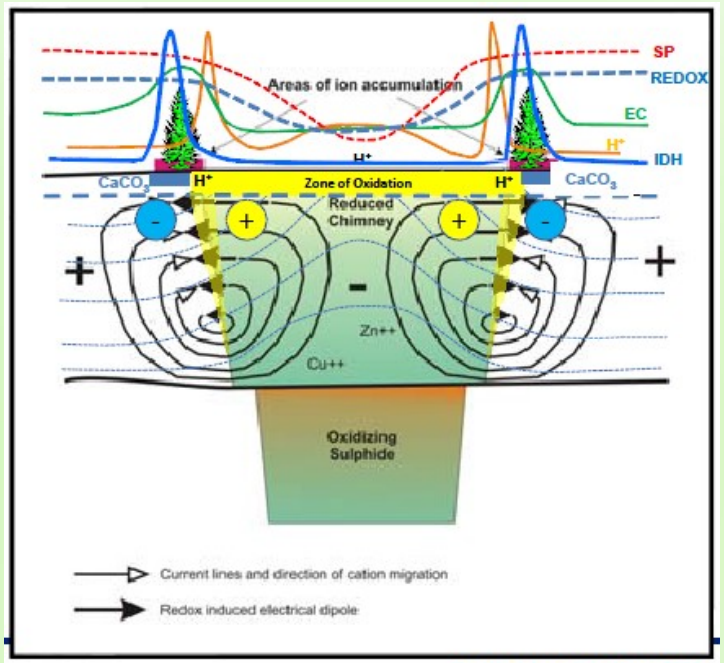


Surficial geochemical methods

- Sample materials can be minerogenic and organic soils, plant materials, peat and snow
- Mineral horizons are available for sampling everywhere besides on the peatlands and the uncovered bedrock
- Quick sampling and low sample pre-preparation
  - For the soil geochemical sampling, small test pits or soil drills can be used => sampling depth c. 10-25 cm under the contact of humus and mineral soil
  - For the biogeochemical sampling, many different plant spieces available => sampling from different parts
  - For the snow geochemistry, sampling into
- Plenty of (commercial) analysis methods available
- Sampling lines are effective in the recognisance phase, nowadays recommended to use grid sampling for determining anomaly patterns
- Small environmental impact!!!

Ion migration: Vertical ion movement mechanisms

- Biological processes
- Capillary action
- Convection
- Advection
  (incl. Seismic dilatancy pumping)
- Evaporation/Evapo-transpiration
- Gas/Vapour diffusion /
  microbubble transport
- Groundwater movement
- Hydromorphic dispersion

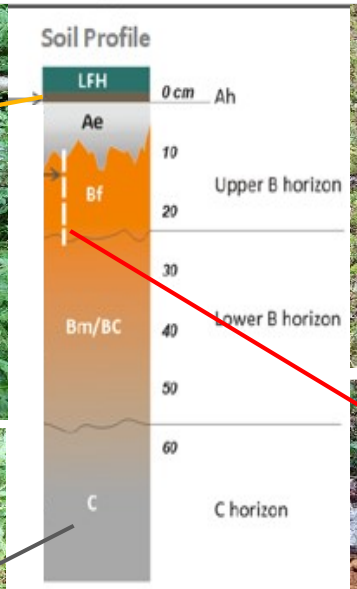


Electrochemical transport (Reduced chimneys)
= oxidation causes release of electrons
-> upward deflection in the earth's potential field (Hamilton, 1998)

Upper soil sampling

Ah horizon sampling

C horizon sampling



B horizon sampling

Only field observations and the pH measurements are needed before sending samples to the laboratory

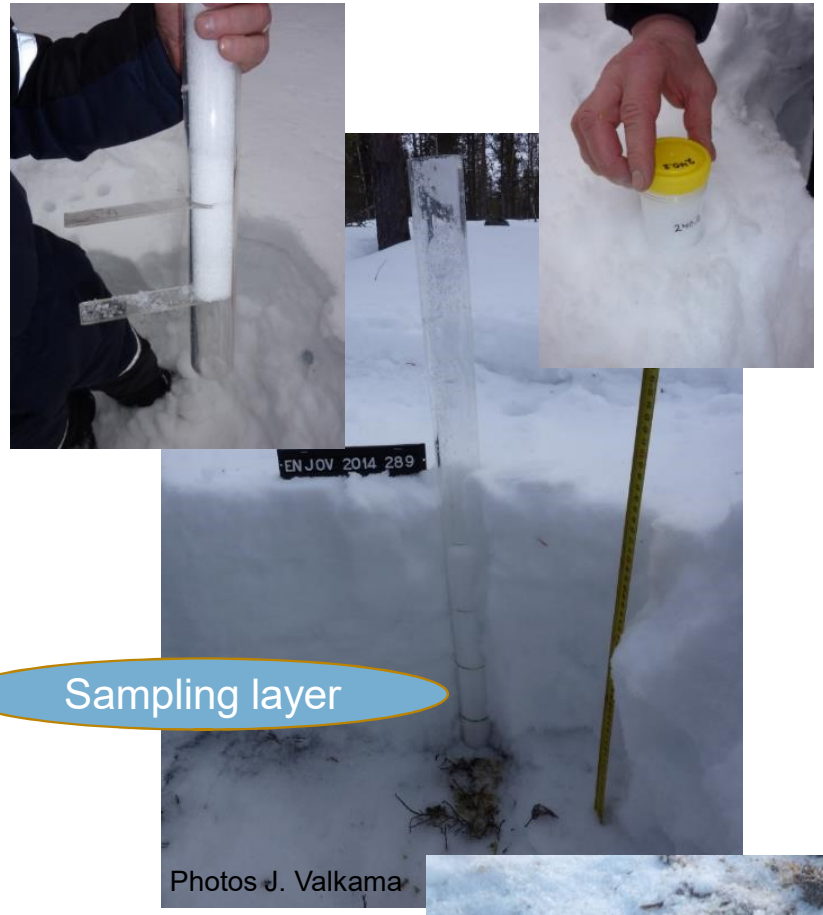
Plant sampling

- Typical plants in northern Europe: e.g., Norway spruce, Pine (Pinus silvestris), Birch (Betula pubescence and pendula), shrups (Common juniper, Labrador tea), and berries (blueberry, lingonberry)
- Sample materials:
  Bark, twigs, leaves and/or needles, cones, also peat

Plant materials

Snow geochemistry and sampling

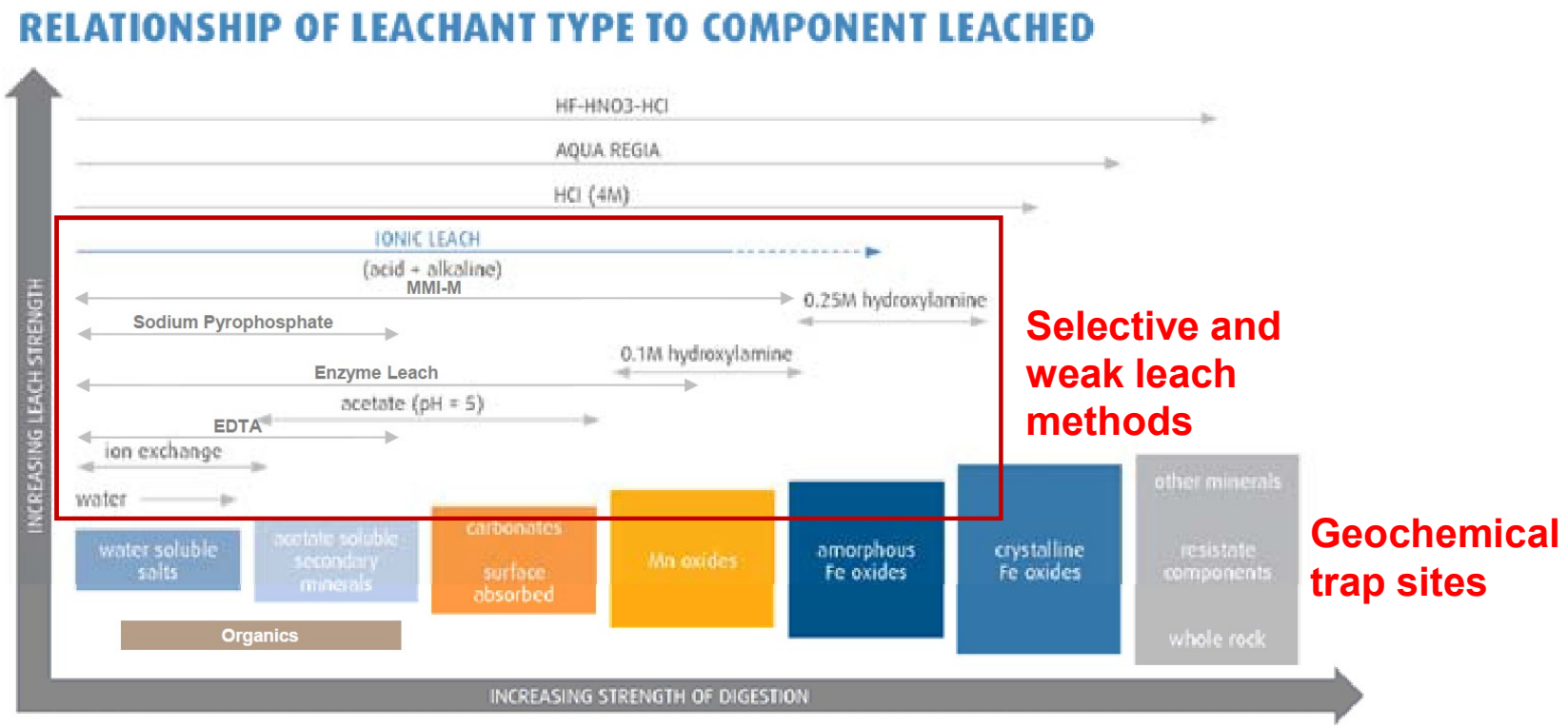
- Snow covers the terrain 4-6 months/year in Finland
  - Snow traps the soil gases and mobile ions. Aerial contamination is regionally equal
- Snow cover should be at least 3-4 weeks old
- Ideal snow sampling time is in mid-winter January – March
  - Long accumulation, high contrast no basal melting
- Sampling from the basal part of snow cover
  - Strongest influence on soil gases
  - Lowest atmospheric contamination
- Sampling using acryl plastic tupe or directly into acid-treated plastic jars; sample storing as frozen before analysis
  - No need of acid treatment of the samples



Choosing the analytical method(s)

- Elements and detection limits required
- Effect of matrix
- Possible trap sites
- Absolute values or relative (contrast)
- Representative size of sample or size limitation
- Budget/Costs

Chemical leaching techniques for upper soil

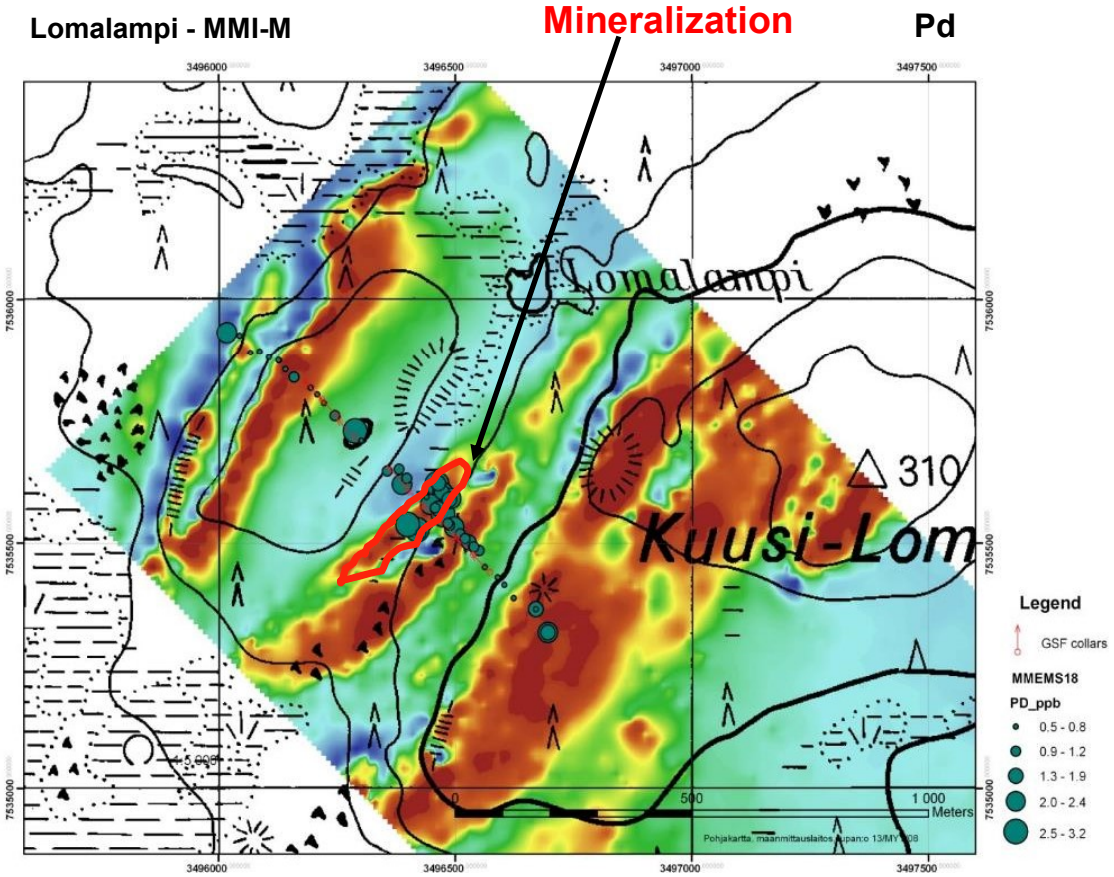


Spatiotemporal Geochemical Hydrocarbons (SGH) and HR-SC-ICP-MS

- SGH (earlier known as Soil Gas Hydrocarbons) method can be used for analysis of the hydrocarbon compounds transported by mobile gases produced by bacteria
  - The analysis involves the testing for 162 hydrocarbon compounds in the C5-C17 carbon series
  - The hydrocarbons in the SGH extract are separated by high resolution capillary column gas chromatography
  - Hydrocarbons are divided in 19 groups sensitive for certain ore types
  - Concentrations analysed using ICP-MS
- Another way is to detect element concentrations directly from the melted snow samples using HR-SC-ICP-MS
  - So far analyses have been done in the Finnish Geosciences Research Laboratory in GTK, Espoo
  - Element contents in ppb/ppt levels
  - Contamination risk high during the sampling!

Example – Case Lomalampi, PGE-Ni

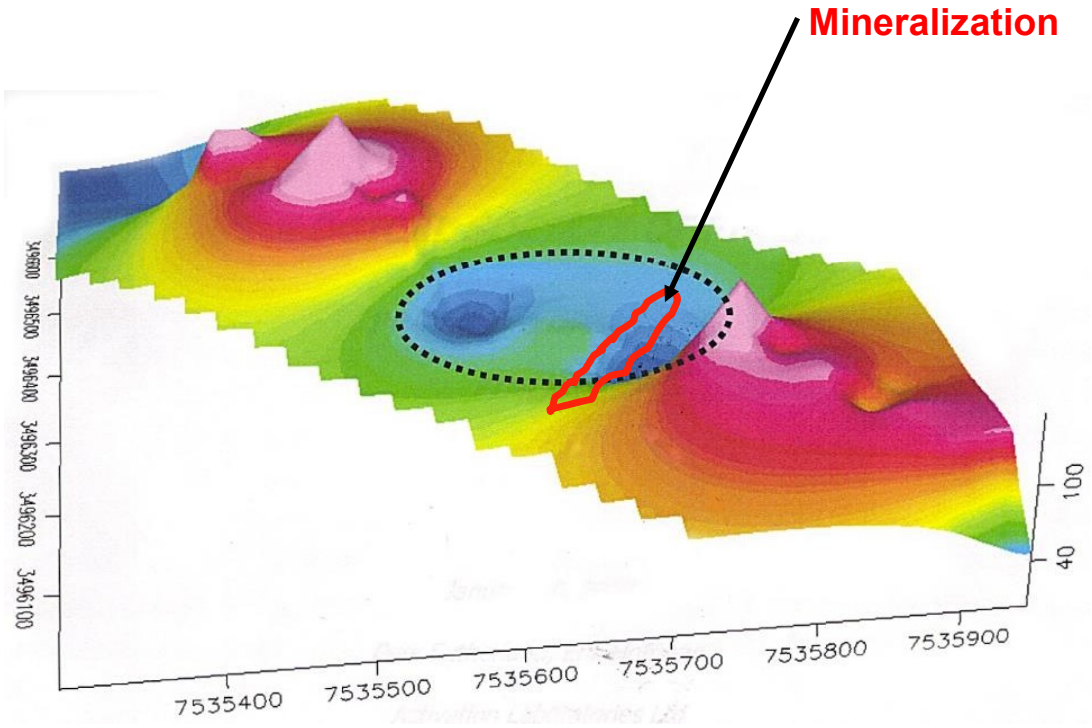
- Known Pt-Pd-Ni-Cu mineralization in Lomalampi, Sodankylä, north ern Finland
- Found based on bedrock mapping, detailed geophysical measurements and diamond drilling
- Bedrock is composed of mafic volcanic rocks and intrusive rocks
- In MMI-M analyse the mineralization is seen as strong Pd-, Ni- and Cu-anomaly
- Till cover 2-6 m



Example – Case Lomalampi, PGE-Ni (cont.)

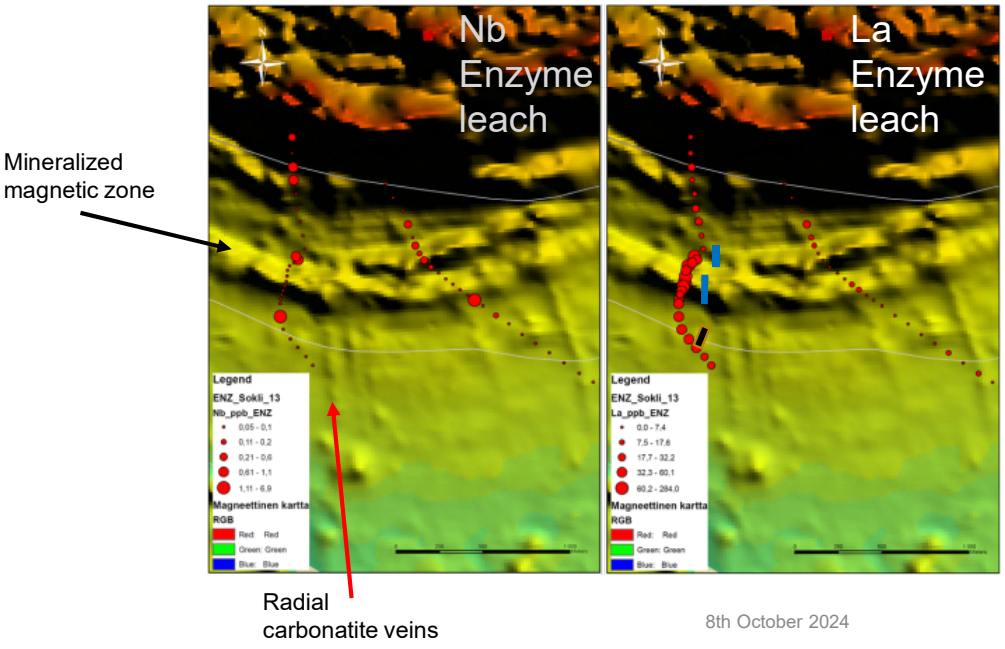
- By the SGH method clear negative anomaly with ”rabbit-ears” is showing the location of mineralization
- Interpretation as a 3D-presentation was done by the laboratory, where the total result of different components was considered with emphasis of Pd-Ni ore potentiality

FINAL RESULT:
Known Pt-Pd-Ni(-Cu) mineralization is detectable with all weak leach methods!

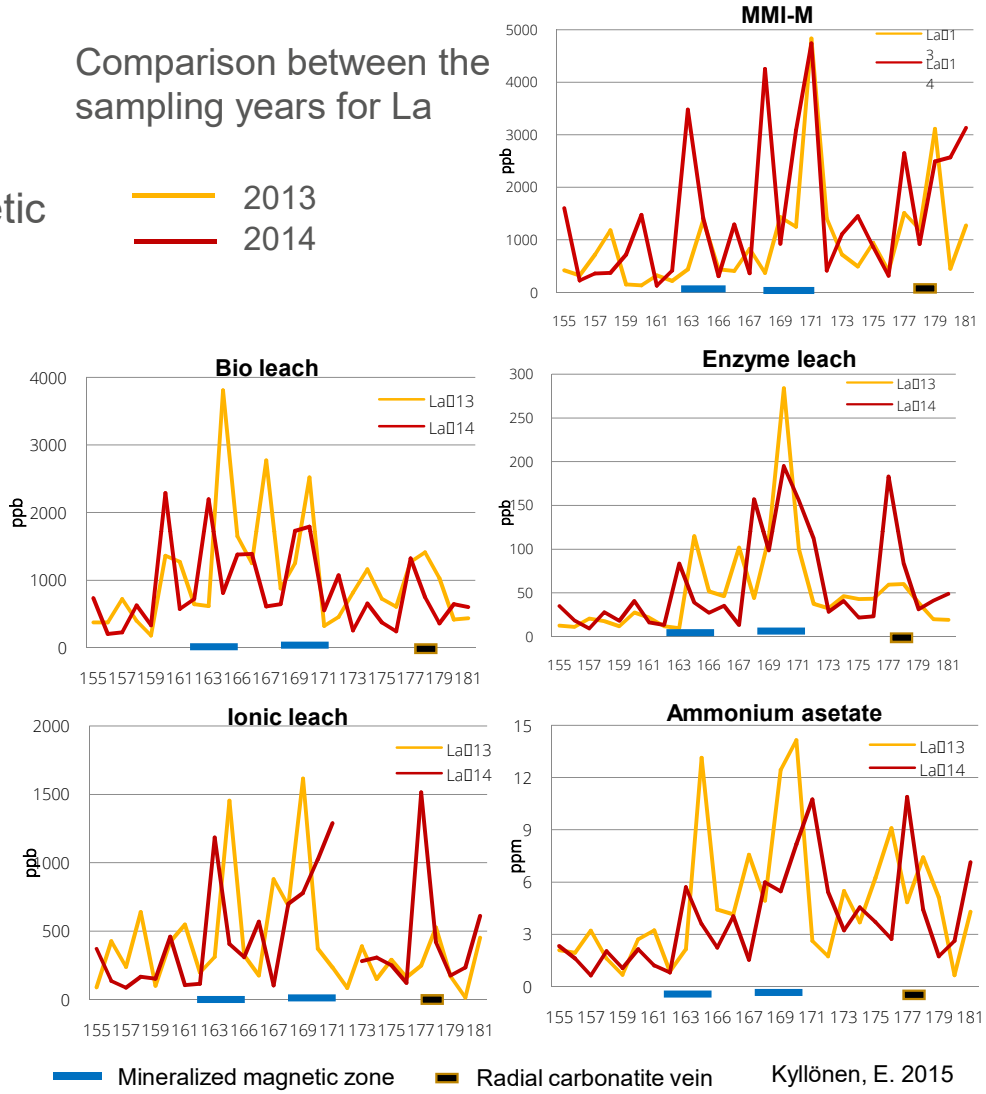


Sokli – P-REE

- Strong P, La, REE anomaly related to magnetic anomalies in the southern fenitic zone of the Sokli carbonatite massif
- Till cover 2-5 m



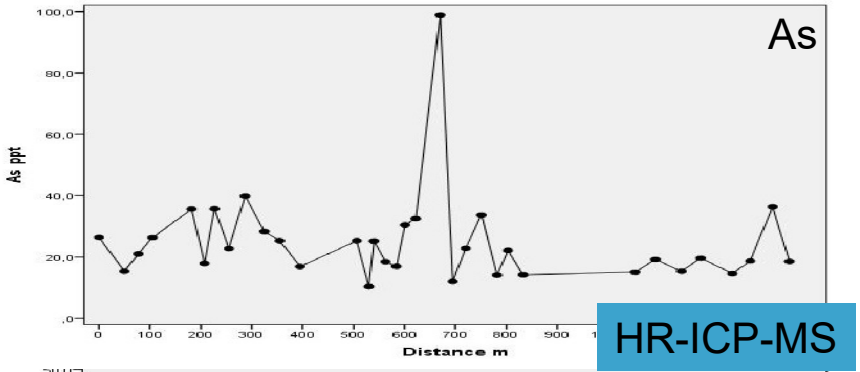
Comparison between the sampling years for La

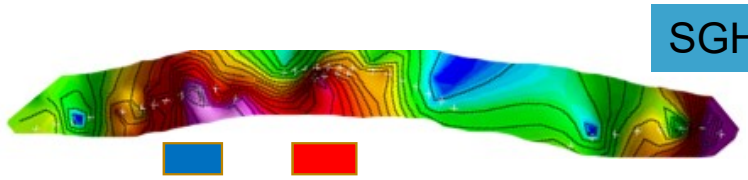


Kyllönen, E. 2015

Example: Snow – Au-Cu sulphidic deposit

- **Snow** samples collected from Juomasuo, Kuusamo, eastern Finland
- Analysed by SGH (Spatiotemporal Geochemical Hydrocarbon) and HR-ICP-MS analytical techniques
- Drumlin field, till cover 8-10 m
- Two distinct anomalies traced by SGH as positive anomalies, and HR-ICP-MS for several ore or pathfinder elements





Blind ore body
(> 150 m depth)

Pyrite-rich subsurface deposit in the centre

Conclusions – Surficial geochemistry

Benefits:

- All minerogenic and organic material can be used
- Mineral horizons are available for sampling everywhere besides on the peatlands and uncovered bedrock
- Plenty of (commercial) analytical methods available
- Quick sampling and only plant samples need pre-processing
- Snow sampling easy from constant sampling depth
- Small environmental impact
- Suitable for deep ore exploration


Photo P. Sarala

Restrictions:

- All leaching methods not suitable for all elements
- Soil horizons sometimes limited for sampling (dry sites), slow sampling
- Soil sampling in the summer (peat and plant sampling possible also during the winter)
- Snow sampling only in the areas where the snow cover available enough long during winter
- Interpretation of results sometimes challenging due to unknown geology and sources in different depths

Low environmental impact

Sampling point 2013

Sampling point 2014

Funded by the European Union

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