# Use of different fractions and heavy minerals of till for ore prospecting in ribbed moraine areas in southern Finnish Lapland


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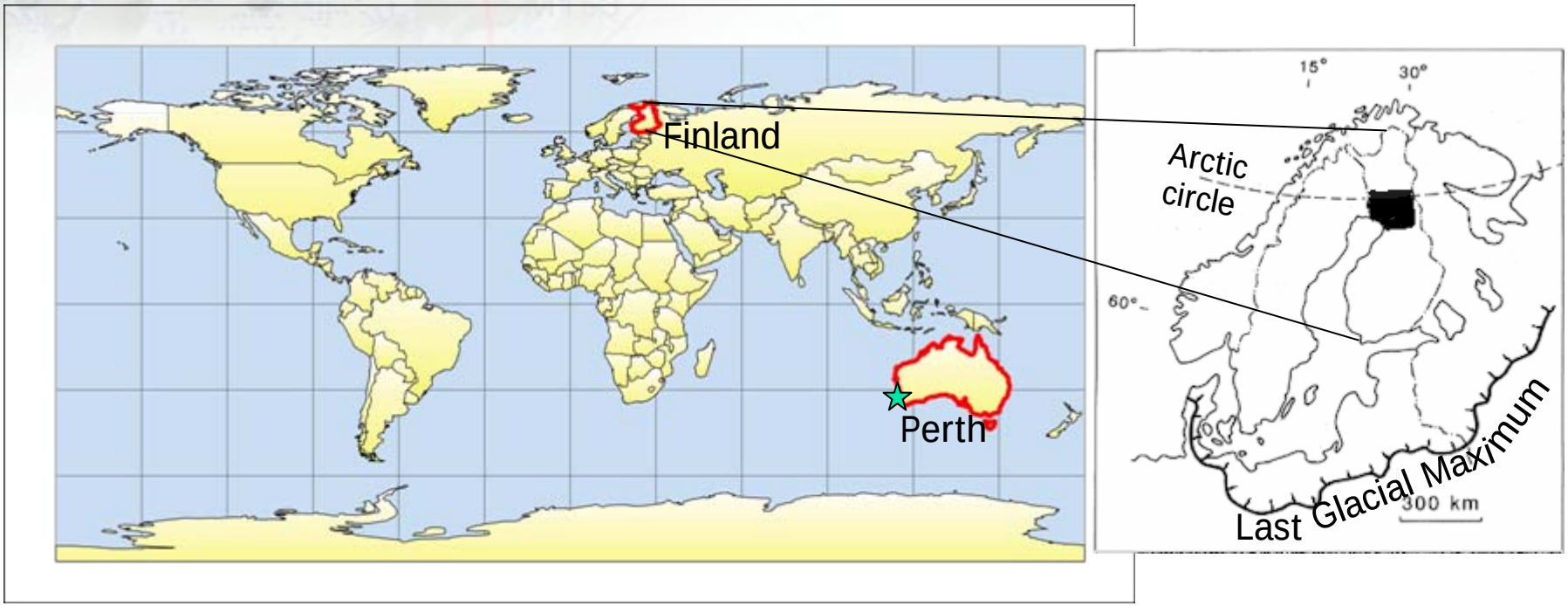
# Outline

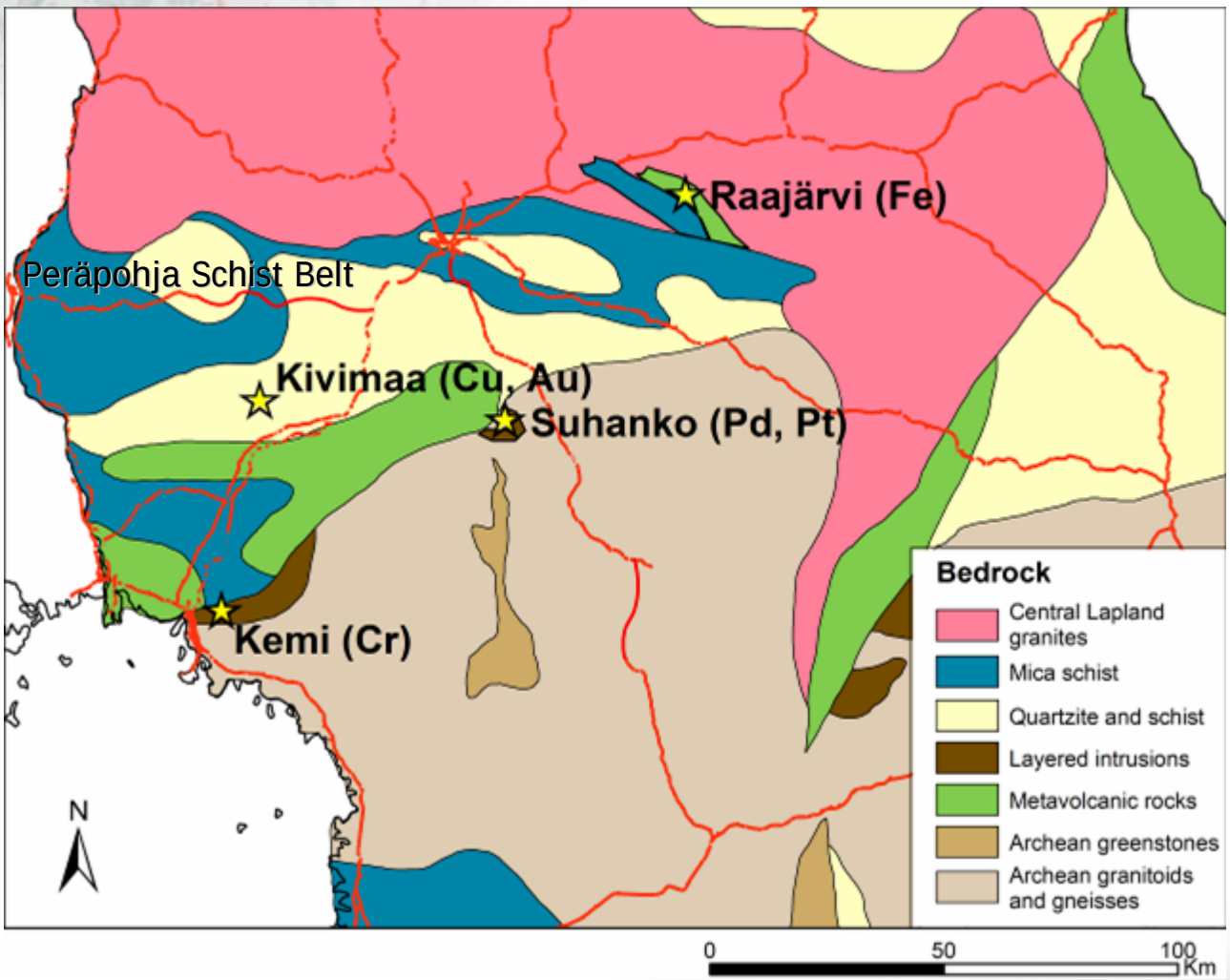
- Location of southern Finnish Lapland
- Geological background
- Ribbed moraines – what and where they are?
- Case studies and prospecting examples
  - Till geochemistry
  - Heavy minerals
  - Boulders
- General prospecting strategy in ribbed moraine areas
- Conclusions

# Location of southern Finnish Lapland

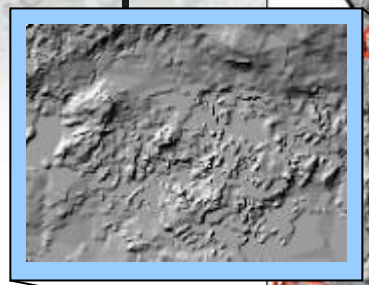



- Southern Finnish Lapland is located in Northern Hemisphere near the Arctic Circle
- Glacial centre of the Last Glacial Maximum was situated in the area

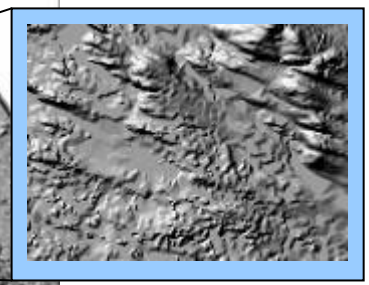
# Bedrock and mines



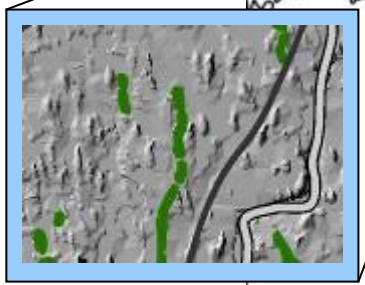
# Relief ja landforms



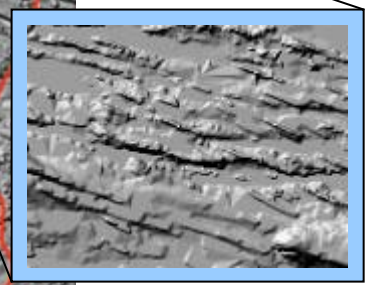
Hummocky ribbed moraines



Ribbed moraines and drumlins



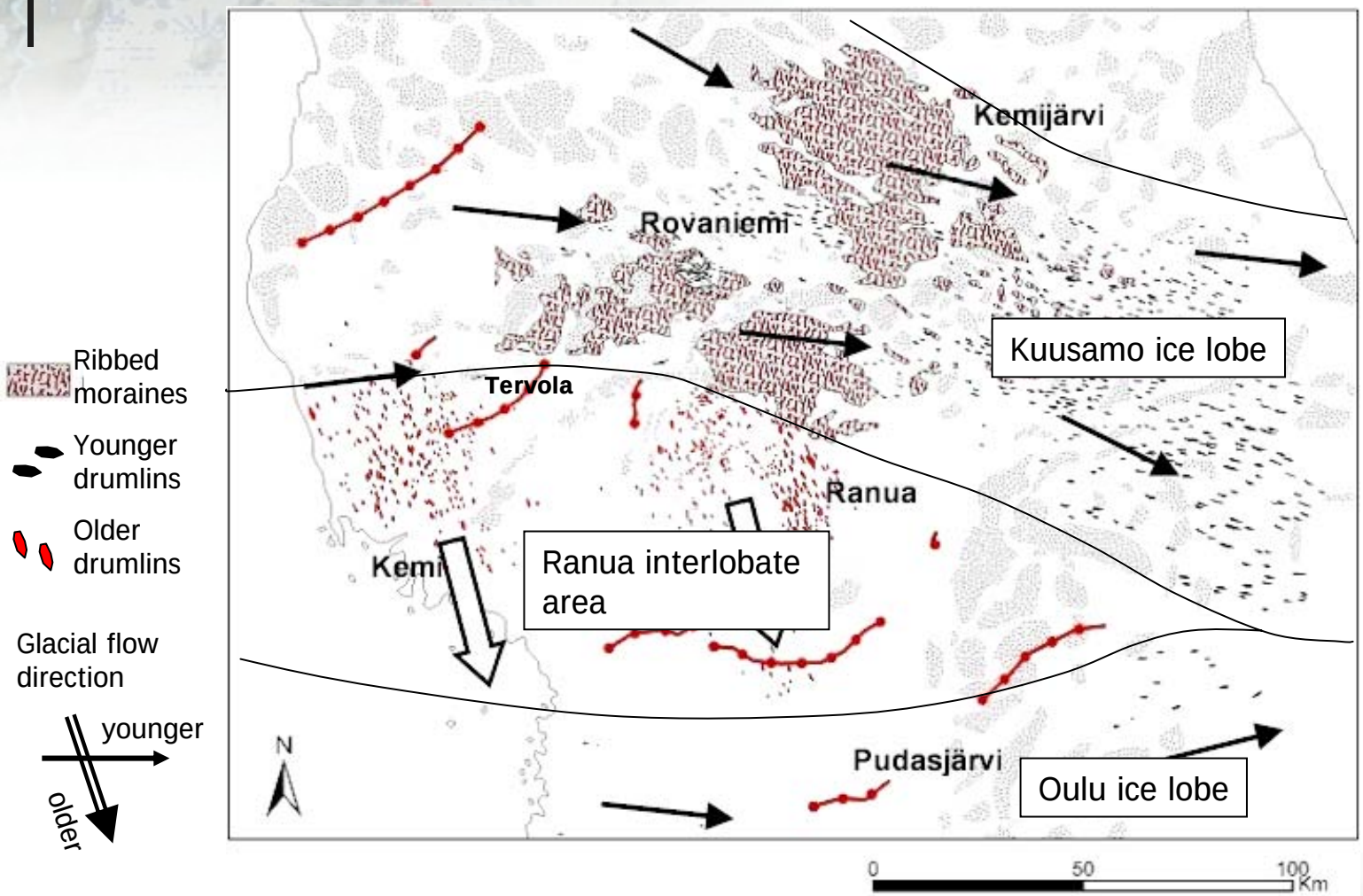
NW-SE oriented drumlins and mostly till-covered esker chains



Drumlins in Kuusamo drumlin field

0 50 100 Km

# Glacial morphology



# Ribbed moraines

- Ridges perpendicular to the latest glacial flow direction (200 m – 1.5 km in length, 50-200 m in width and 5-20 m in height)


**Hummocky ribbed moraine**

**Rogen moraine**

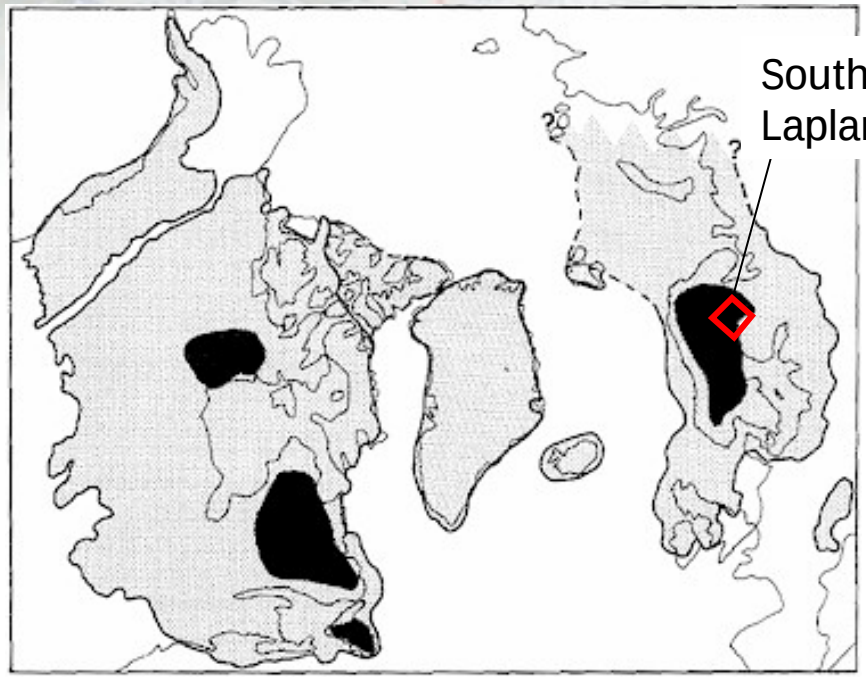
**Flow direction**

**Blattnick moraine**

**Minor ribbed moraine**

Hättestrand 1997

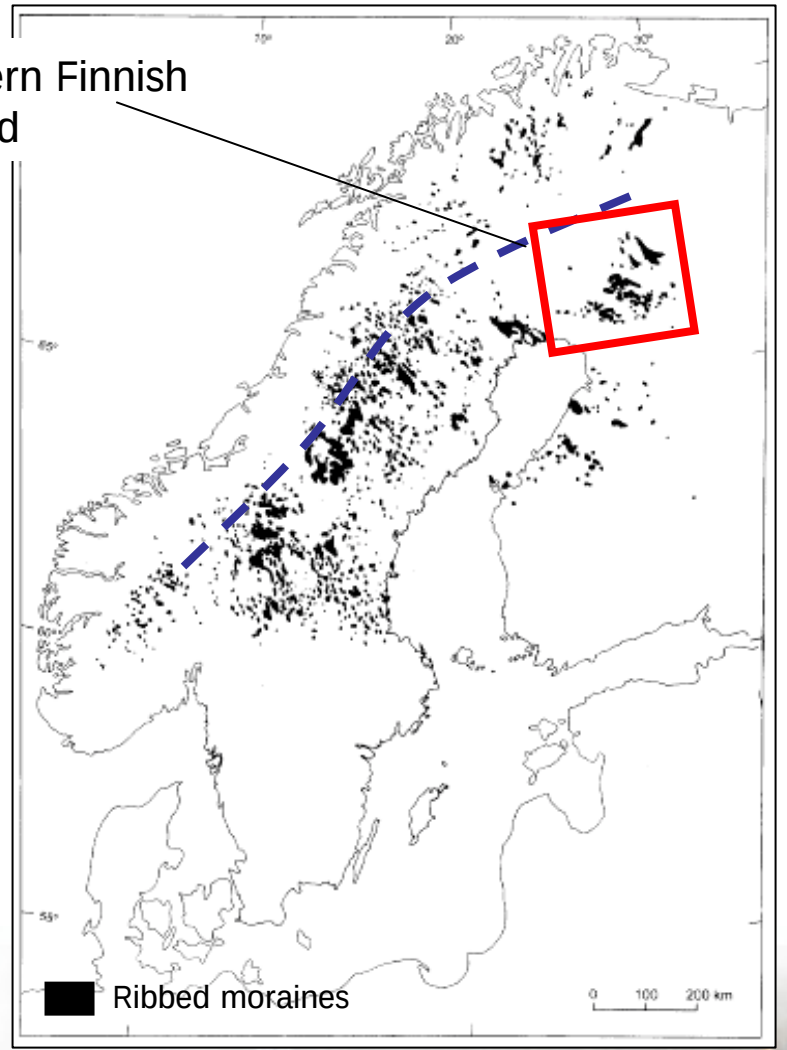
# Location of ribbed moraines



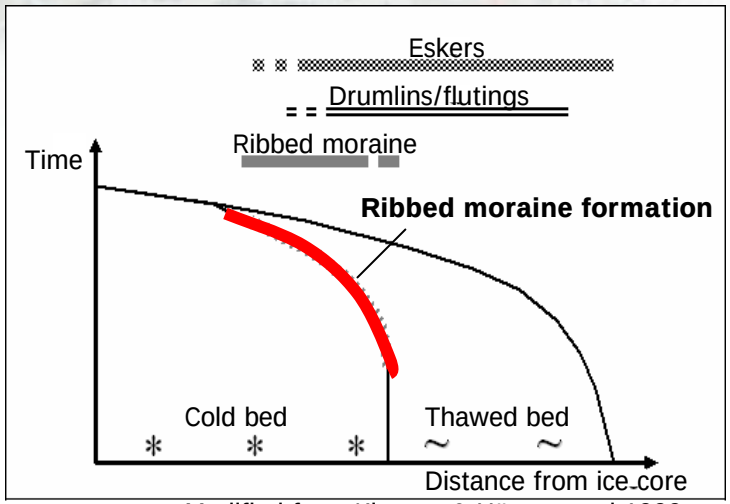
Maximum extent of Last Glaciation (Weichselian)

Cold-based central areas

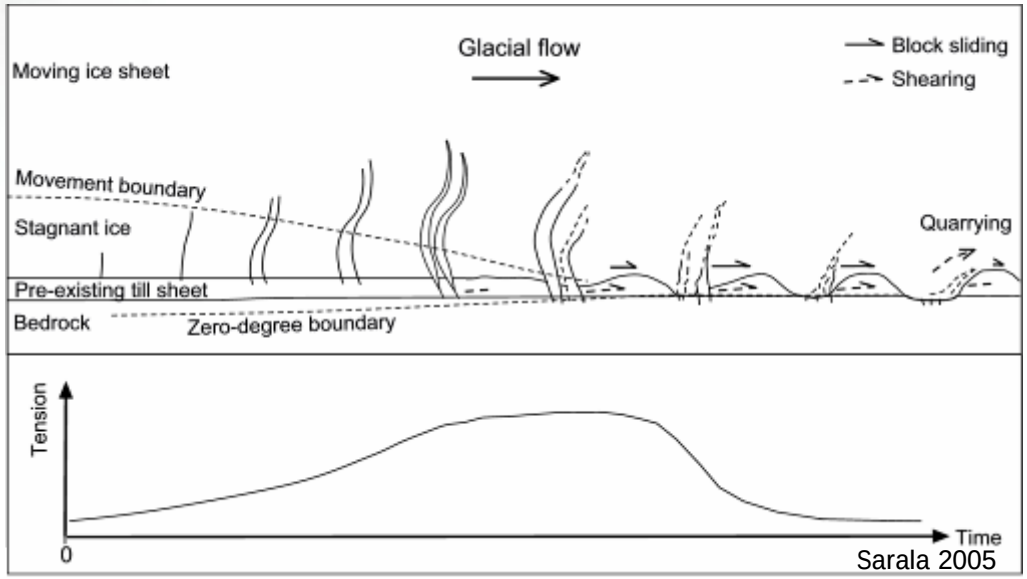
Hättestrand & Kleman 1999



# Ribbed moraine formation



Modified from Kleman & Hättestrand 1999

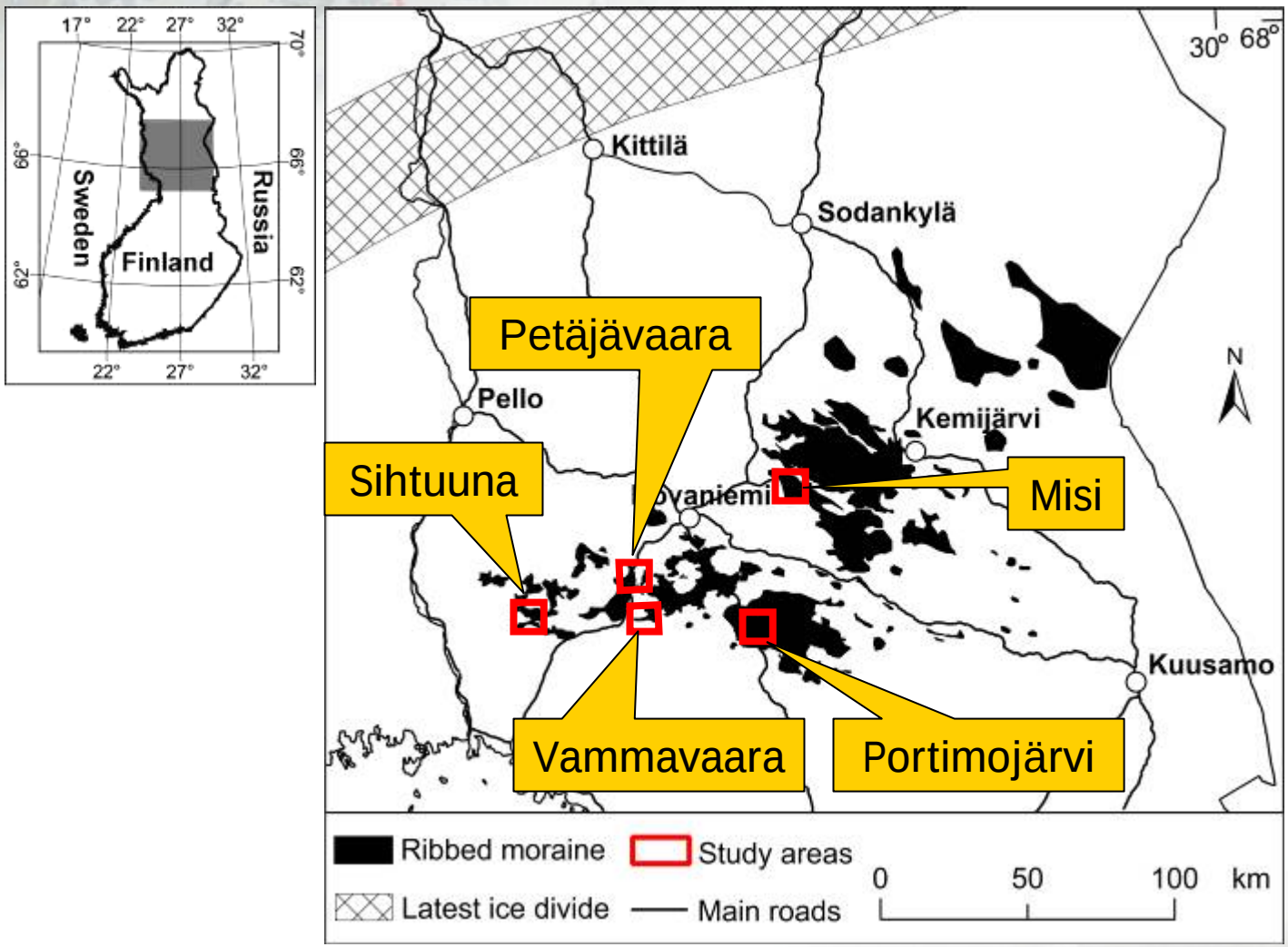


Sarala 2005

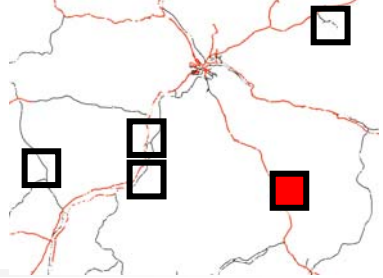
- The formation of ridges was a two-step process where at the initial phase, frozen and stagnant ice–pre-existing drift sheet core fragmented due to cracking under high pressure and tension and followed transition along moving ice-sheet

- At the second step, prevailed cold subglacial conditions led to the beginning of freeze-thaw process where the quarrying in between the ridges, a short transportation and the deposition onto the surface of the next ridge happened.

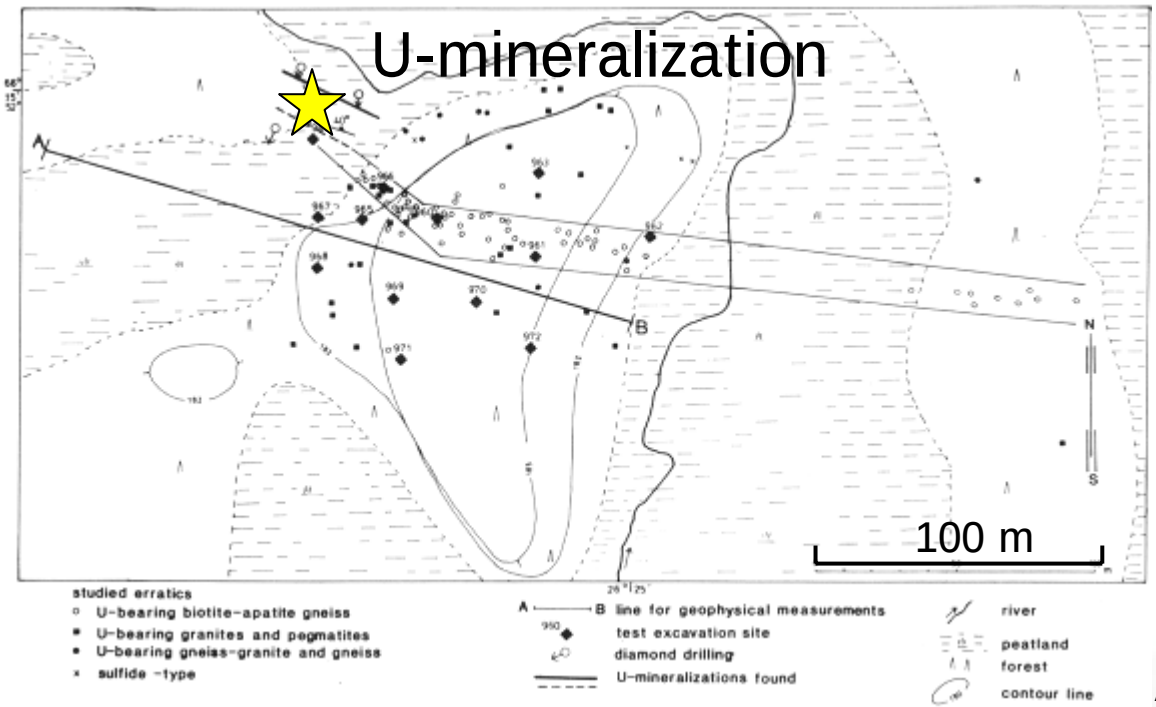
# Ribbed moraines in southern Lapland



# Case studies: Portimojärvi

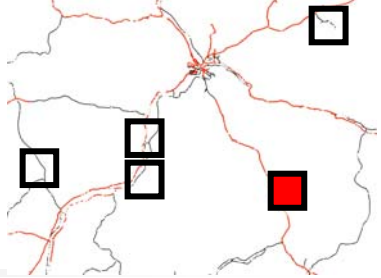


- Investigations concerning with U-bearing surficial boulders in Rogen moraine area at the beginning of 1980's
- Bedrock: Archean gneisses and granitoids



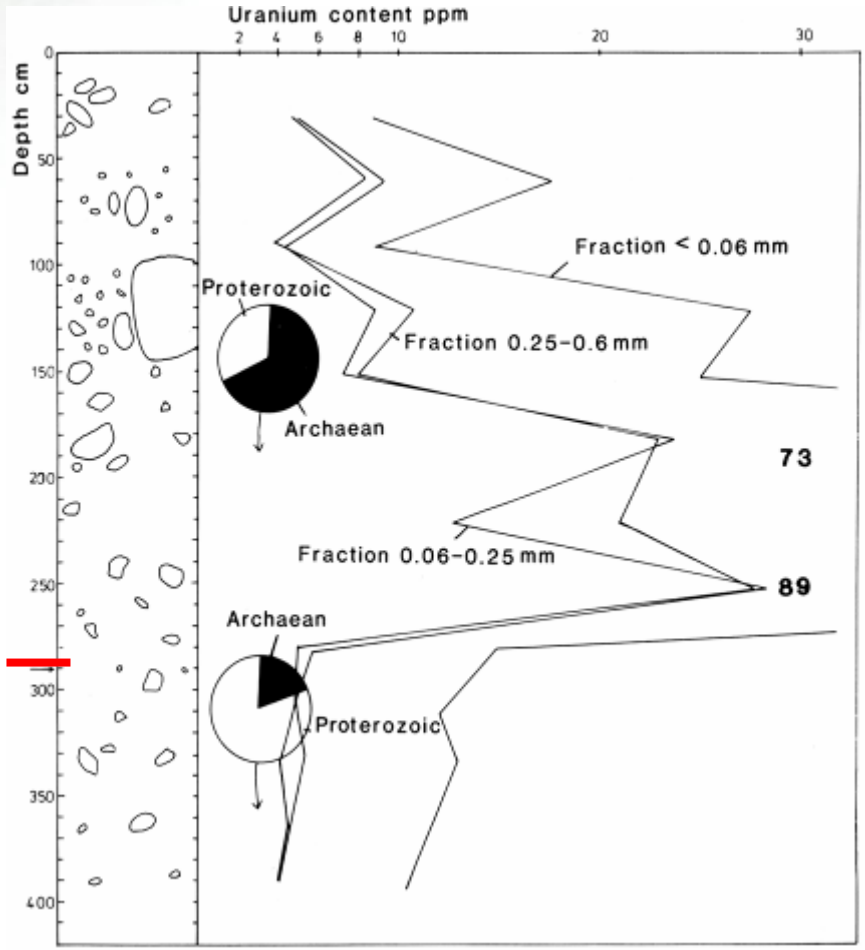

Aario & Peuraniemi 1992

# Case studies: Portimojärvi



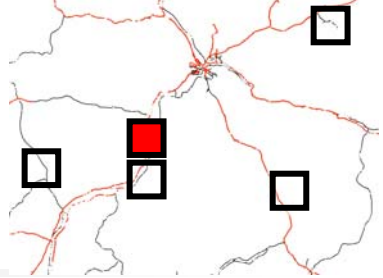
Upper till bed:
Sandy or gravelly basal till
- heterogeneous
- sandy layers and lenses
- shear structures
- large, angular (local) boulders

Lower till bed:
Sandy basal till
- homogeneous
- some lamination
- long-distance, rounded boulders

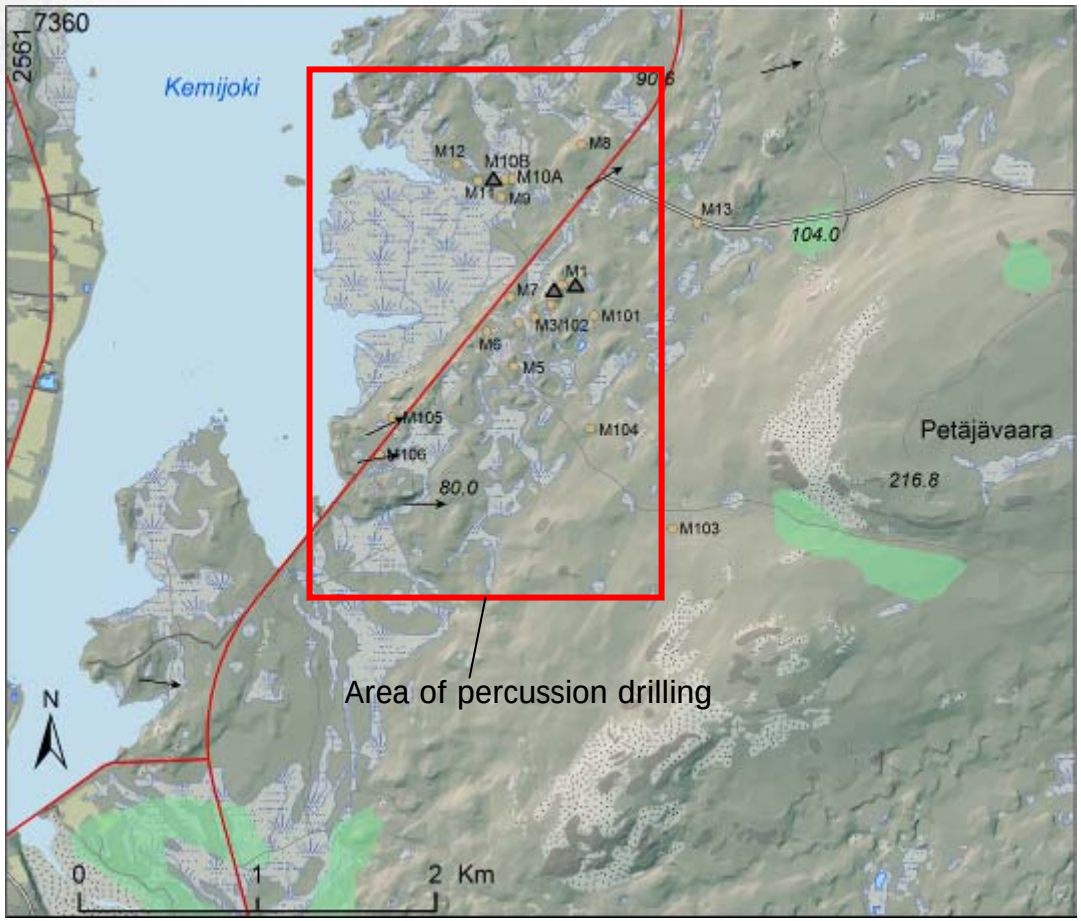



Aario & Peuraniemi 1992

# Case studies: Petäjävaara



- Investigations for Au-Cu-bearing surficial boulders in ribbed moraine area
- Bedrock: metasedimentary and metavolcanic rocks of Peräpohja Schist Belt
- Two till units representing advance and retreat phases



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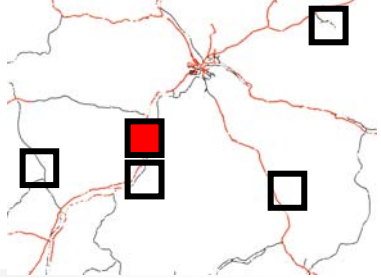
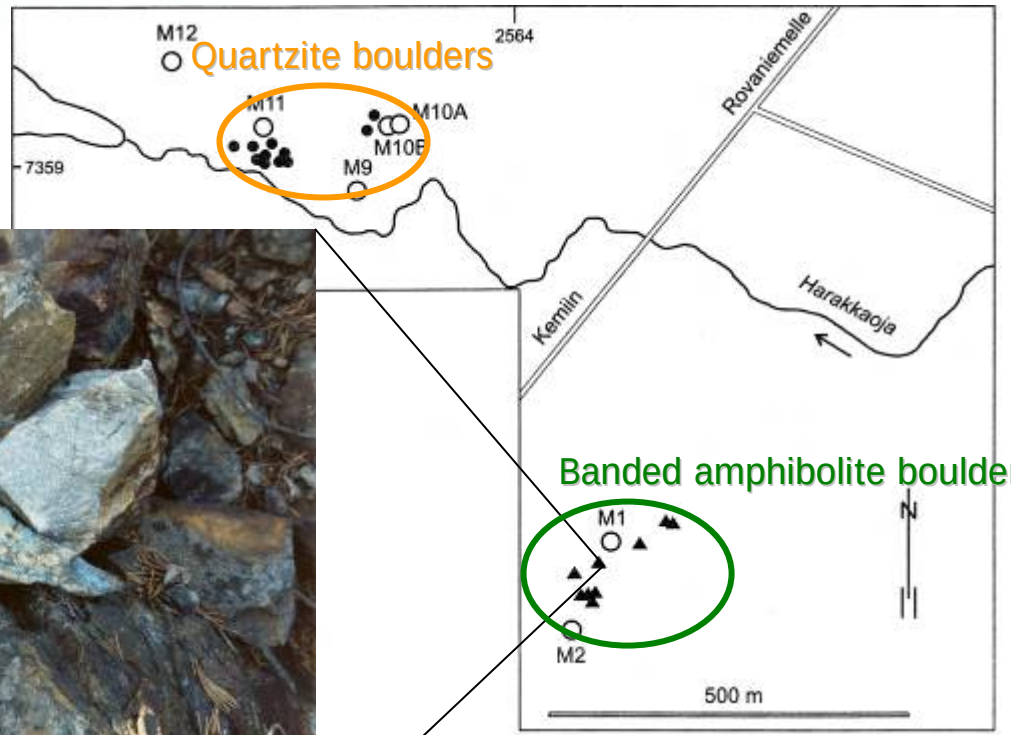


- Many hydrothermally altered Cu-Au-bearing boulders found on the top of ribbed moraine ridges

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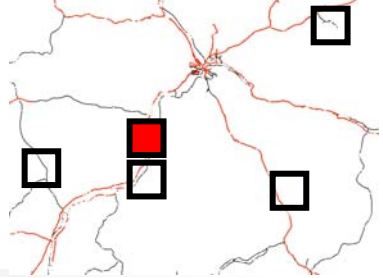
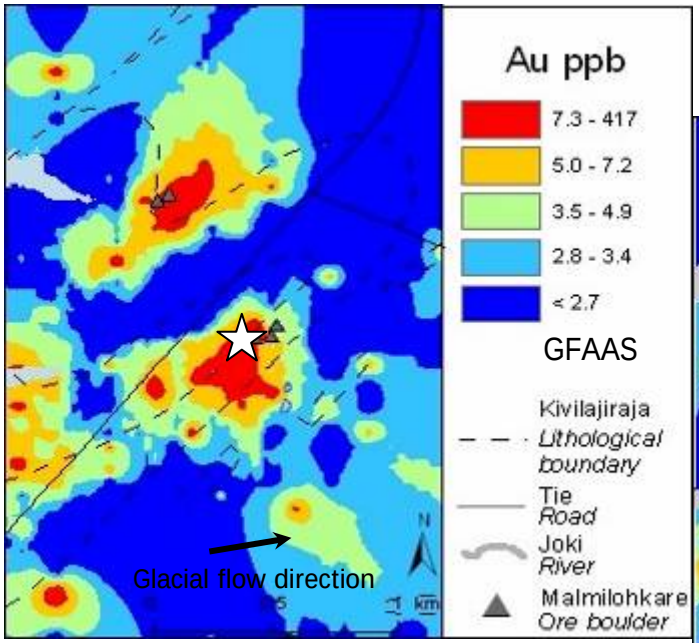
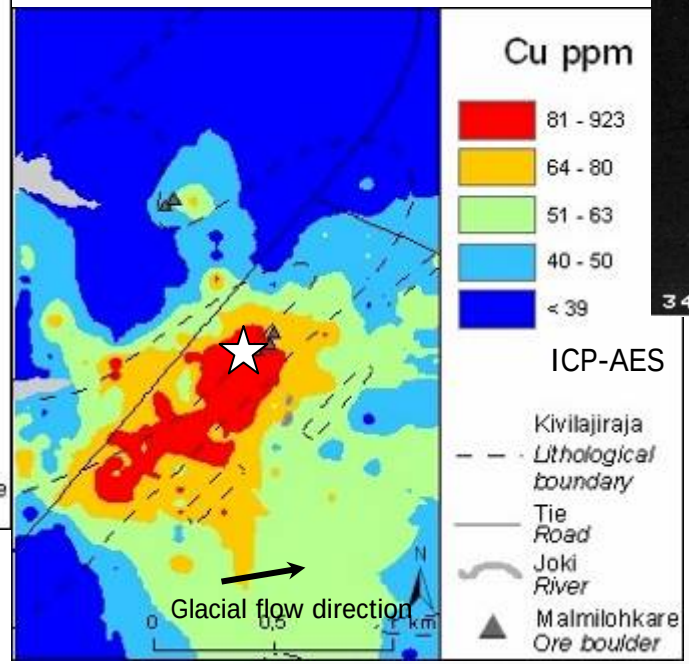
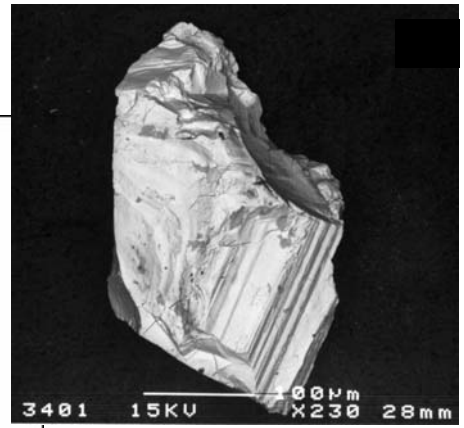


- Sampling: percussion drilling and test pits
- Distinct metal anomalies in upper till (e.g. < 0.06 mm fraction)



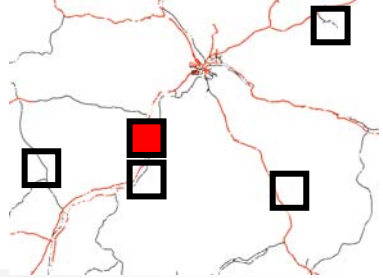

☆ Known Cu-Au mineralization



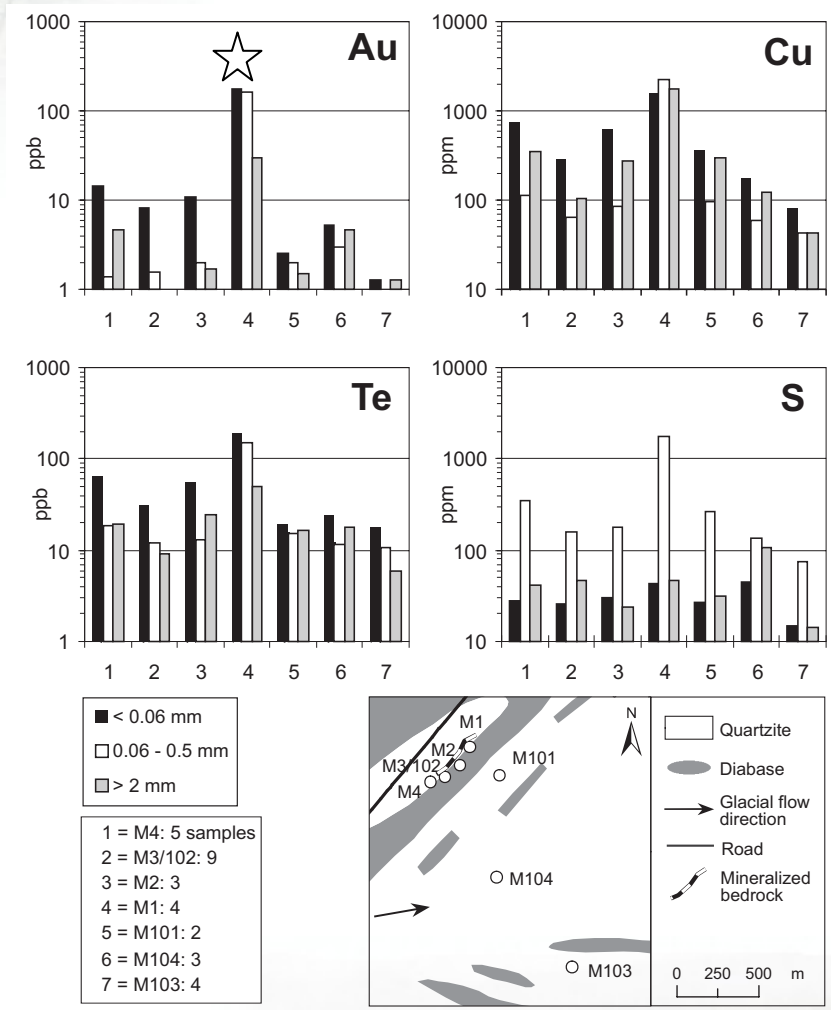

Fresh chalcopyrite grain in till (SEM photo)

# Case studies: Petäjävaara

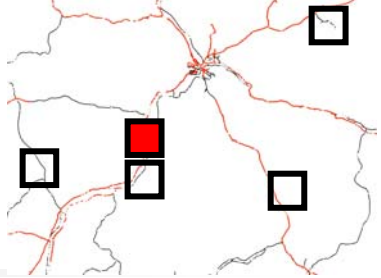


- Study of different till size fractions: < 0.06 mm, 0.06-0.5 mm and > 2 mm
- Near the source metal concentrations are high in every till size fractions
- The coarsest fraction very sensitive near the Au-mineralization

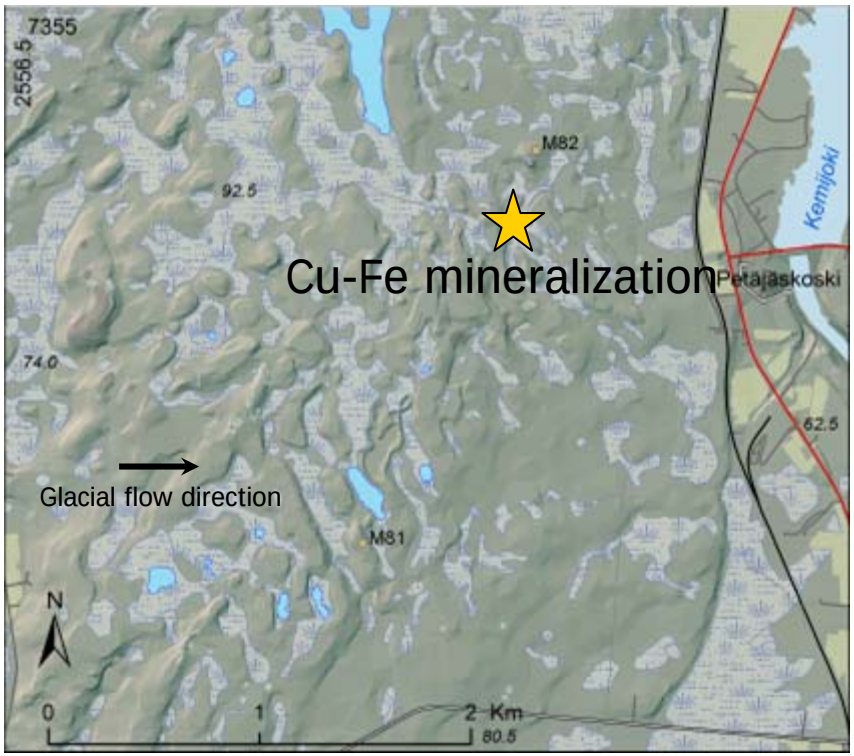
☆ Test pit next to known Cu-Au-mineralization

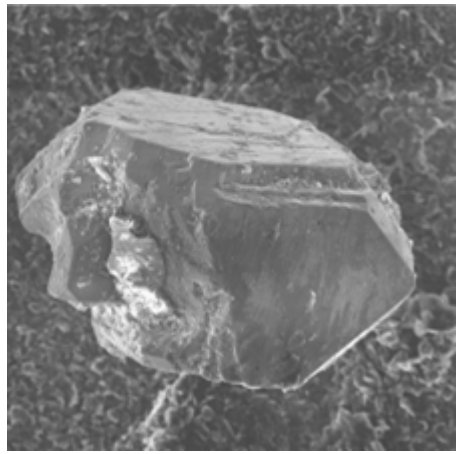


# Case studies: Petäjäskoski

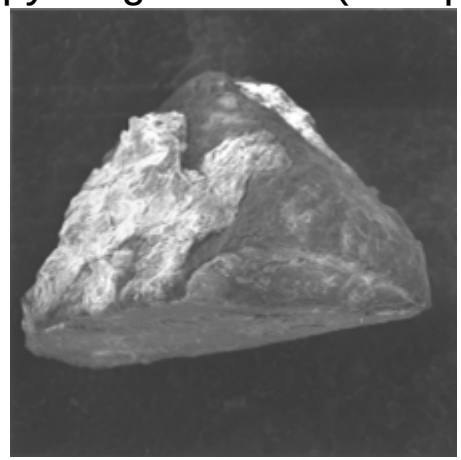


- Till geochemical exploration and heavy mineral studies relating with Cu-Fe-mineralization (Peuraniemi 1982)



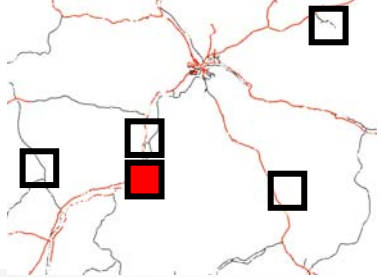



Fresh pyrite grain in till (SEM photo)

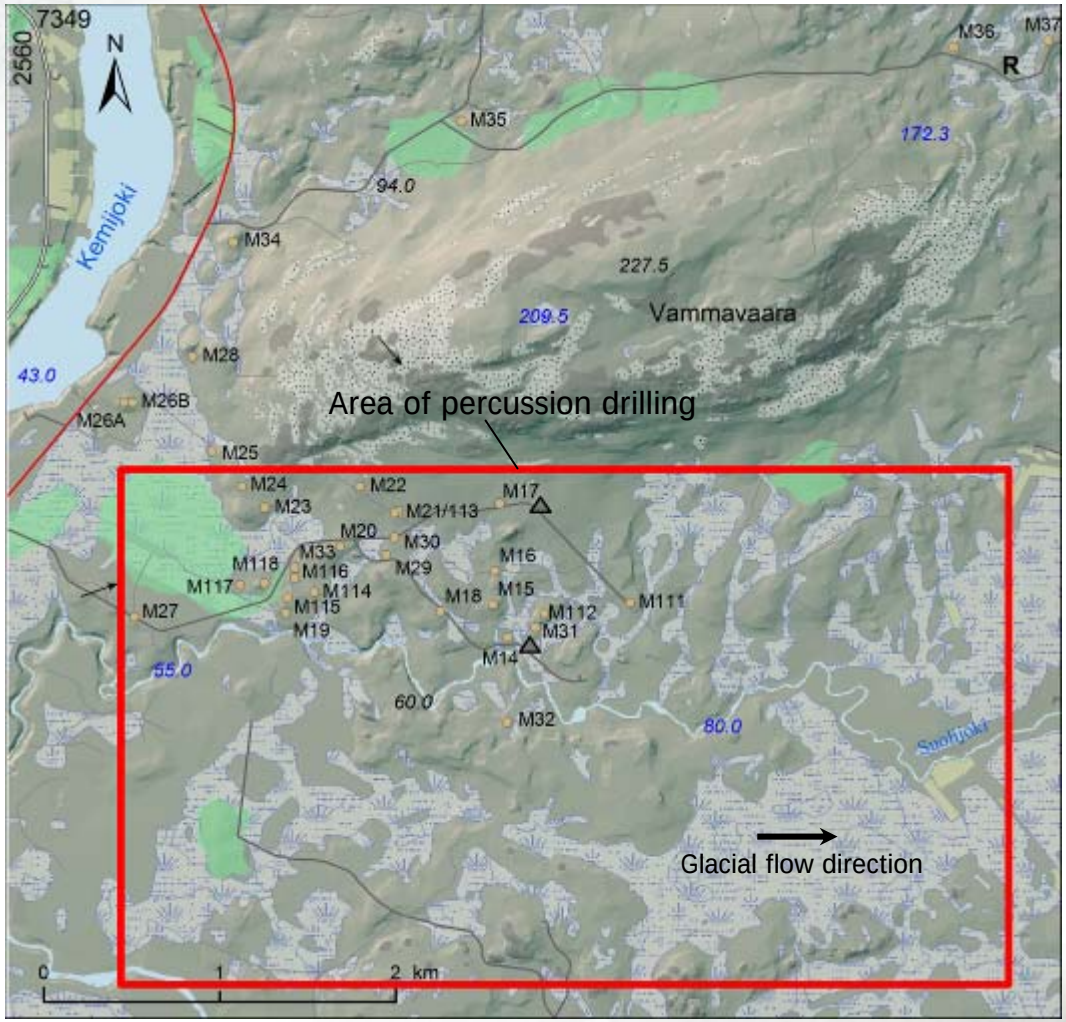


Pyrite grain with goethite alteration rim in till (SEM photo)

# Case studies: Vammavaara



- Two mineralized volcanic boulders found on the top of ribbed moraine ridges
- Bedrock: metasedimentary and metavolcanic rocks of Peräpohja Schist Belt
- Two Weichselian till beds: lower bluish grey till (330°) and upper includes grey and brownish grey till units (270°)



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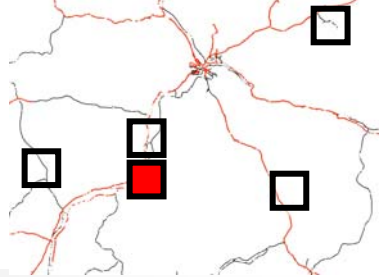
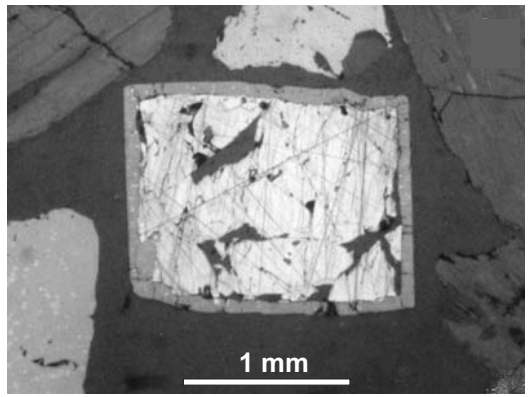
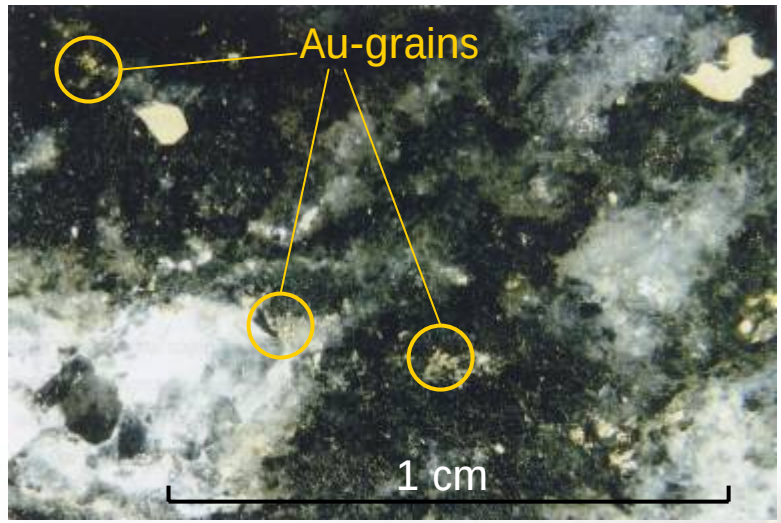


- Au-Cu-bearing, hydrothermally altered volcanic boulders
- Microscopic Au-grains in relation with pyrite grains and quartz veins




Fresh pyrite´grain in till

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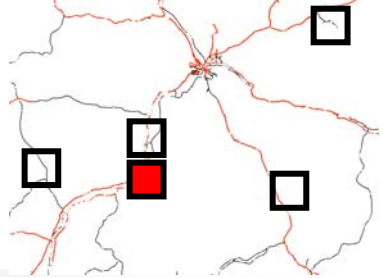
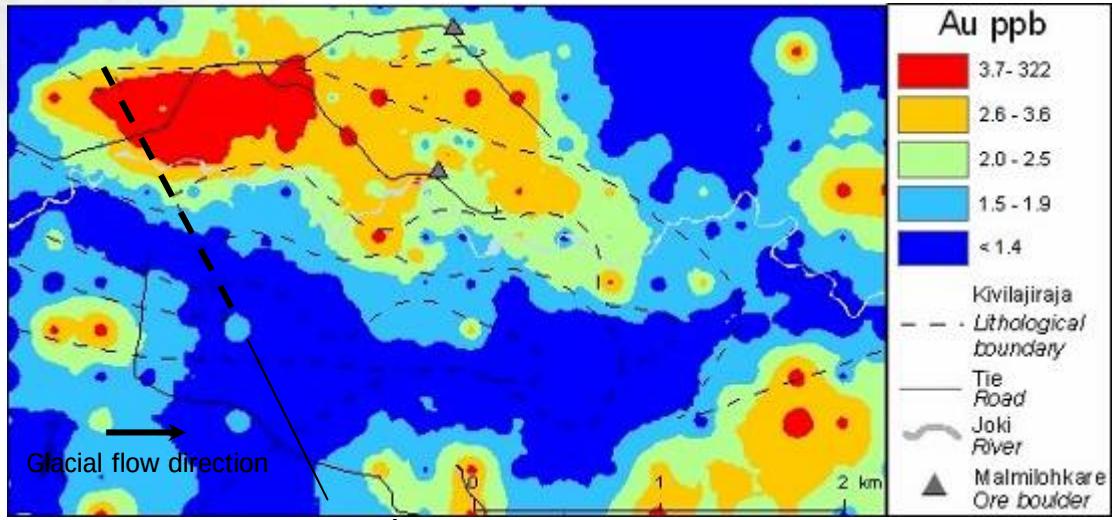
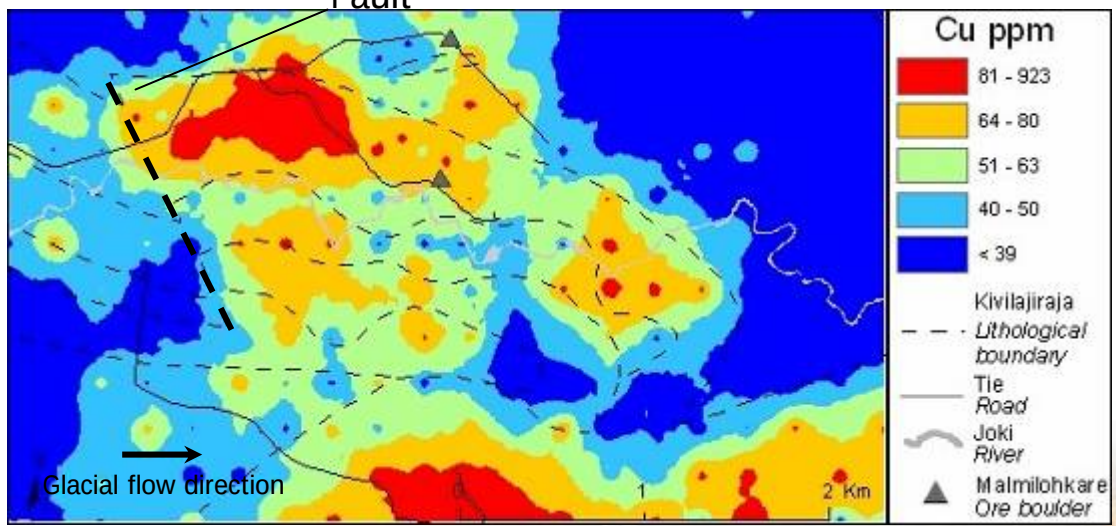


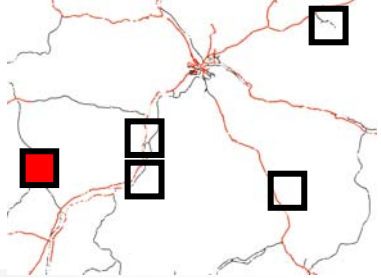
- Strong Au and Cu anomalies in upper till
- Probable source is hydrothermally altered volcanic rock related with NW-SE oriented fault in western part of sampling area
- Some deep drillings were done but the source was not found so far



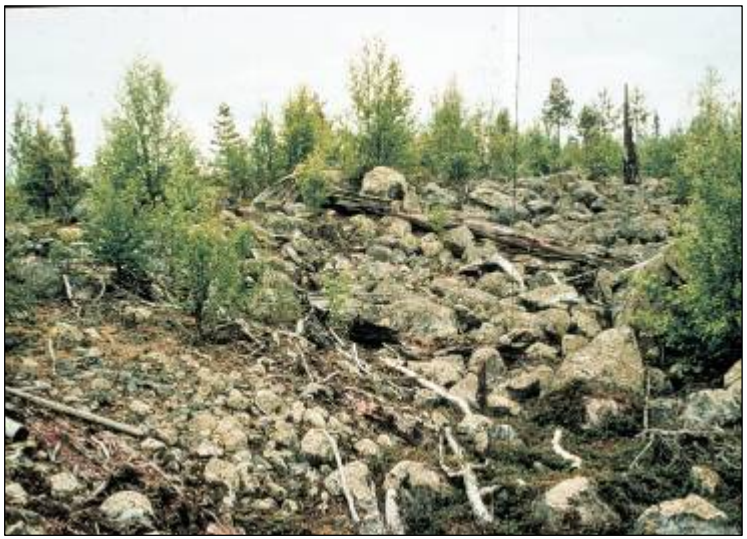

Fault



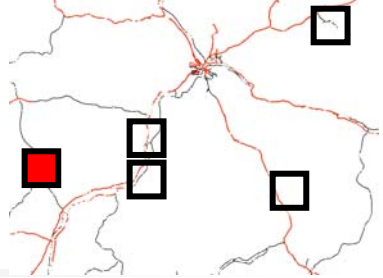
# Case studies: Sihtuuna



- Sihtuuna moraines, i.e. minor ribbed moraines (100-500 m in length, 10-50 m in width and 2-10 m in height)
- Surface covered with boulders, transport distance usually not more than 50-300 m

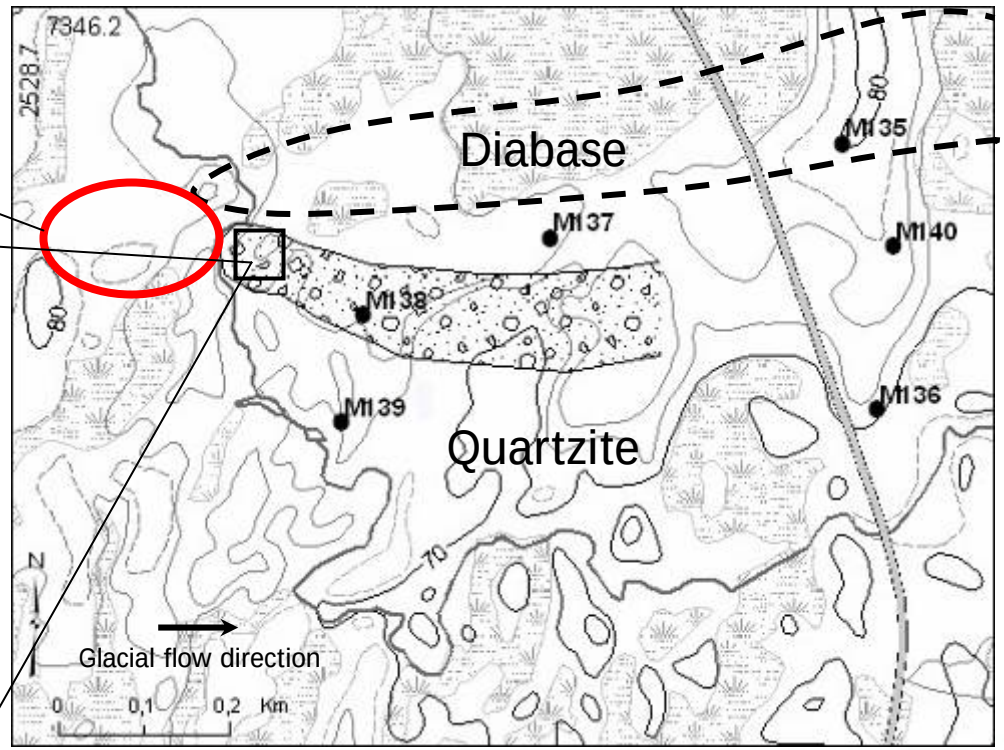


# Case studies: Sihtuuna



- Sharp W-E oriented conglomerate fan

A source for conglomerate boulders



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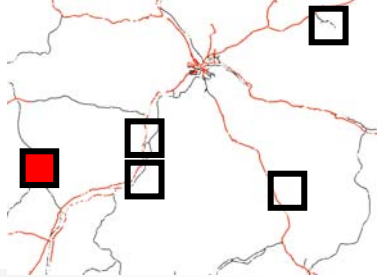
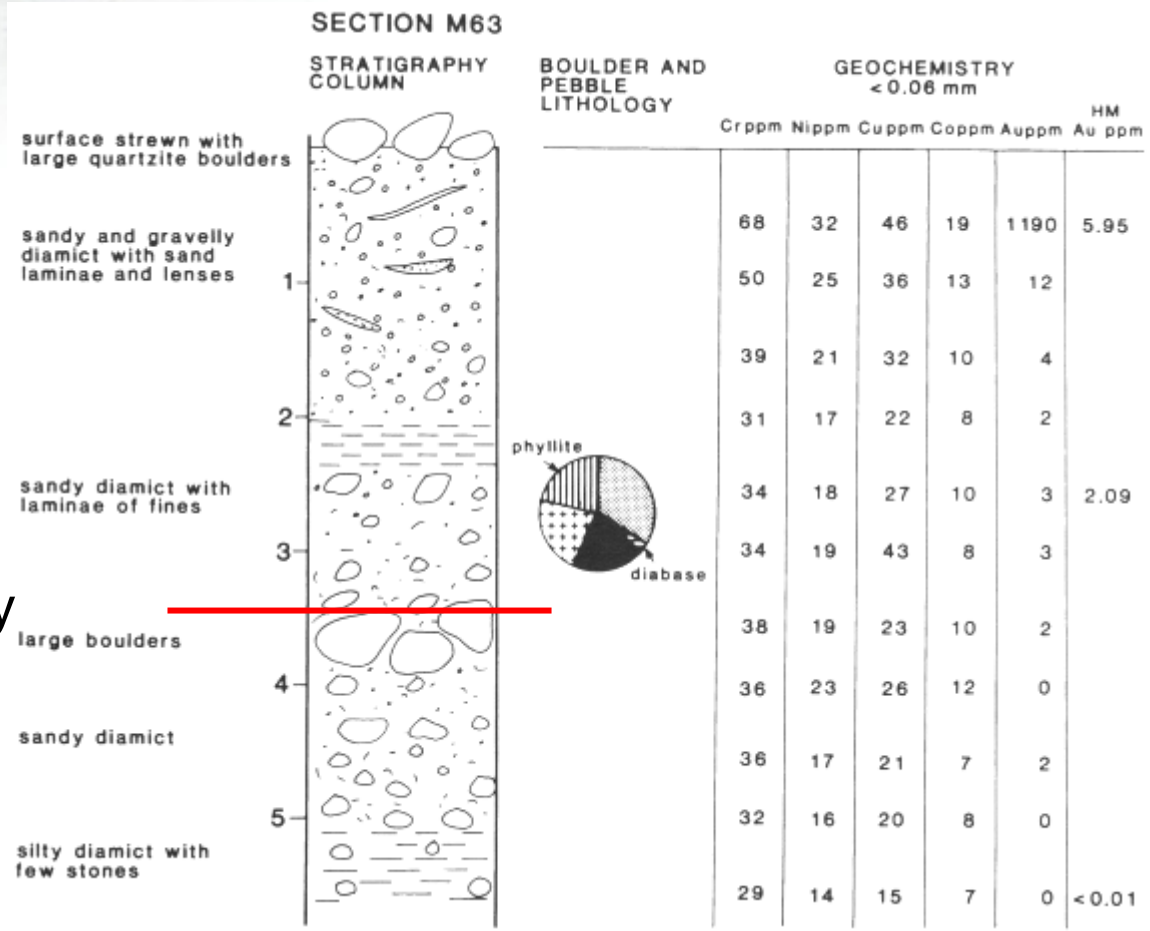
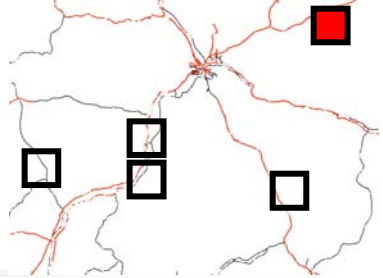


- Au-Cu-Co boulders found in the area of Sihtuuna moraines
- Bedrock: metasedimentary and metavolcanic rocks of Peräpohja Schist Belt
- Two Weichselian till beds: lower bluish grey till (330°) and upper, sandy or gravelly, brownish grey till (270°) and interstadial sand deposit between them

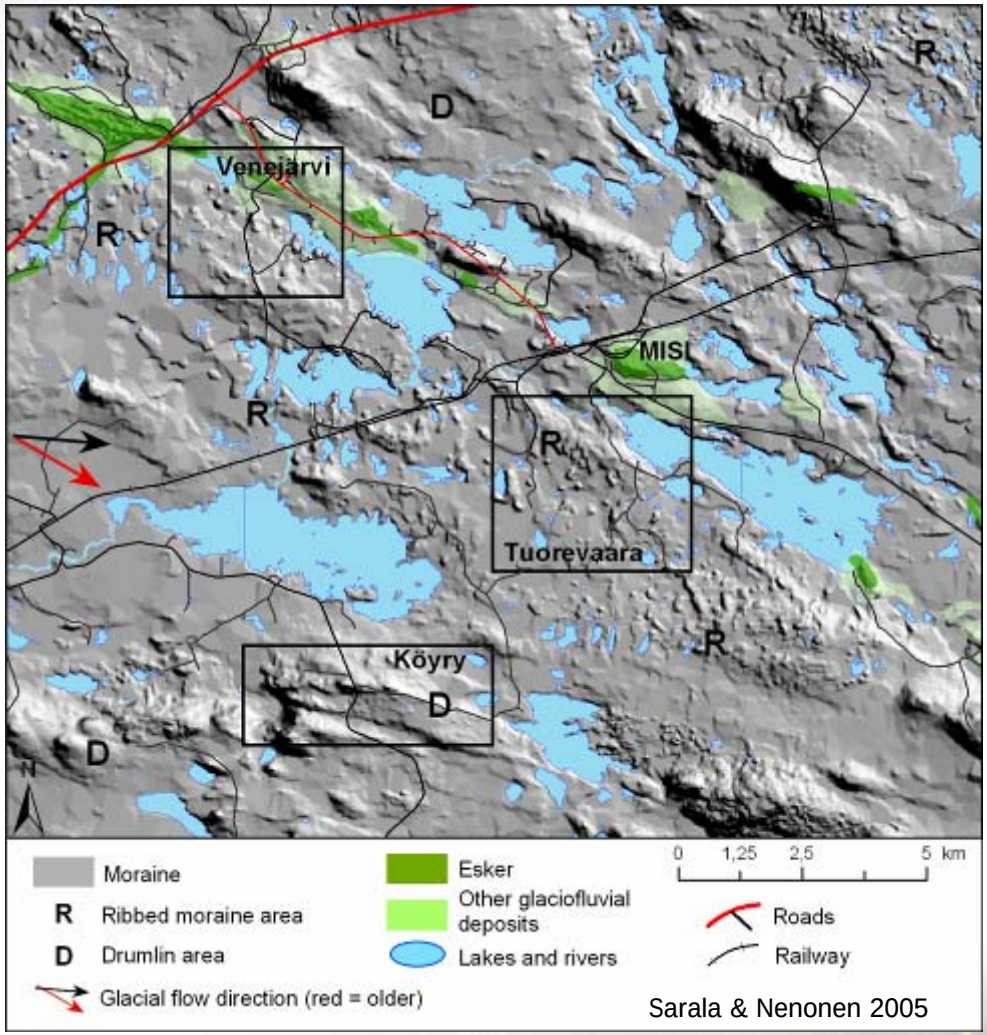



| Cr ppm | Ni ppm | Cu ppm | Co ppm | Au ppm | HM Au ppm |
|---|---|---|---|---|---|
| 68 | 32 | 46 | 19 | 1190 | 5.95 |
| 50 | 25 | 36 | 13 | 12 | |
| 39 | 21 | 32 | 10 | 4 | |
| 31 | 17 | 22 | 8 | 2 | |
| 34 | 18 | 27 | 10 | 3 | 2.09 |
| 34 | 19 | 43 | 8 | 3 | |
| 38 | 19 | 23 | 10 | 2 | |
| 36 | 23 | 26 | 12 | 0 | |
| 36 | 17 | 21 | 7 | 2 | |
| 32 | 16 | 20 | 8 | 0 | |
| 29 | 14 | 15 | 7 | 0 | < 0.01 |

# Case studies: Misi



- Latest studies for tracing the origin of Au-Cu- and Zn-bearing boulders
- Bedrock: metasedimentary and metavolcanic rocks of Peräpohja Schist Belt, granites on northern part
- Two Weichselian glacial flow phases: older (330°) and younger (270°-280°)



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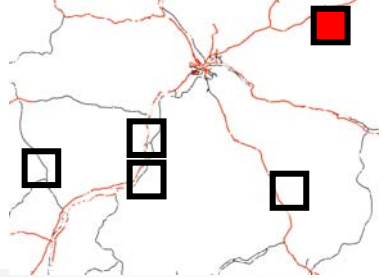


Test pit M5 (2005)

Upper till unit
-heterogeneous
-almost gravelly matrix
-local, angular pebbles

Lower till unit
-homogeneous
-far-travelled, rounded pebbles

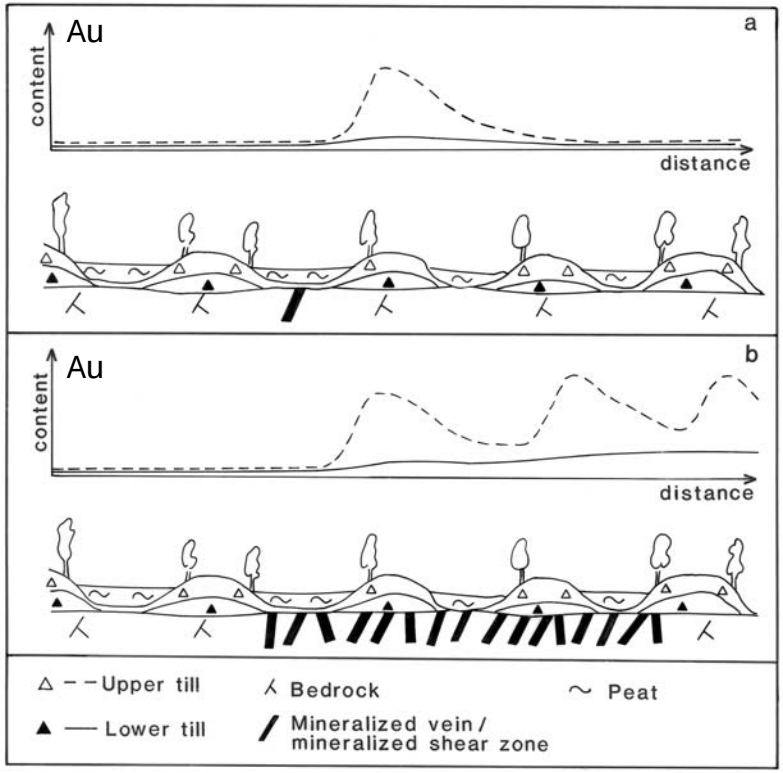
| Depth m | As ppm | Cu ppm | Au ppb |
|---|---|---|---|
| 1.0 | 9 | 39 | 1.2 |
| 1.5 | 9 | 54 | 3.3 |
| 2.0 | 5 | 40 | 4.6 |
| 2.5 | 4 | 27 | 1.0 |
| 3.0 | 4 | 27 | 2.0 |

# Prospecting strategy in ribbed moraines

- Generalized model of the distribution of Au in till in the ribbed moraine ridges, where two till units are present and:

a) one Au-rich vein with clear peak in upper till or,

b) larger Au-rich shear zone with several veins and clear indication in upper till but also increased contents in lower till




Sarala & Rossi 2000

# Conclusions

- The features of the upper till unit of ribbed moraines and the surficial boulders strongly indicate the variation of underlying bedrock that is clearly evident in both horizontal and vertical dimensions of the till cover
- Short glacial transport distance of the till is seen in a sharp and anomalous dispersal of Au and its pathfinder elements. Specifically, boulders on the surface and in the upper till represent the local, quarrying activity of the ice during the deposition of ribbed moraine
- Ore indicators – mineralized boulders, metal-rich till and sulphide indicator (heavy) minerals in ribbed moraine fields are useful indicators of mineralized bedrock
- The study of moraine formations, glacial flow directions, till structures and stratigraphy of moraine formations is essential before analysing the results of the till sampling and successing in till geochemical prospecting in glaciated terrain

# Thank you!

Northern lights i.e. Aurora borealis in the Finnish winter sky