



Aalto University  
School of Engineering

# Evidence for long-term pollution from mine sites in lake sediment records in the Haveri and Ylöjärvi mine sites, SW Finland

**Annika Parviainen**, Aalto University School of Engineering

**Tommi Kauppila** and **Kirsti Loukola-Ruskeeniemi**,  
Geological Survey of Finland



IAGS 21-26.8.2011  
Rovaniemi, Finland

Annika Parviainen  
annika.parviainen@aalto.fi

26.8.2011

# Introduction

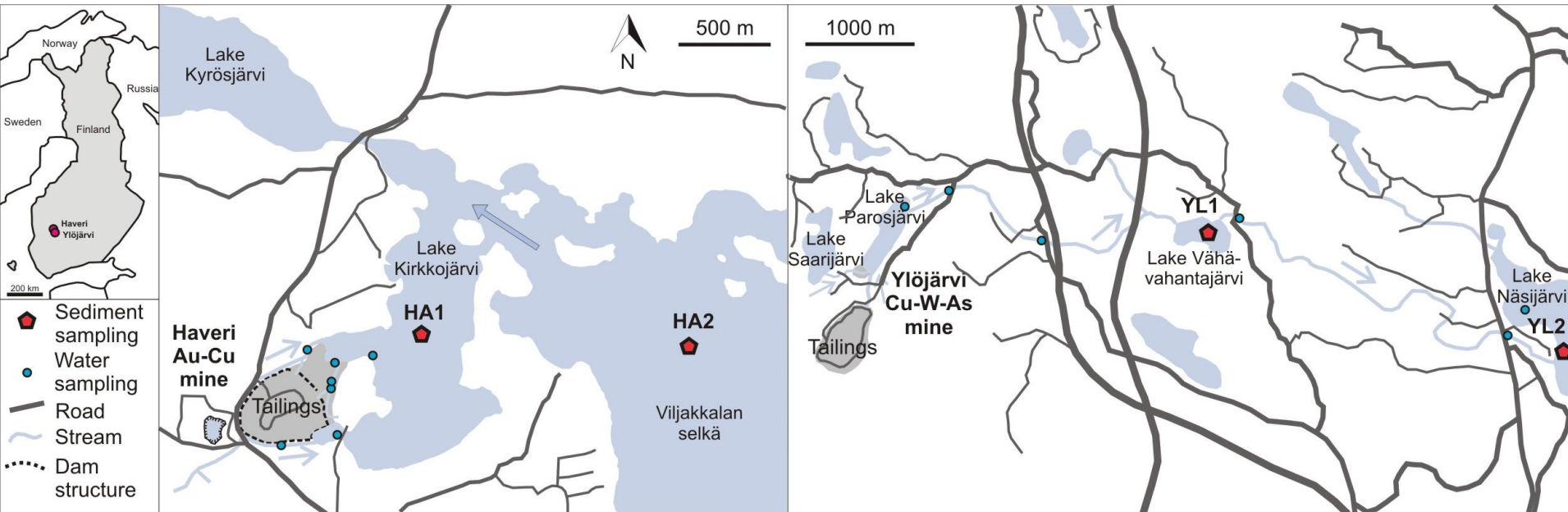
- Mining-derived metal(oid) drainage
  - During active mining (ore processing, waste management, ore deposit characteristics etc.)
  - After ceasing (sulfide oxidation, acid mine drainage, attenuation, remediation measures)
  - Old mine legacy (uncontained tailings and lack of remediation)
- Lake sediment records
  - Sink of pollutants transported by surface waters
  - Age dating by radionuclides,  $^{137}\text{Cs}$
  - Can help reconstruct the history of events in a mine site and estimate metal loading in surface waters during and after mining



# Site description and sampling

## Haveri Au-Cu mine 1942-1961

## Ylöjärvi Cu-W-As mine 1943-1966



# Site description and sampling

## Haveri Au-Cu mine 1942-1961

- Cyprus-type volcanogenic massive sulfide; pyrrhotite ( $\text{Fe}_{1-x}\text{S}$ ), chalcopyrite ( $\text{CuFeS}_2$ ) and pyrite ( $\text{FeS}_2$ )
- Low sulfide (av. 3 wt.%) and low carbonate content
- 1.5 Mt tailings  $\rightarrow$  18.4 ha
- Cu froth flotation, Au cyanide leach (since 1948)

## Ylöjärvi Cu-W-As mine 1943-1966

- Tourmaline breccia; pyrrhotite, chalcopyrite, arsenopyrite ( $\text{FeAsS}$ ), and scheelite ( $\text{CaWO}_4$ )
- Low sulfide ( $\sim$ 1 wt.%) and low carbonate content
- 4 Mt tailings  $\rightarrow$  4 and 17 ha
- Cu froth flotation,  $\text{WO}_3$  and As by flotation (during 13 and 5 years, respectively)

# Site description and sampling

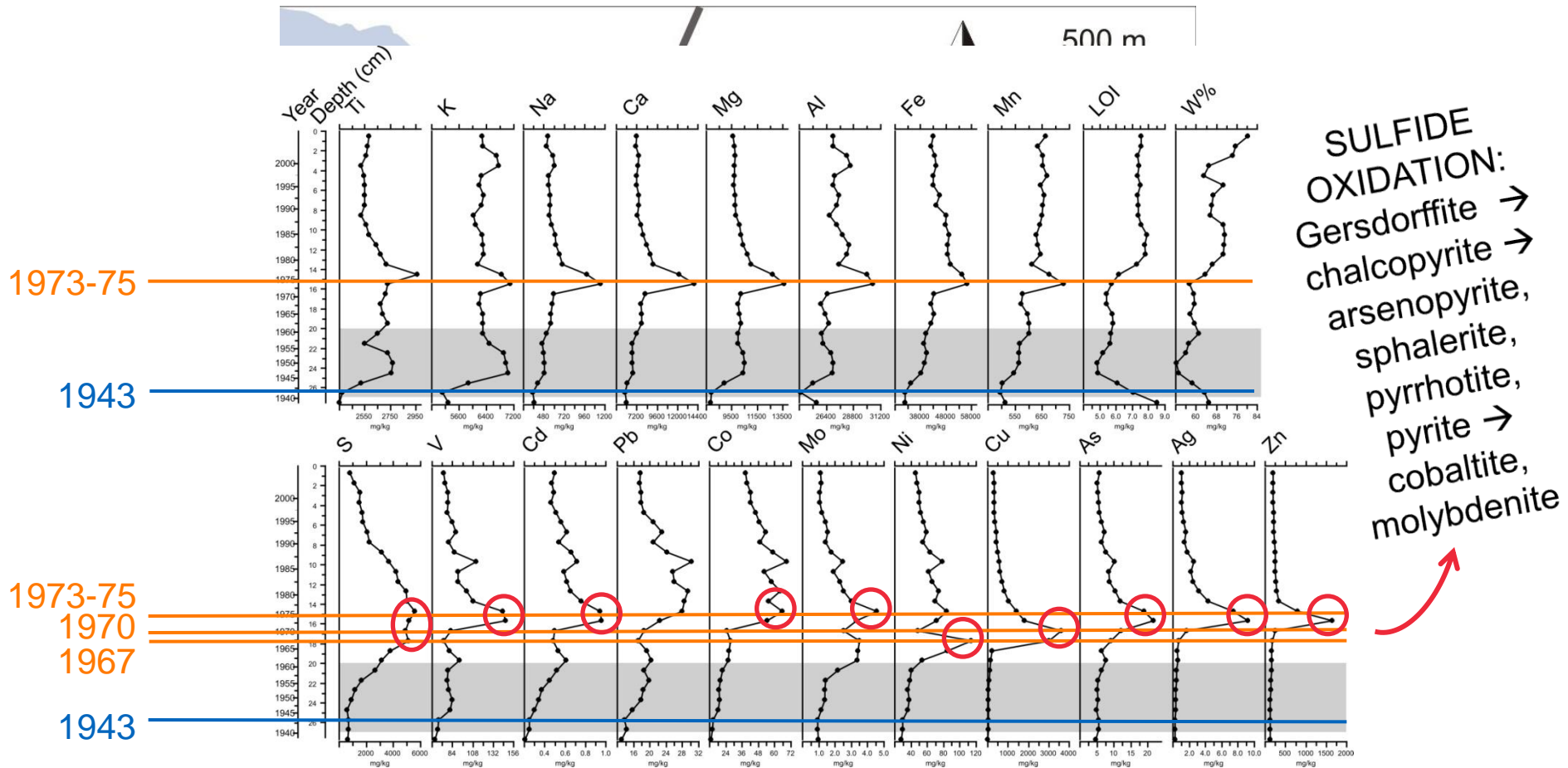
- Two lake sediment samples from recipient lakes using a Kajak-type gravity corer in March 2005 and 2006
- Geochemistry and  $^{137}\text{Cs}$  age dating

- HA1 and HA2 at Haveri
- YL1 and YL2 at Ylöjärvi



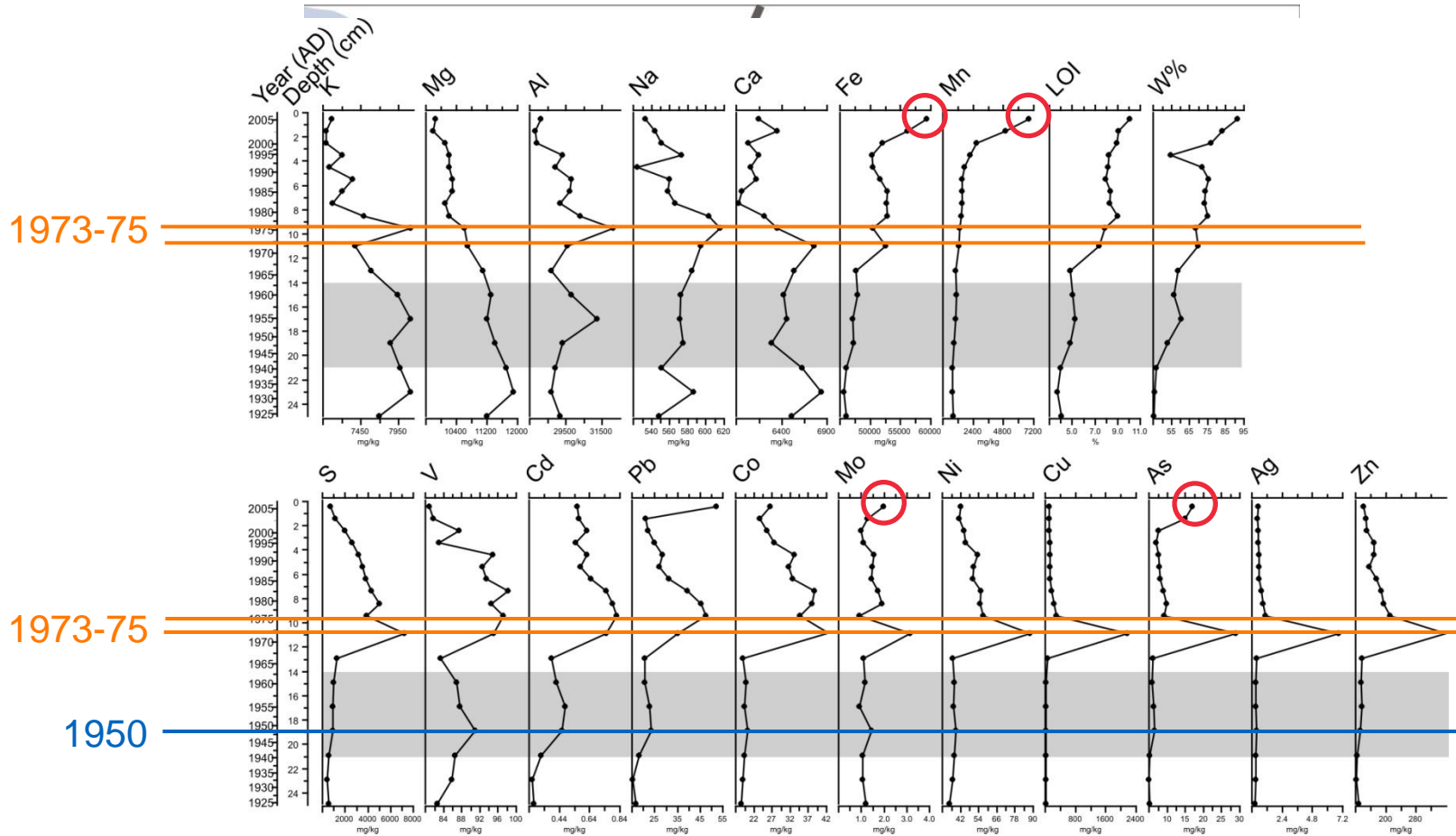
# Results

## HA1, 1km from Haveri mine



# Results

## HA2, 2,3km from Haveri mine



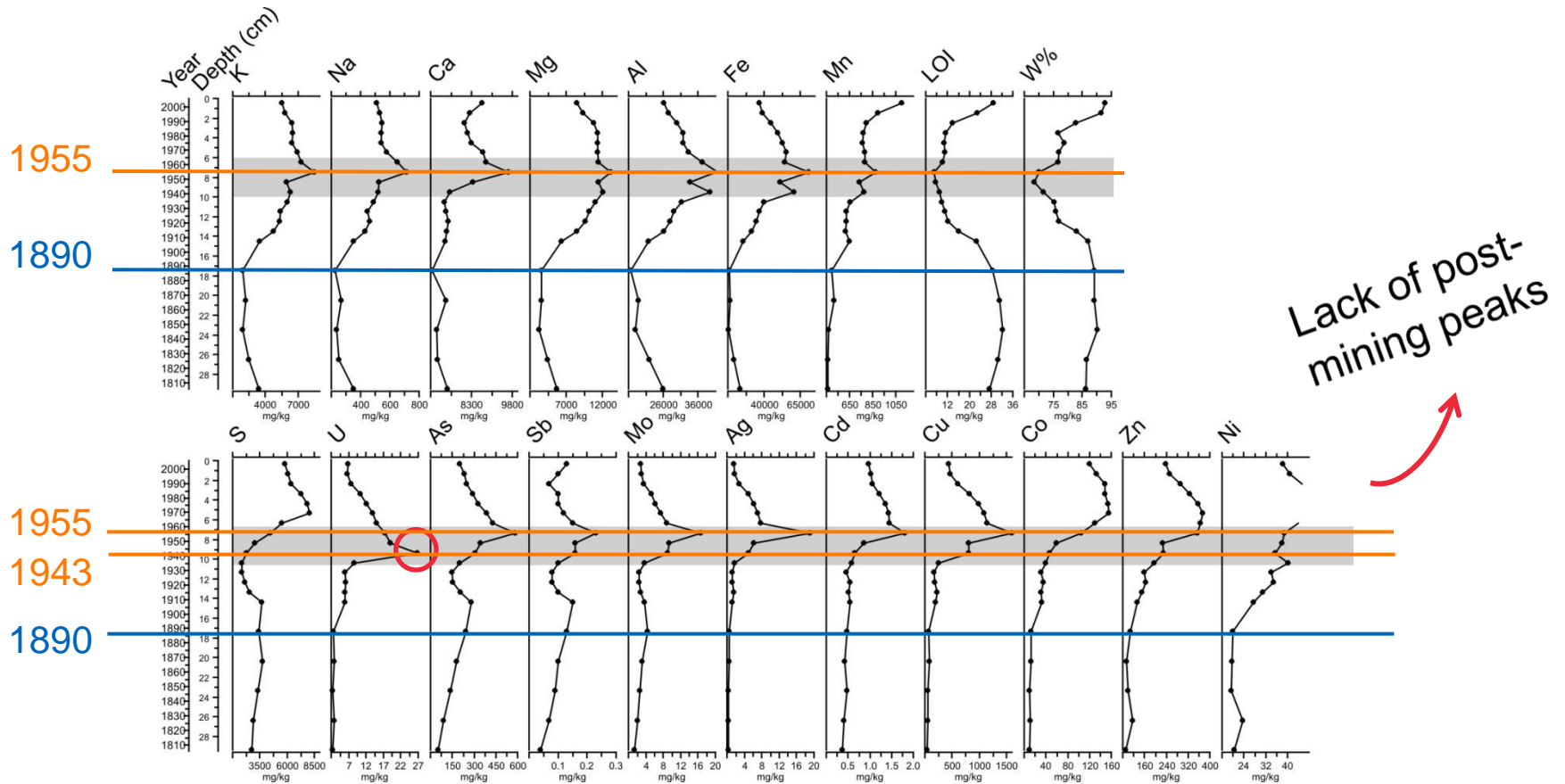
# Summary of the results

## Haveri

- Small contemporary impact, yet **6-fold Cu** concentrations
- Start of cyanide leach was not detected in lake sediment profiles – As, Ni, Co and Zn (reagent)
- Clear after-mining peaks due to sulfide oxidation →AMD. S and Fe exhibited spread peak
- In recent sediments As, Cd, Fe, Mo, Ni, U, S and Zn exhibit 1.2 - 2.3 fold concentrations, while Ag, Co and **Cu** present 4.5, 3 and **17-fold** values, respectively

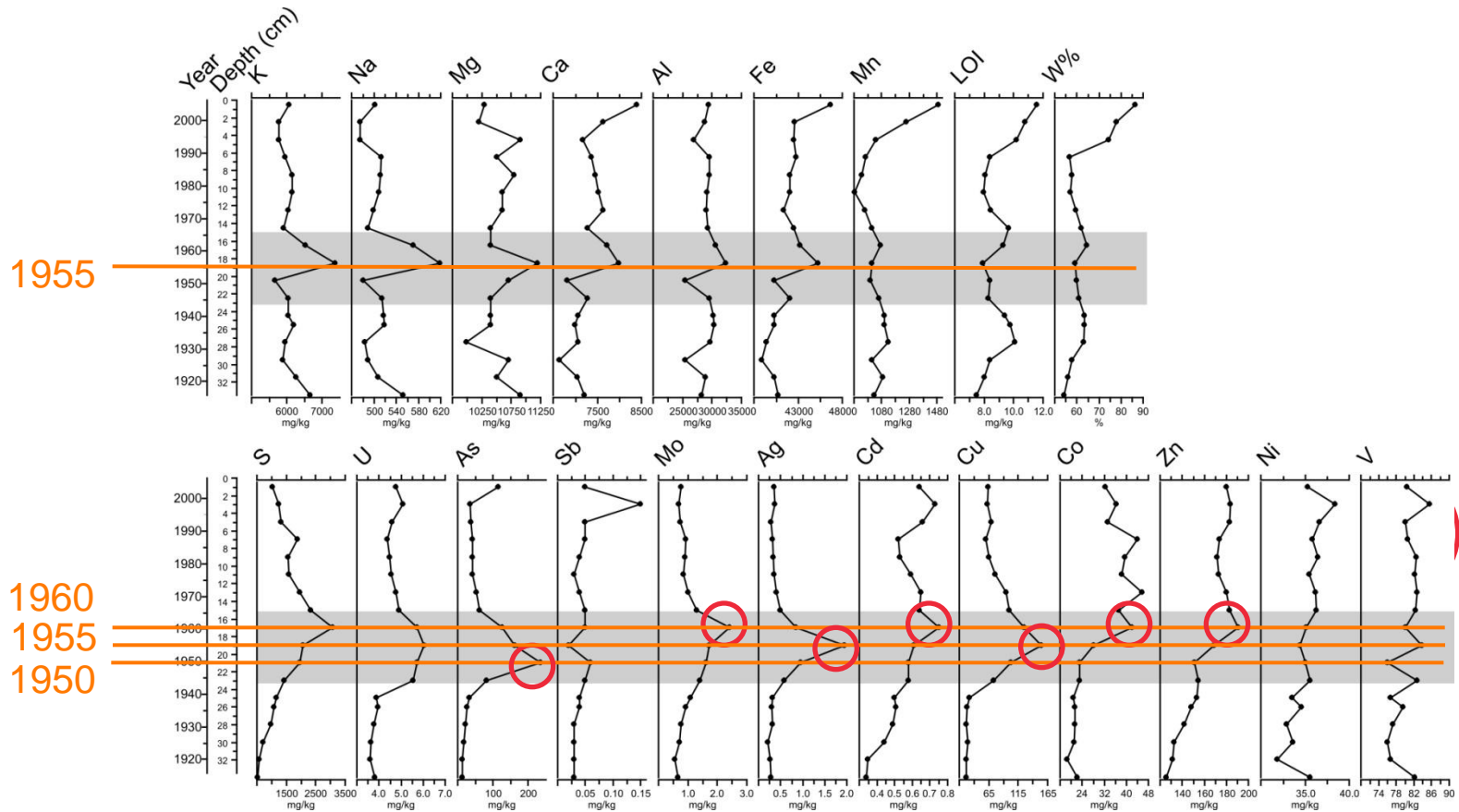
# Results

## YL1, 3km from Ylöjärvi mine



# Results

## YL2, 7km from Ylöjärvi mine



# Summary of the results

# Ylöjärvi

- Anthropogenic impact since late 19<sup>th</sup> century
- Contemporary peaks in mid 1950's coincide with the disposal of waste waters in an outlet of Lake Parosjärvi
- Post-mining metal inputs (Cd, Co, Fe, Ni, Zn and S) but NO post-mining peaks
- Elevated concentration in recent sediments (**Cu 10-fold**)

# Conclusions

- In metal-enriched catchment metal(oid)s may be mobilized by other land uses, *e.g.* agriculture
- **Cu** was the principal mine-derived metal
- Metal loading on lake sediments derived from mining depends on ore processing, waste management, catchment, natural attenuation
- Attenuating processes mitigate metal loading in recent lake sediments: downward moving oxidation front and consequent low-quality plume, secondary Fe(III) minerals (Parviainen, 2009; Placencia-Gómez *et al.*, 2010)

# THANK YOU!

## Acknowledgements

- This study was funded by the Finnish Graduate School in Geology and the EU LIFE-Environment project RAMAS (focused on risk assessment and risk management procedures for arsenic in the Tampere region, Finland).

## References

- Placencia-Gómez, E., Parviainen, A., Hokkanen, T. and Loukola-Ruskeeniemi, K., 2010. Integrated geophysical and geochemical study on AMD generation at the Haveri Au-Cu mine tailings, SW Finland. Environmental Earth Sciences, Volume 61 (7), 1435-1447.
- Parviainen, A. 2009. Tailings mineralogy and geochemistry at the abandoned Haveri Au-Cu mine, SW Finland. Mine Water and Environment, 28(4), 291-304.