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# Depth of sulfidic materials: challenge to sustainable management

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# Drainage exposes sulfidic materials to oxidation

Installation of subsurface drainage pipe within sulfidic materials

Photo: Raija Suomela

- Required drainage efficiency dependent on land use
- If deep drainage required, sulfidic materials are more vulnerable
- Drainage water quality is affected by the depth of sulfidic materials

# Different landscape positions and land uses of acid sulfate (AS) soils of Finland

- Forested (potential) AS soils
  - sometimes drained with shallow  open ditches
- Recently emerged meadows and fields next to the sea
- Agricultural land drained to rivers
  - drained with subsurface pipes at 100 – 120 cm
- Peatlands, partly used for peat mining
  - removal of peat exposes sulfidic materials to oxidation

# Reedy coast with sulfidic sediments in Helsinki

**New sulfidic sediments emerging from the sea. Isostatic rebound 5-10 mm/yr.**

Photos: Seija Virtanen

**Reedy areas, meadows and fields bordering to the sea**

# A Histic Sulfaquent from Helsinki at sea level

| Horizon | Depth cm | pH fresh ated | pH incub- | Total S % |
|---|---|---|---|---|
| Oi | 0-20 | 4.8 | 3.6 | 1.4 |
| Cg1 | 20-30 | 6.5 | 3.9 | 1.8 |
| Cg2 | 30-40 | 7.1 | 3.0 | 0.9 |

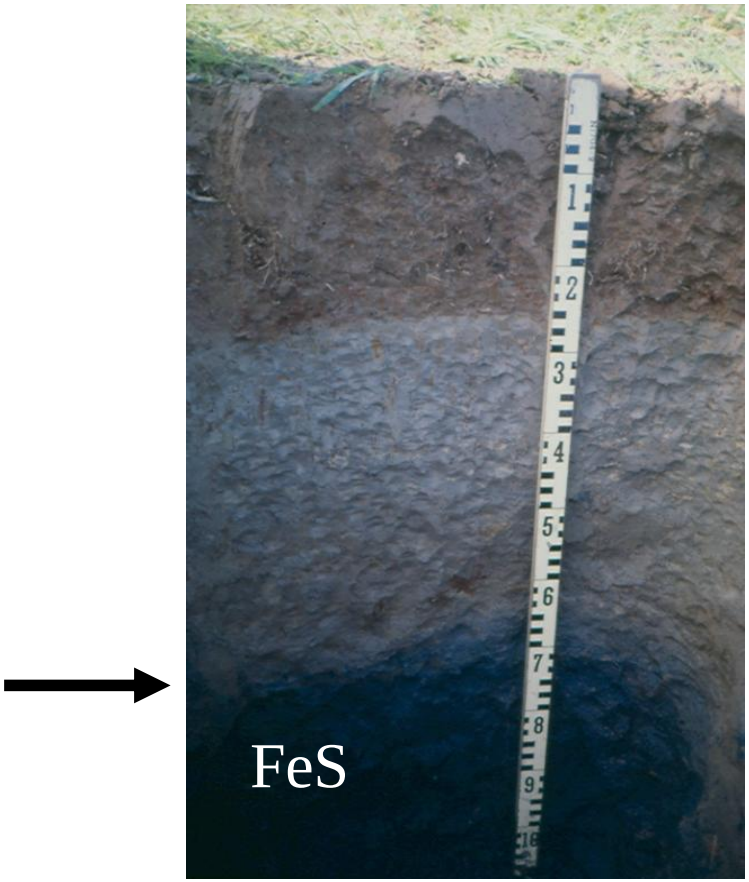
- Sulfide is very close to the soil surface.
- Acidic drainage waters go directly to the sea.
- Effective dilution of acidity
- Environmental problems not probable

# AS soils in agricultural use are effectively drained

- In certain landscapes AS constitute a major part of the fields
- Acidic drainage waters are **concentrated** in the river
- Environmental problems probable

Photo: Pertti Sevola

# What is the common depth of sulfidic materials in agricultural AS soils of Finland?




Liminka: sulfide at 65 cm

Sulfic Cryaquepts

Mustasaari: sulfide at 110 cm

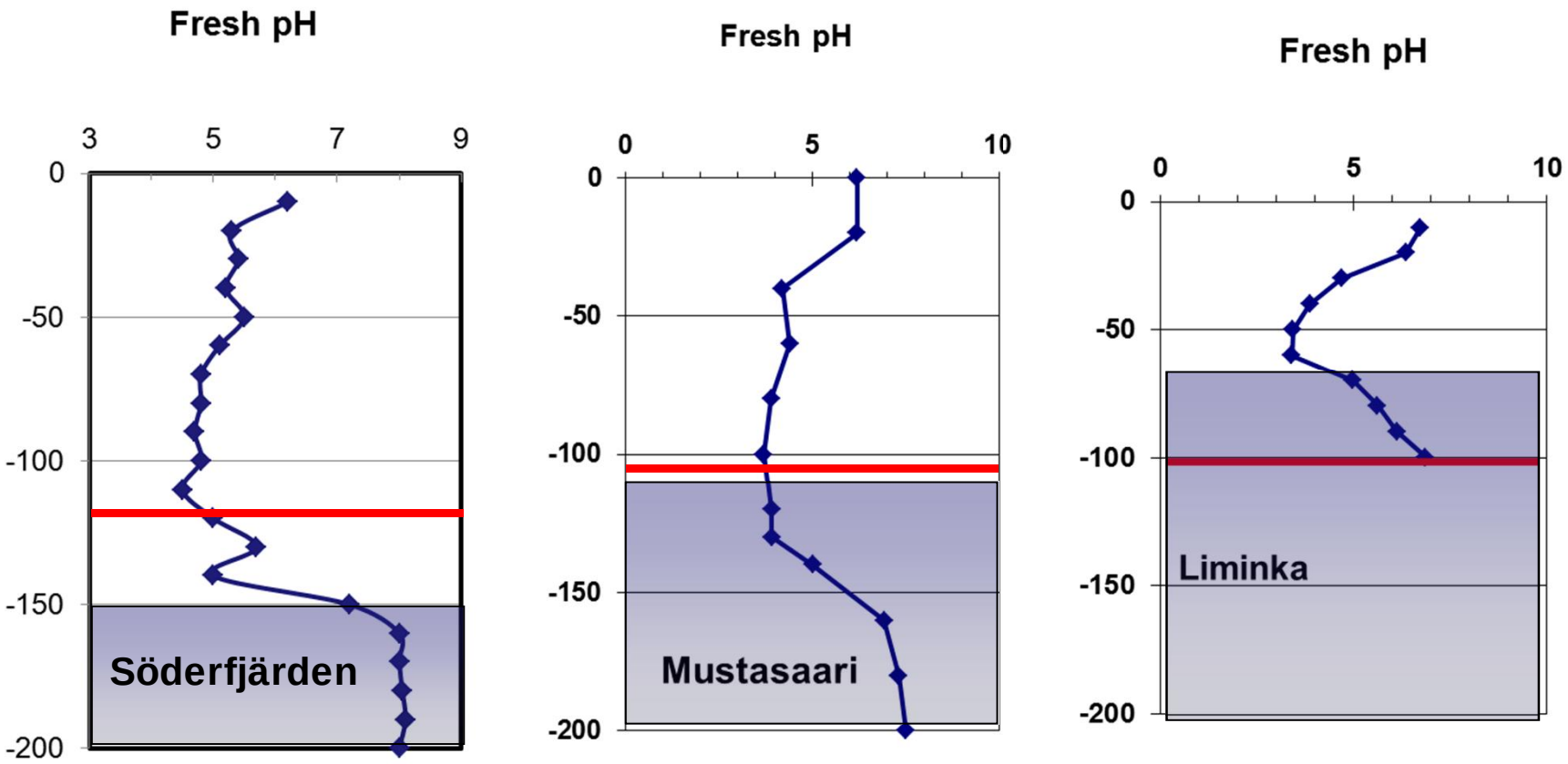
Sulfic Cryaquepts

Sulfic Cryaquepts

**Söderfjärden: sulfide at 150 cm**

**Ylistaro: sulfide at 220 cm**

# Sulfidic materials in relation to drainage pipes




= drainage pipes

= sulfidic materials

# Different soils - different drainage waters

| Charact-eristic | Treshold in river water | Söder-fjärden 1) **S: 150 cm** | Musta-saari 2) **S: 110 cm** | Liminka 3) **S: 65 cm** |
|---|---|---|---|---|
| Acidity, mmol/l | 0.3 | 2.5 | 11.5 | 18.0 |
| pH | 5.5 | 4.0 | 3.8 | 3.5 |

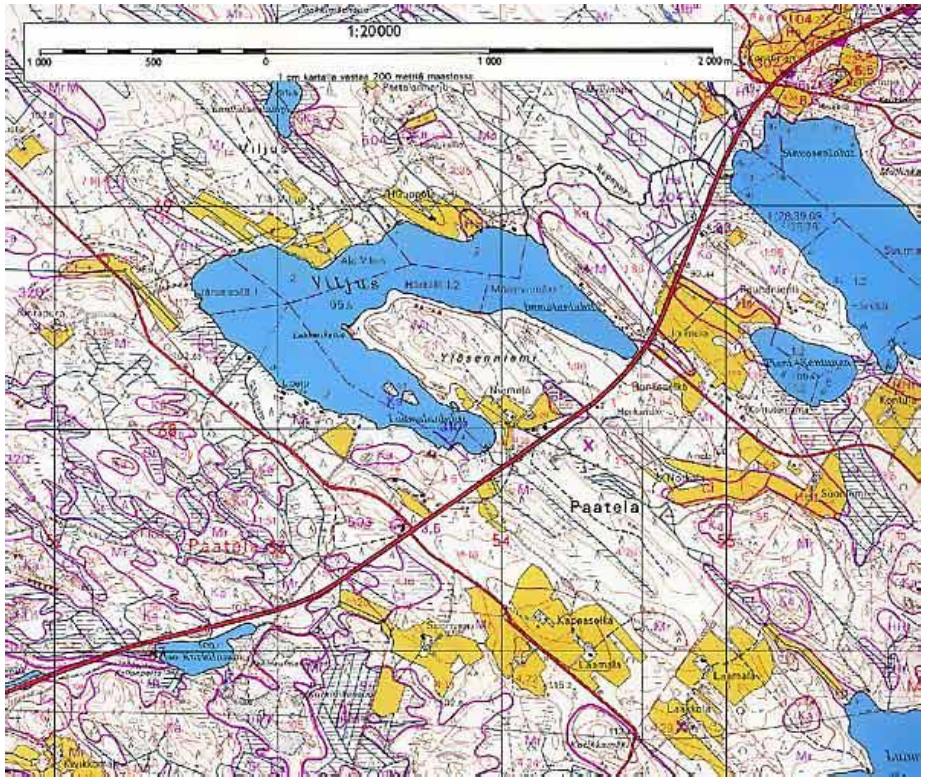
**1) CATERMASS project**

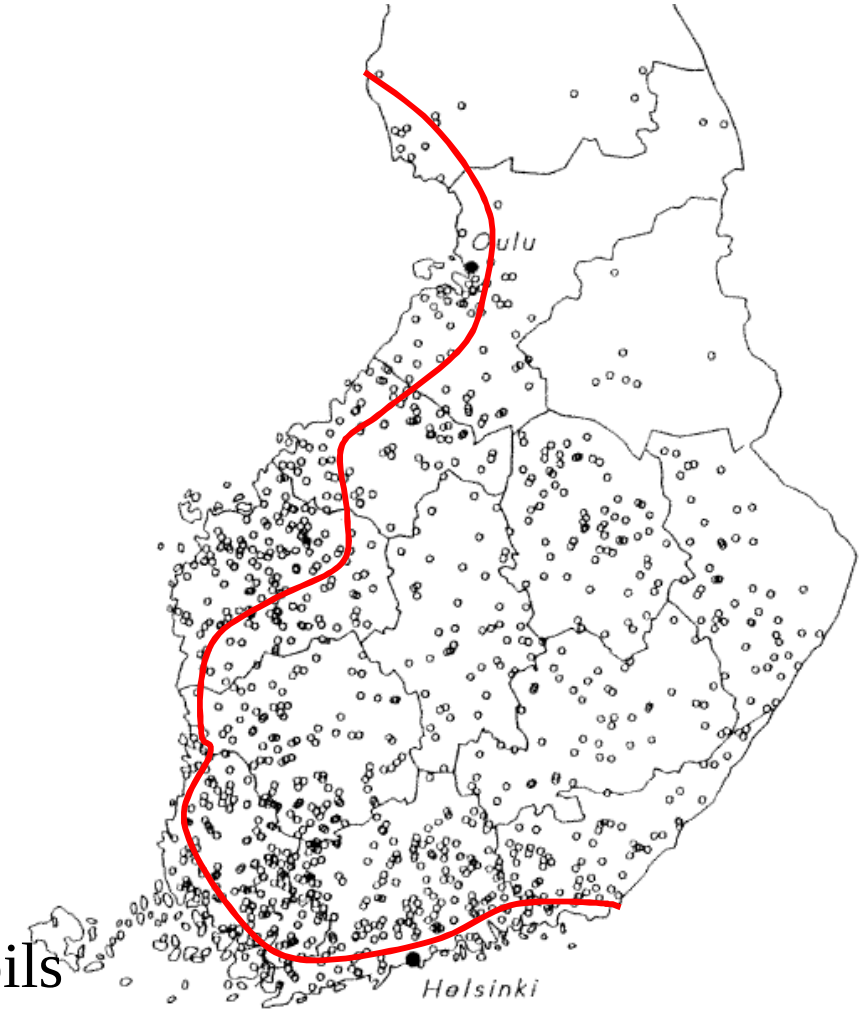
**2) Joukainen & Yli-Halla 2003. Agric., Ecosyst. & Environ. 95: 297-309.**

**3) Palko 1988. Vesi- ja ympäristöhallituksen julkaisuja 19.**

# Common depth of sulfidic materials?

# Survey of drainage status of fields: KUTI




1065 fields throughout Finland:

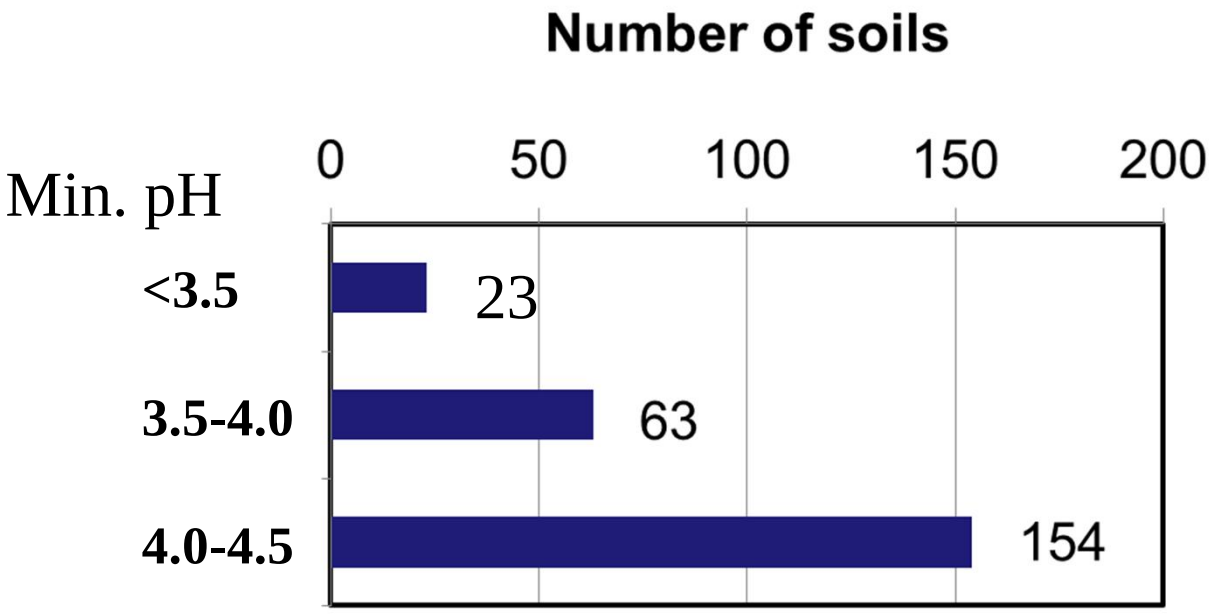
All kinds of fields, no bias to AS soils

Each sample represents 2100 ha of field

## Extraction of AS soils from the KUTI material

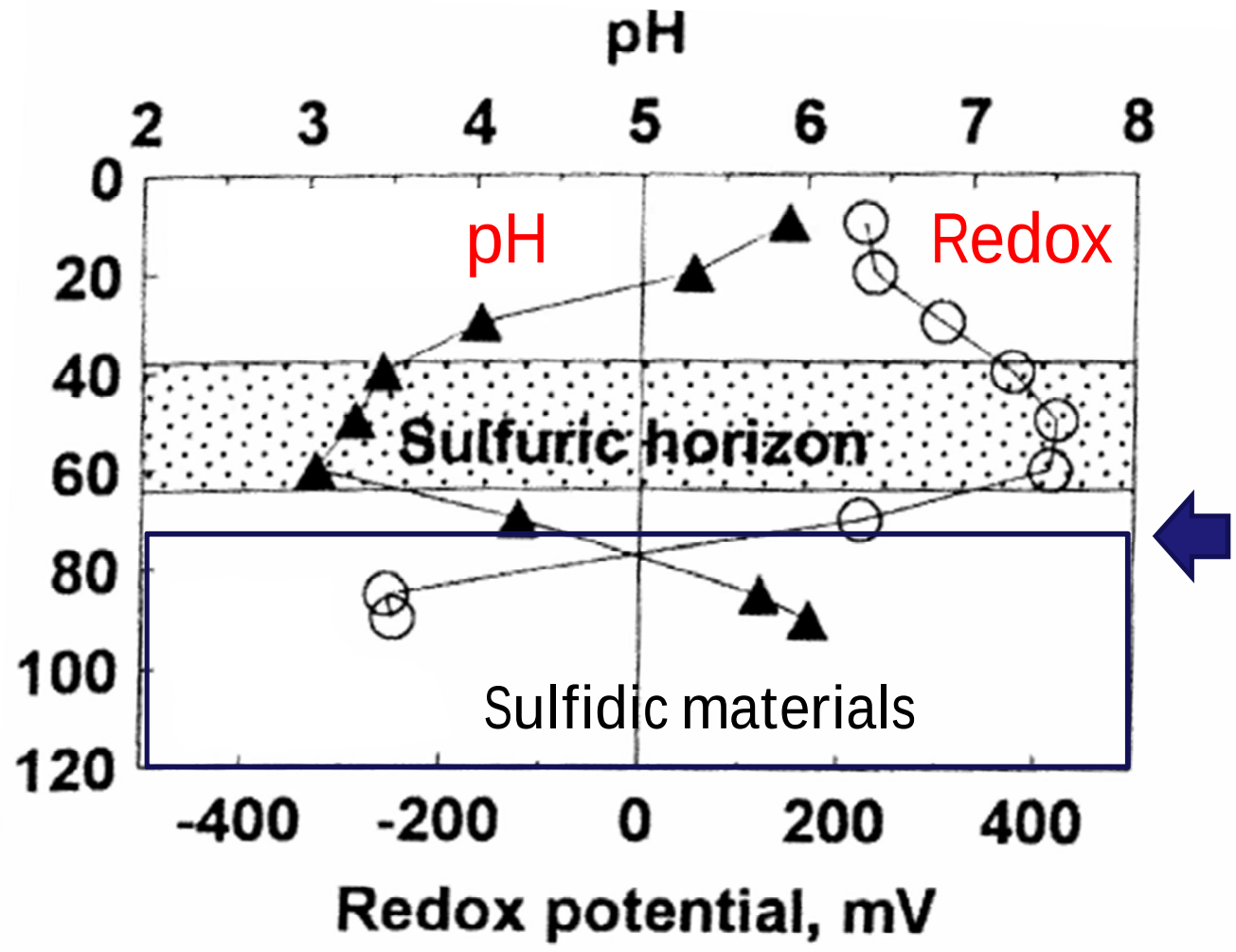
- In this material AS soils probably had the same representation as in fields of Finland
- Augering to the depth of 2 m
- pH and redox potential measured at 10 cm intervals
- **230 (22%) soils had a minimum pH < 4.5 in the subsoil**
- They were studied in more detail

# Minimum pH between 25 and 200 cm




Soils with a minimum pH < 4.0 represent real AS soils
They can be estimated to cover 180, 000 ha

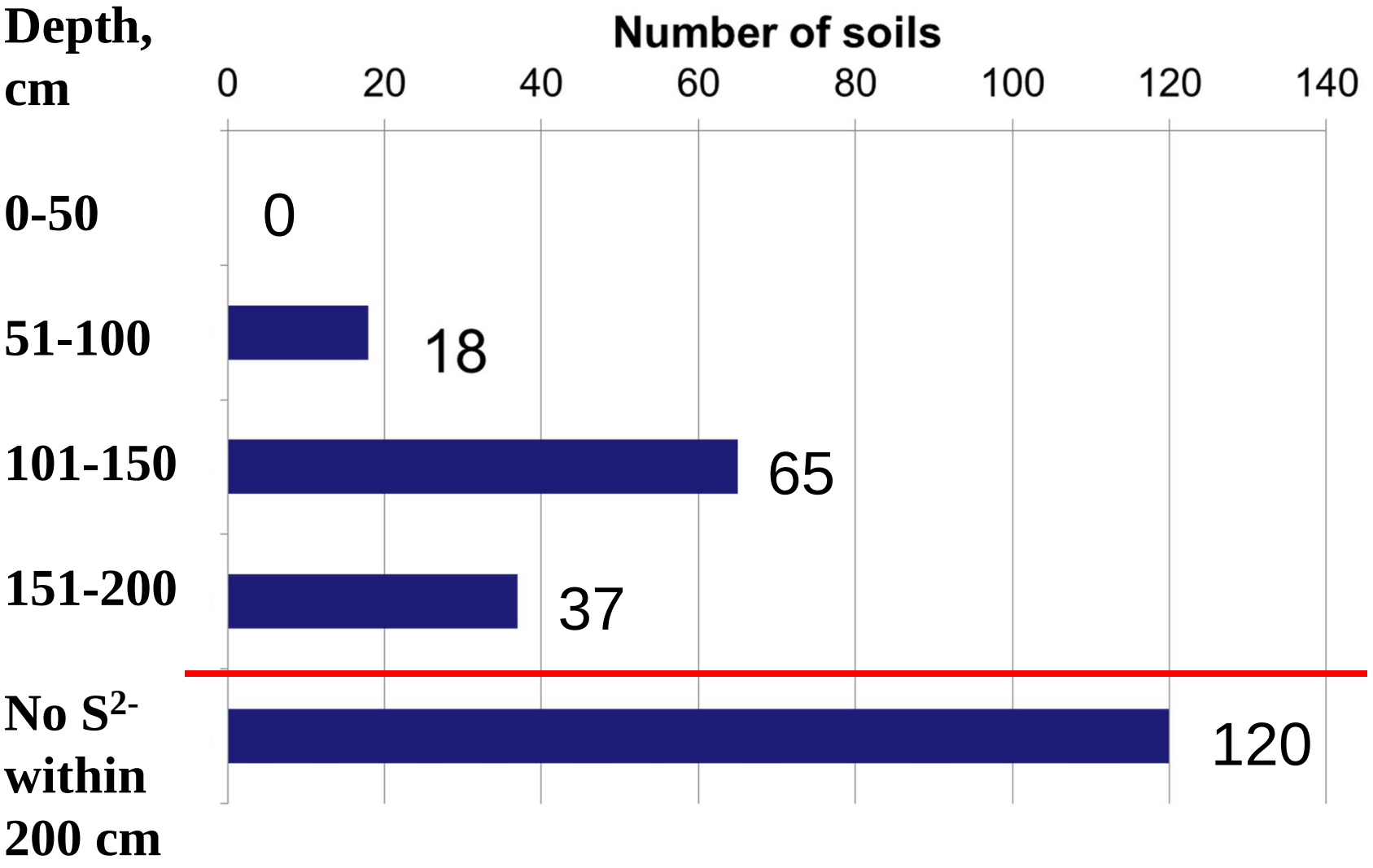
# Sulfidic materials on the basis of pH and redox potential




- Sharp in-crease of pH
- Sharp de-crease of redox potential

-> Presence of sulfidic materials probable

# Starting depth of sulfidic materials in FIELDS

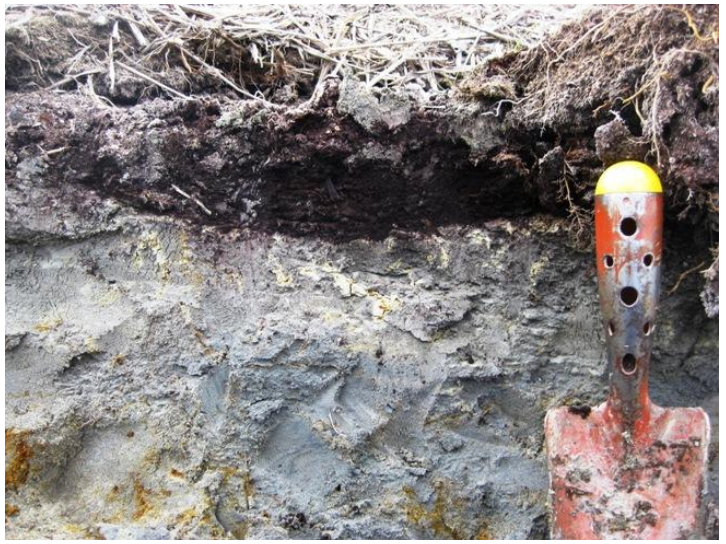


# Observations

- In no soil did sulfidic materials start within 50 cm of soil surface
  - No Typic Sulfaquepts/Sulfaquents in arable agricultural use
- In some cases (15%) sulfidic materials started between 50-100 cm. These soils may cover about 30,000 ha of agricultural land.
- Most commonly (54%), they started between 100-150 cm from soil surface.
  - Sulfic Cryaquepts are commonly in arable agricultual use
- **Almost all soils (86%) with a pH<4.0 had sulfidic materials**
- In 70% of soils with a minimum pH 4.01-4.5, there was no sulfidic materials within 200 cm of soil surface.

# Some peat mining areas in black shale areas

- Sulfidic minerals in parent rock
- Excavation of peat
- → Truncated soil profiles
- → Sulfidic materials at soil surface
- → Rapid oxidation



# Soil and water quality

- Topsoil pH 3.6 (2.6-4.4, n=12)
- Soluble S in topsoil 750 mg/dm$^3$ of soil
- Ionic strength in soil solution 0.08 (0.03-0.17)

- Subsoil pH 3.3 (2.6-3.9)

- Highly acidic drainage waters
- pH 3.2
- Dissolved Fe 50-100 mg/l
- Local acidification of recipient waters

# Conclusions

- **In agricultural AS soils**, depth of sulfidic materials varies widely.
- In many agricultural AS soils of Finland sulfidic materials occur closer to the soil surface than the common depth of subsurface drainage pipes.
- In those soils substantial environmental loading is likely, and new techniques for drainage need to be adopted.
- Soils with a minimum pH 4.0-4.5 seldom contain sulfidic materials within 2 m.
- **In peat mining areas with sulfidic subsoils** oxidation of sulfidic materials can be particularly rapid after peat removal.
- These areas need to be recognized and managed in order to avoid the highly acidic load to recipient waters.

**Thank you for your attention!**