Kaivosteollisuuden Vesistöuhkat: Haasteet ja Mahdollisuudet

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Taustaa

- Kaivosten ympäristövaikutukset ovat olleet jo pitkään tiedossa:
- Melu (ja Tärinä)
- Pöly
- Muut Ilmansaasteet
- Veteen siirtyvät aineet (typpi yhdisteet, rikki yhdisteet, happamoivat aineet, raskasmetallit)

Multiple mining impacts induce widespread changes in ecosystem dynamics in a boreal lake

Jaakko Johannes Leppänen, Jan Weckström & Atte Korhola

In order to satisfy the needs of constant economic growth, the pressure to exploit natural resources has increased. Since accessible mineral resources are becoming scarce, the mining industry is constantly looking for novel techniques to allow commercial exploitation of lower-grade deposits. However, mining can have considerable impacts on freshwater ecosystems. Here, we present the ecological damage inflicted by mine water originating from the massive Terrafame Talvivaara polymetal mine (central Finland), where bioheap leaching is being applied to high-sulphur low-grade ore. We found that saline mine water has turned the lake meromictic, and sediment is heavily contaminated. As a result, important zooplankton and phytoplankton groups have been significantly altered. As the exploitation of poor-grade deposits is the future of the mining industry globally, water management should be taken to a higher level in order to proceed towards a sustainable mining sector.

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The Lake in Question

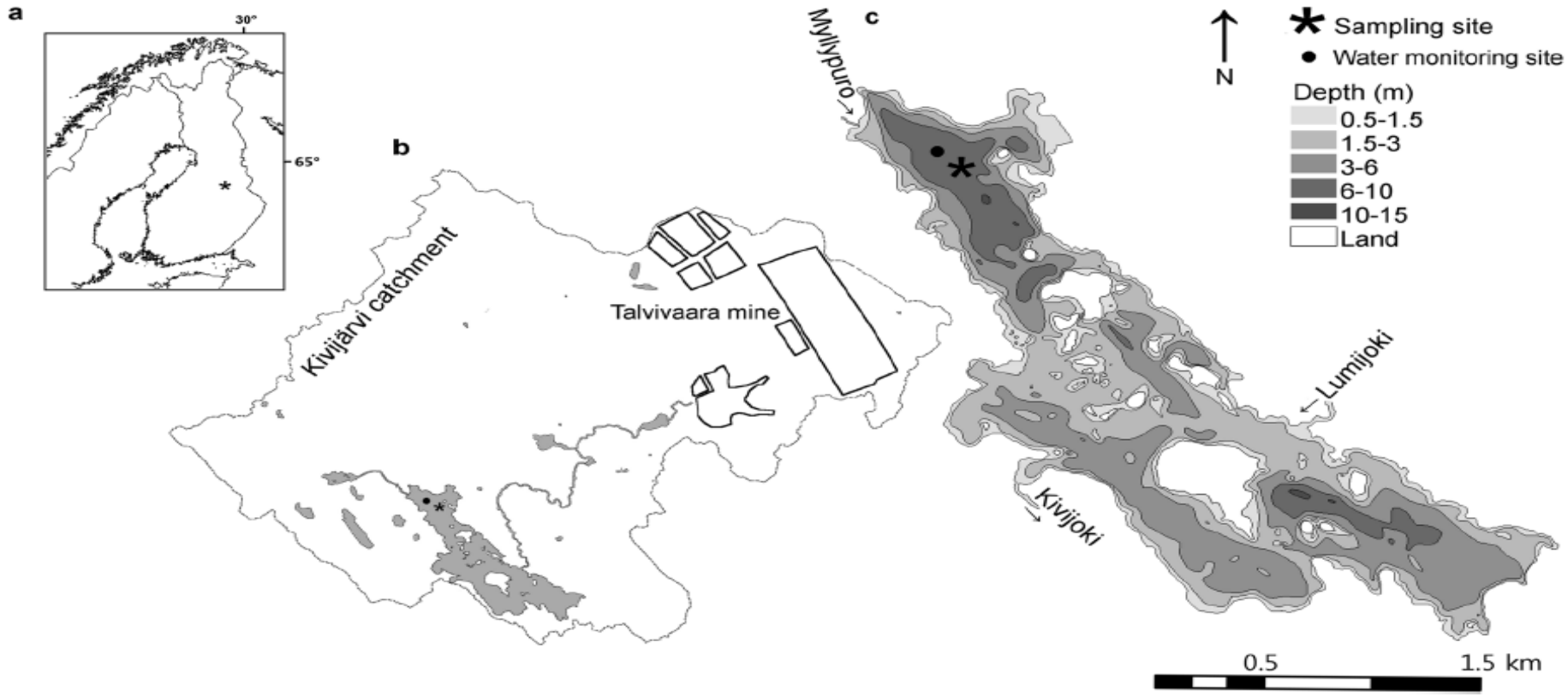


Figure 1. Study site location and lake characteristics. (**a**) Lake location in central Finland, (**b**) catchment boundaries, Terrafame Talvivaara mine and main channels, and (**c**) bathymetry of Lake Kivijärvi and location of data collection sites. The data for the map was retrieved from the National Land Survey of Finland open data databank (http://www.maanmittauslaitos.fi/en/e-services/open-data-file-download-service) under the open data CC 4.0 license (https://creativecommons.org/licenses/by/4.0/), and customized in ArcMap, Version 10.3.1 (http://desktop.arcgis.com/en/arcmap/) and in Corel Draw X8, version 18.0 (http://www.coreldraw.com/en/product/graphic-design-software/).

Water Chemistry

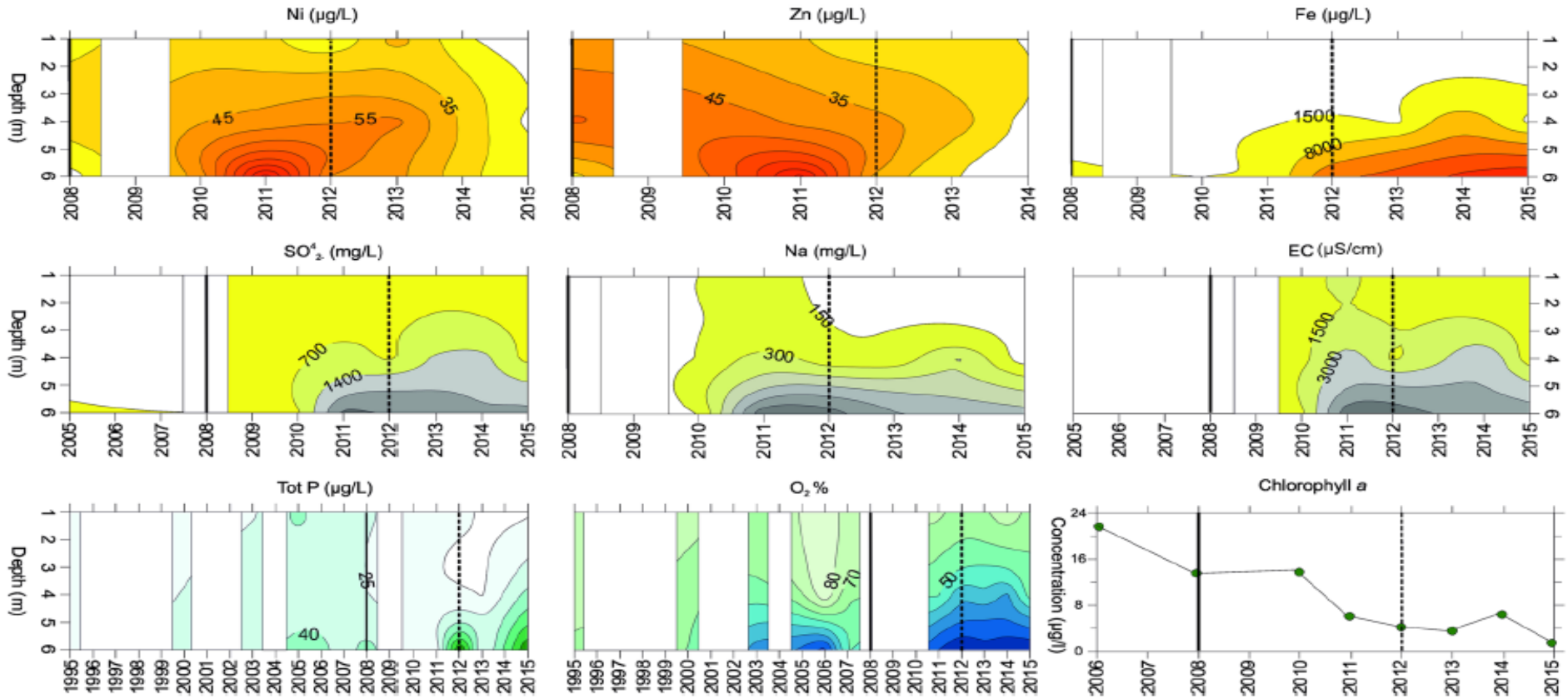


Figure 2. Lake Kivijärvi's water chemistry characteristics. Variation of Ni, Zn, Fe, sulphate (SO^4_{2-}), Na, electrical conductivity (EC), total phosphorus (Tot P), oxygen (O_2) and chlorophyll *a*. The y-axis indicates water sampling depth, except for chlorophyll *a*, where it indicates concentration. The solid vertical line indicates the beginning of mining activities, and the dashed vertical line indicates the 2012 gypsum pond accident. Detailed values and sampling dates, and concentration data regarding pH, Ca and total nitrogen (N) are available online (Supplementary Fig. 1). Data were retrieved from: http://www.syke.fi/avoindata. Data Source: Finnish Environment Institute and the Centres for Economic Development, Transport and the Environment (ELY Centres).

Sediment Geochemistry

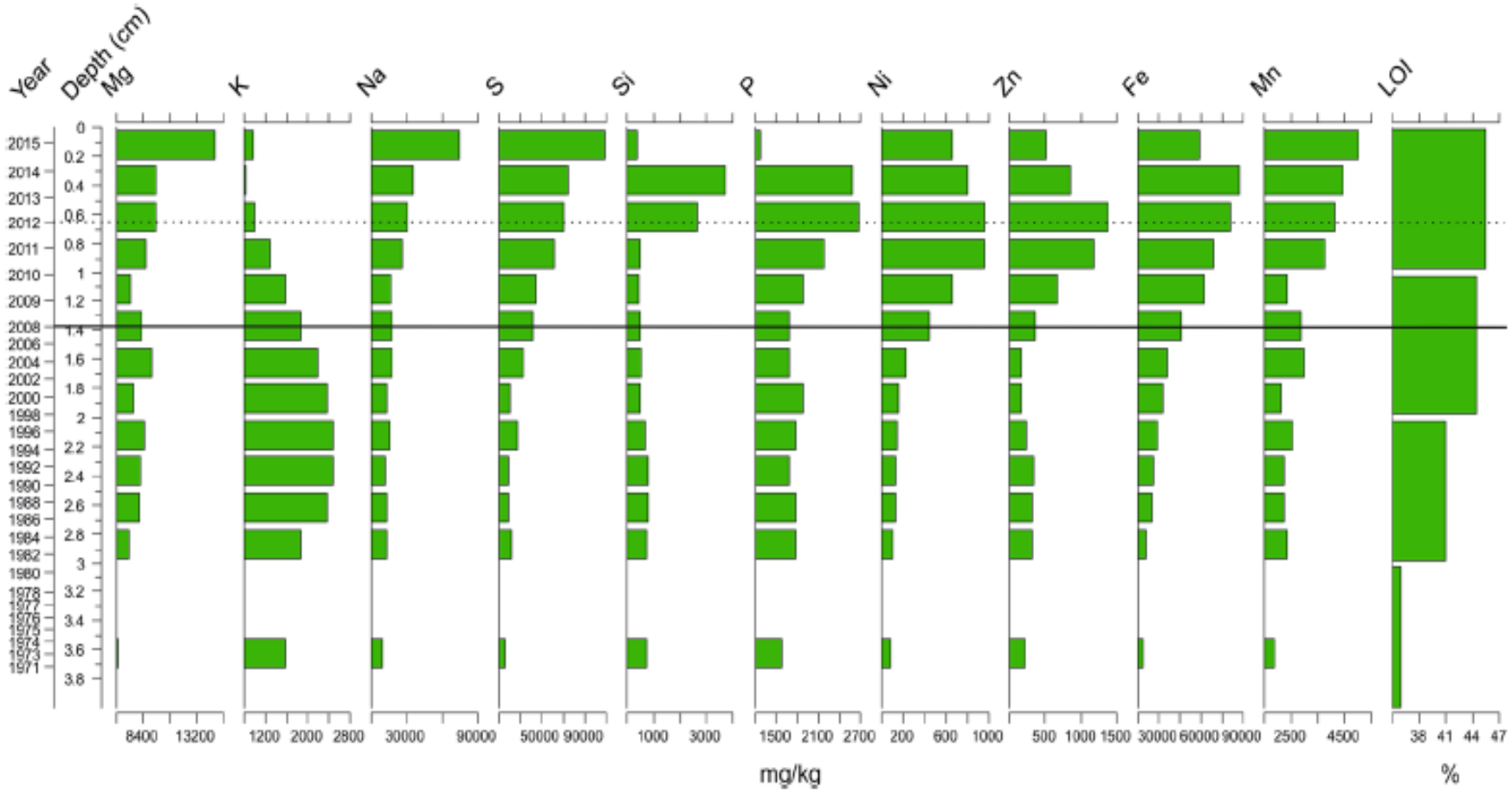


Figure 3. Lake Kivijärvi's sediment geochemistry. The solid horizontal line indicates the beginning of mining, and the dashed horizontal line indicates the 2012 gypsum pond accident.

Cladoceran Stratigraphy

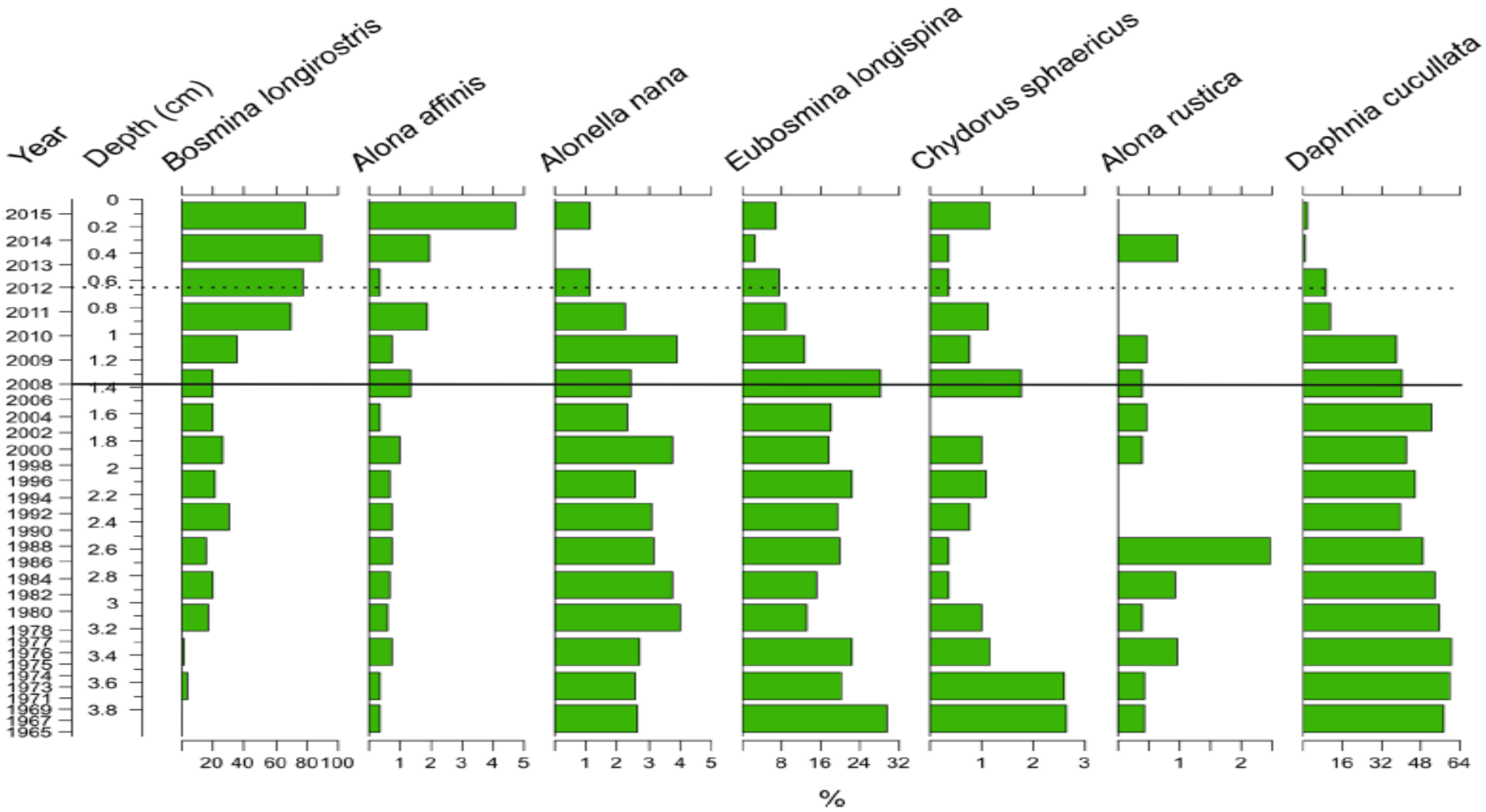


Figure 5. Cladoceran Stratigraphy. Cladoceran stratigraphy. Only the most abundant taxa with the proportional abundance of >2% is shown. The solid horizontal line indicates the beginning of the mining, and the dashed line indicates the 2012 gypsum pond accident.

Diatom Stratigraphy

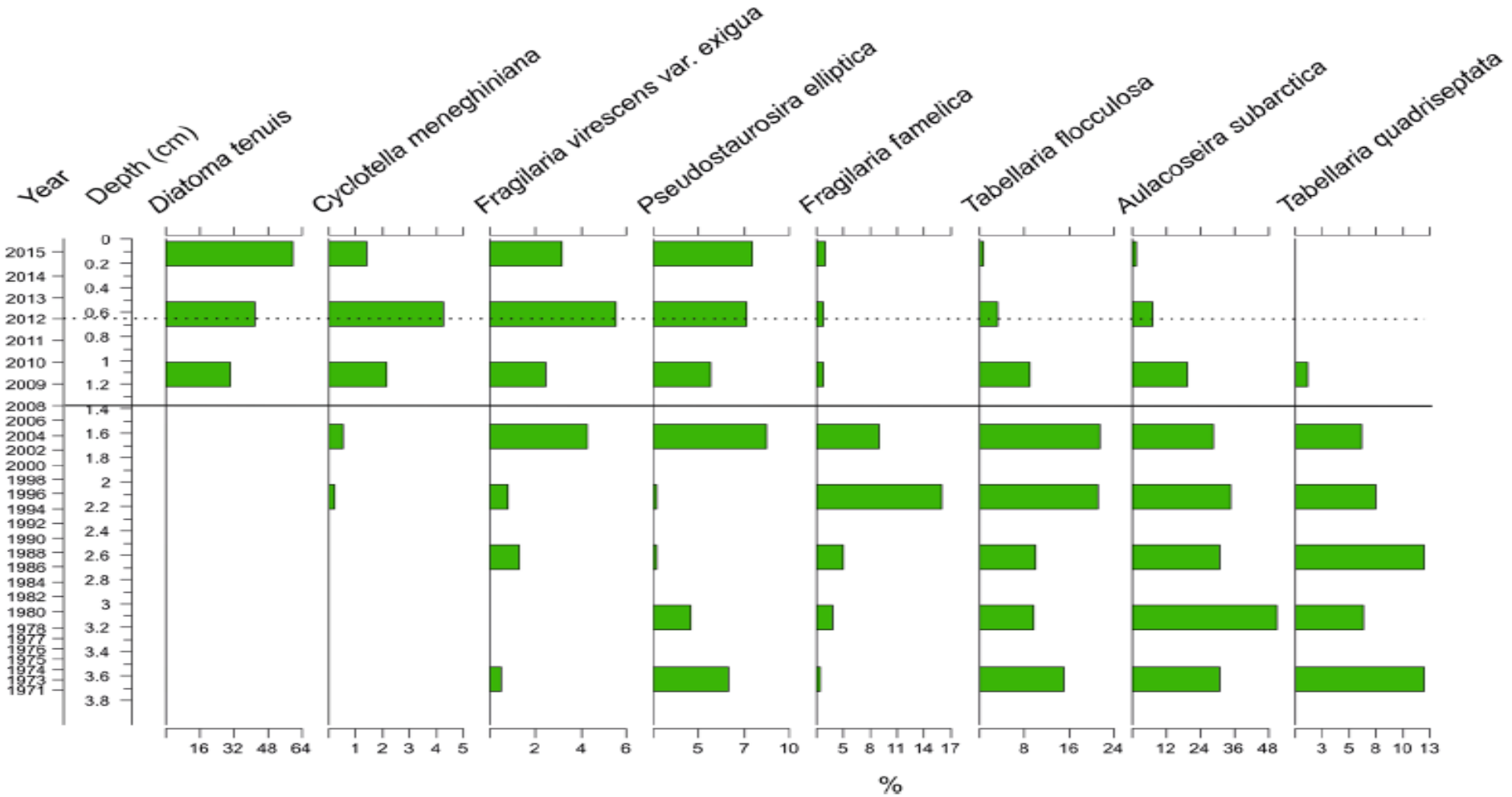


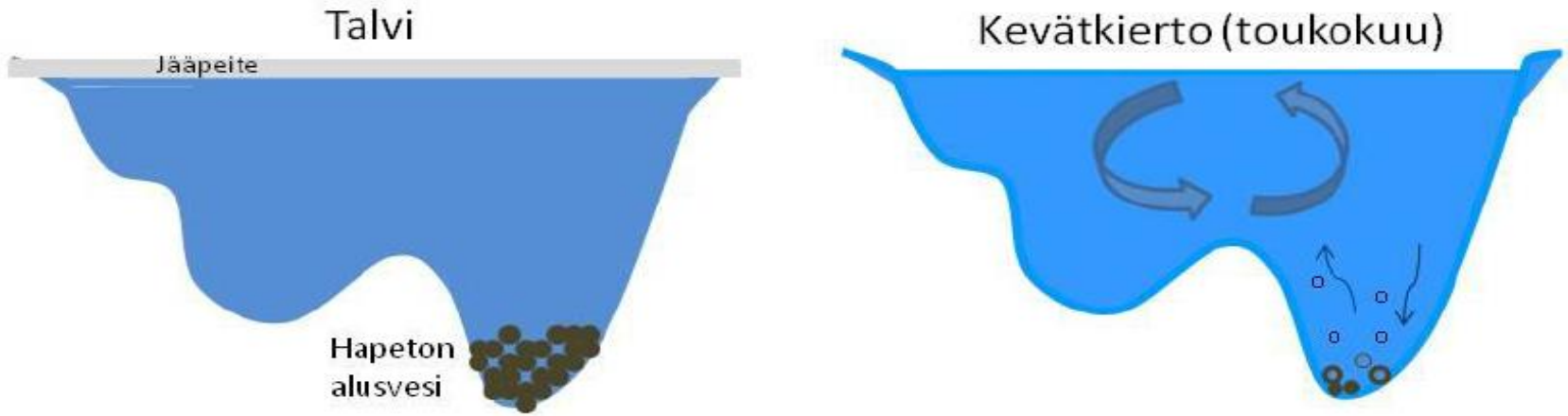
Figure 6. Diatom stratigraphy. Diatom stratigraphy. Only the most abundant taxa with the proportional abundance of >4% is shown. The solid horizontal line indicates the beginning of the mining, and the dashed line indicates the 2012 gypsum pond accident.

Timeline of Events

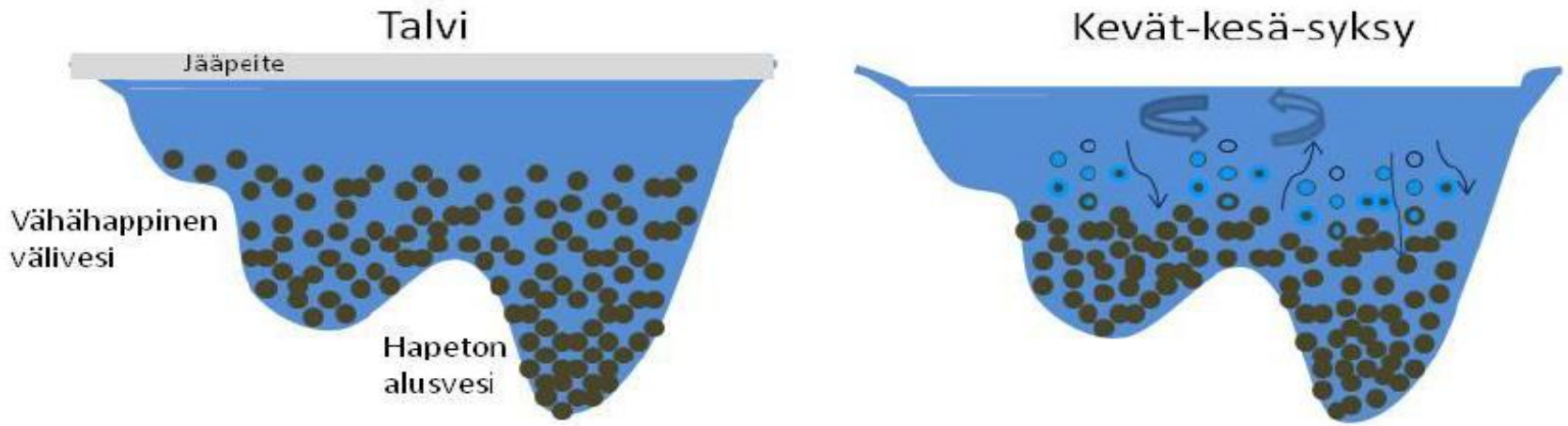
Period	Years	Water characteristics	Sediment chemistry	Cladocera	Diatoms	Interpretation
After the accident	2013–2015	Lake is meromictic. High salinity prevails. Fe and P are released from the sediment to hypolimnion.	Fe and P exhibit lower concentrations, also Ni and Zn decrease due to decreased pollution.	*B. longirostris* dominates.	*D. tenuis* dominates	Lake is clearly impacted by pollution
Pond accidents	2012–2013	Strong stratification. Dam accident derived Ni and Zn stay on top of chemocline.	Ni and Zn peak. Si peaks due to the pollution accident.	*B. longirostris* dominates. Richness and diversity are low.	*D. tenuis* increases	Lake is clearly impacted by pollution
Mining begins	2008–2012	Onset of meromixis and anoxia in deep water. Mine-related elements increase.	Zn, Ni, S and Na increase	*Bosmina longirostris* increases, diversity and richness decreases	*Diatoma tenuis* increases	Saline water and meromixis affects the system
Natural	1971–2008	Not permanently stratified, chemistry resembles natural conditions	K increases due to forestry	*Daphnia* dominates. Rich and diverse community	*Tabellaria* and *Aulacoseira* spp. dominate. Rich and diverse community	Most likely nearly natural boreal lake

Table 1. The main time periods of Lake Kirkkojärvi ecosystem.

Luonnontilainen järvi



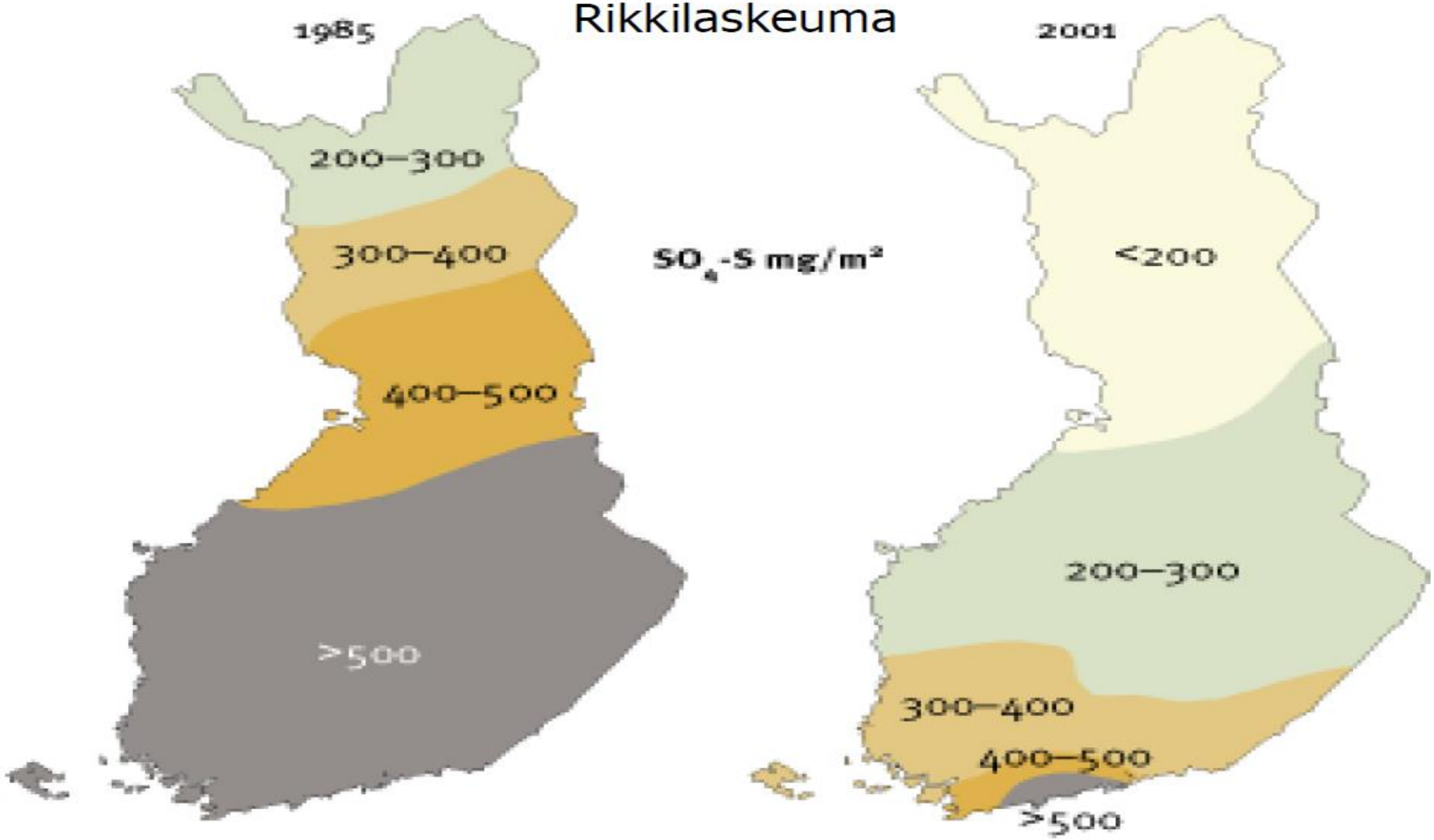
Suolaantunut järvivesi (Salminen/Kalliojärvi/Kivijärvi)



Mistä Sulfaatti ?

- Ilmakehästä (happosade) ?
- Maaperästä (rikki peräiset mineraalit) ?
- Kaivostoiminta ?
- Muu….?

Rikkilaskeuma



Q & A

- Kysymyksiä/Kommentteja ?