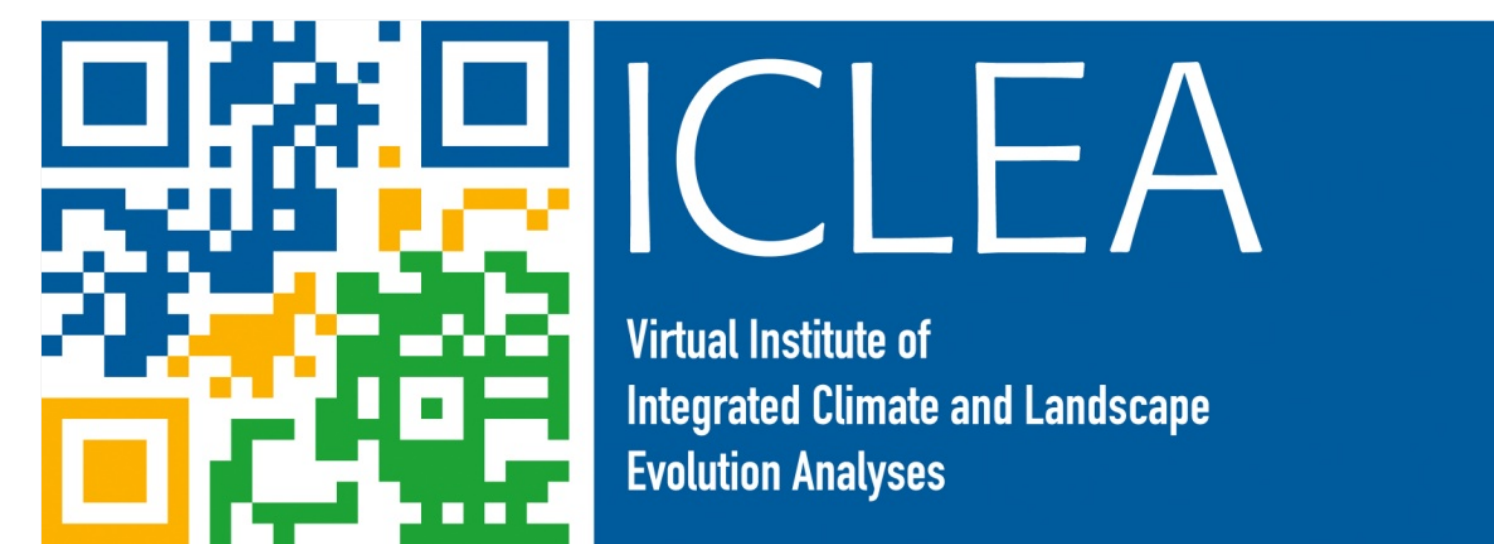


Anthropogenic impact on the sediment record from Lake Czechowskie (N-Poland) - heavy metal contents in combination with high-resolution pollen and varve data: Geochemical background vs enrichment history and landsurface changes

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1. Introduction

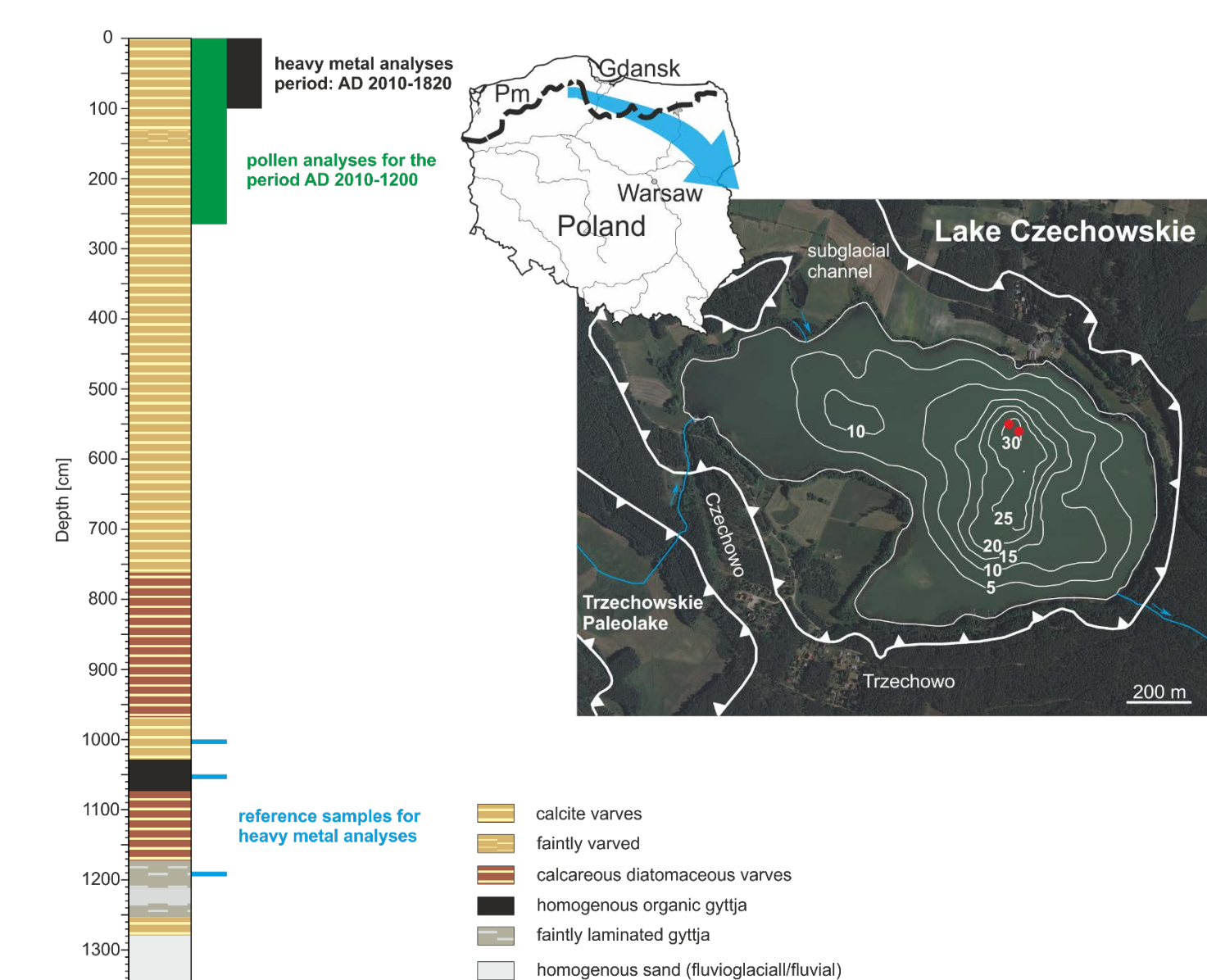


Fig. 1: Study site

- For Czechowskie Lake, situated in a rural environment in N-Poland (Fig.1), we present a detailed heavy metal enrichment history for the last two hundred years at 1 cm intervals from an annually laminated sediment core.
- This data is supplemented by a pollen record with on average a five year resolution for the last 700 years.
- Local geogenic background values of heavy metal concentrations were determined from which enrichment factors were calculated for Cd, Pb, and Zn that represent the anthropogenic heavy metal deposition of the last 200 years.
- Comparison to reconstructed vegetation changes from the pollen record and to XRF-scan determined Si/Ti-ratios are interpreted in terms of varying lake conditions.
- In combination with varve dating ($\pm 3a$ years for the last 200a and $\pm 8a$ years for the last 700a) a precise record for the anthropogenic impact (e.g. heavy metal enrichment; landsurface changes) is presented.

2. Results

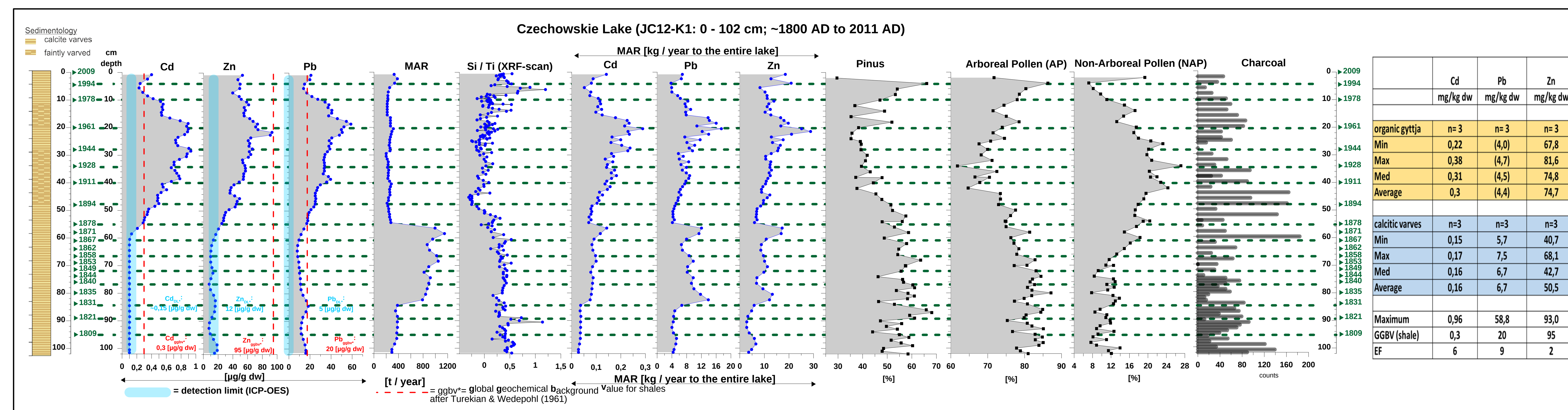


Fig. 2: Heavy metal concentrations (Cd, Zn, Pb), mass accumulation rate (MAR), Si/Ti-ratio, pollen taxa and charcoal pieces for the last 200 a.

Tab. 1: Heavy metal concentrations within pre-industrial sediment types and calculated enrichment factors (EF) for Cd, Pb, and Zn.

- Only for Cd, Pb, and Zn slightly enriched values were measured whereas the other heavy metals show concentrations well below the global geogenic-background values (ggbv) of shales.
- Concentrations begin to rise around 1860 and reach highest values around 1960. Thereafter concentrations decline to reach at the top of the core values near the ggbv of shales (Fig. 2).
- The MAR ($g/cm^2/a$) shows a different distribution over the last two hundred years (sediment in t/a; Fig. 2):
 - Moderate MAR ($\sim 200-400$ t/a) are observed between 1800-1820 AD which increase between 1820 to 1880 AD to maximum values of $\sim 800-1100$ t/a. Thereafter (~ 1880 AD) the MAR drops to ~ 200 t/a and remains on a $\pm$ constant level.

- Mass accumulation rates for Cd, Pb, and Zn show highest values also around 1960 but also an earlier increase between $\sim 1830 - 1880$.
- The increase in MAR is linked to the Si/Ti-ratio but only partly related to clear-cutting (AP, NAP).
- The pollen record shows a clear increase in NAP starting around 1400 that is accompanied by an increase in charcoal pieces.
- A second increase in NAP is visible ~ 1850 and slightly later also the heavy metal concentrations rise. With the recovery of the AP also the heavy metal concentrations decrease.
- The detailed pollen count ($\sim 1200-2011$; Figs. 2, 3) reveals distinct periods with high percentages of NAP and a general increasing trend until ~ 1940 .

3. Conclusions / Outlook

- Higher heavy metal concentrations occur $\sim 1860 - 1980$:
 - in accordance to an increasing industrialization (Industrial Revolution)
 - accompanied by highest proportion of clear-cutting ($>NAP\%$)
- Highest MAR not necessarily occur with $>NAP\%$ but may be related to historical events or development measures (e.g. railway installation)
- charcoal pieces peak when changes occur also in other sedimentary parameters:
 - ~ 1880 : MAR and heavy metal concentrations begin to rise;
 - $\sim 1760, \sim 1600, \sim 1480$ when changes in the NAP-% occur.
- Strongest declines in anthropogenic pressure on the landscape are related to periods following war or economic regression and subsequent regeneration.
- Five phases of significantly lower human activity interrupted by stronger human impact were distinguished before the Industrial Revolution by $<NAP$ and $<Carpinus betula$ percentages:
 - $\sim 1700-1780$
 - $\sim 1650-1660$
 - $\sim 1480-1600$
 - $\sim 1380-1450$
 - $\sim 1290-1340$following Polish-Teutonic War periods
- AP-% and Si/Ti-ratio show parallel records: with increased AP-% higher Si/Ti-ratios occur and may reflect decreased detrital input.
- Increased AP-% paralleled by decreased input of charcoal pieces point to decreased human impact.

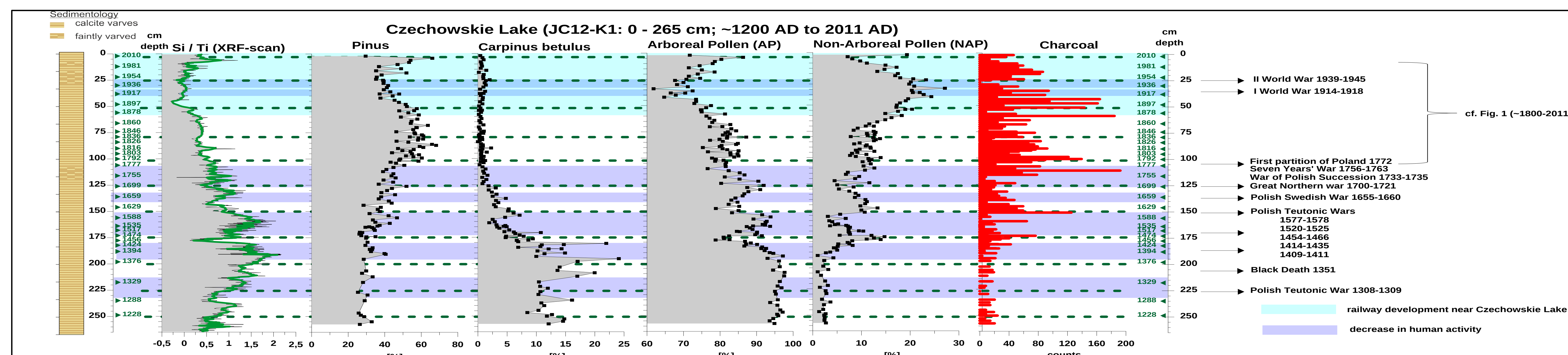


Fig. 3: Si/Ti-ratio and selected pollen taxa from and charcoal pieces from ca. 1200-2011 AD. Historical events with possible influence to land-surface changes are listed.

