

A 13-kyr-long palaeoclimate record revealed by ostracod oxygen isotopic data, northern Estonia

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A small karstic Lake Sinijärv, fed by groundwater, is located in a depression of Ordovician limestone in northern Estonia. After the Late-Weichselian glaciation late-glacial sands and silts accumulated in the basin. Freshwater marl formation has taken place continuously during the last 13.3 ^{14}C cal kyr. The alkaline lake water is transparent to the bottom (max. depth 7.3 m). The annual average temperature of inflowing groundwater varies between 6.1–6.5 °C.

In this particular lake marl sequence (thickness c. 400 cm) subfossils of freshwater ostracods are well preserved. *Candona candida* has been present across the whole time interval, and carapaces of it were utilized for isotopic analyses. According to species seasonality and habitat preferences the isotopic composition ($\delta^{18}\text{O}$) of carapace calcite of *C. candida* demonstrates temperature and hydrology changes at the lake bottom during winters. Oxygen isotope stratigraphy reflects relative temperature changes across the studied time interval (from 13.3 cal kyr BP to present). Between 13.3–11.7 ^{14}C cal kyr BP the values of $\delta^{18}\text{O}$ vary from -11 to -8‰. Positive O-excursions are similar to the GS 1 stage of GRIP (LOWE et al. 2008). At the beginning of the Holocene an abrupt change occurred in the composition of carapace $\delta^{18}\text{O}$ values (correlated with the Preboreal Oscillation), which turned to more positive, from -8 to -6‰ (c. 11.7–5.5 ^{14}C cal kyr BP). Increasing ^{18}O values reflect climate warming during the first part of the Holocene (c. 11.7–5.5 ^{14}C cal kyr BP). This period was characterised by dry and stable climatic conditions in northern Europe (HAMMARLUND et al. 2003). Since 5.5 ^{14}C cal kyr BP depletion in ^{18}O values by 1.5‰ is notable, indicating more humid and cooler ambient conditions than earlier across the Lake Sinijärv area. During the Late Holocene climate has been cool and humid in northern Europe (e.g., HAMMARLUND et al. 2003; SEPPÄ & POSKA 2004; ANDERSSON 2010). A slight positive excursion of $\delta^{18}\text{O}$ (by c. 0.75‰) between 4.0–2.5 ^{14}C cal kyr BP suggests an episode of drier conditions in the study area. A similar episode was found in Sweden, evidenced by *Chara* $\delta^{18}\text{O}$ values (ANDERSSON 2010). Relatively negative $\delta^{18}\text{O}$ values of ostracod carapaces that were secreted between 1.25–0.8 ^{14}C cal kyr BP may indicate the Little Ice Age cold episode. An abrupt shift towards positive $\delta^{18}\text{O}$ values of *C. candida* carapaces at the top of the section is related with the warming at the very end of the Holocene.

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