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A submerged pine forest from the early Holocene in the Mecklenburg Lake District, northern Germany: indicating dead-ice melting or lake-level dynamics?

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For the first time, evidence of a submerged pine forest from the early Holocene could be documented in a central European lake. Subaquatic tree stumps were discovered in Lake Giesenschlagsee (c. 90 km NW of Berlin) at a depth of between 2 and 5 m using scuba divers, side-scan sonar and a remotely operated vehicle. Several erect stumps, anchored to the ground by roots, represent an in situ record of this former forest. Botanical determination revealed them to be Scots pine (Pinus sylvestris) with an individual tree age of about 80 years. The trees could not be dated by means of dendrochronology, as they are older than the regional reference chronology for pine. Radiocarbon ages from the wood range from 10,880 $\pm$ 210 to 10,370 $\pm$ 130 cal. a BP which is equivalent to the mid-Preboreal to early Boreal biozones. The trees are rooted in sedge peat, which can be dated to this period as well, using pollen stratigraphic analysis.

The height difference between the uppermost and the lowermost recorded position of the pine stumps and basal peat layers is c. 3 m and c. 4 m, respectively. This tilting of the sedge peat bed is an exceptional sedimentary feature if one assumes an originally synchronous and semi-horizontal peat layer growing in a groundwater dominated setting. Consequently, a geomorphic dislocation can be inferred which requires explanation. Subsidence of the former forest soil could be related to local dead-ice melting. This process is considered responsible for the formation of numerous lake basins in the Weichselian glacial belt of northern central Europe and beyond. While the majority of the basins formed during the Lateglacial (mostly Allerød, i.e. 13.9-12.9 cal. ka BP), lake formation in several instances was delayed until the early Holocene (i.e. 11.6-9.2 cal. ka BP). The final phase of dead-ice melting was dated to the Preboreal for northern central Europe and to the Atlantic for northeastern Europe. By contrast, the sedimentary properties observed at the study site and the permafrost dynamics reconstructed for the last termination in northern Europe present evidence against possible alternative explanations, such as an absolute (e.g. climate-driven) lake level rise and a thermokarst lake formation in ice-rich permafrost, i.e. a thaw lake development, respectively.

Together with recently detected Lateglacial in situ tree occurrences in nearby lakes, the submerged pine forest at Giesenschlagsee represents a new and highly promising type of geo-bio-archive for the wider region. Comparable in situ pine remnants occur at some terrestrial (buried setting) and marine sites (submerged setting) in northern central Europe and beyond yet partly differ in age. In general, the in situ pine finds document shifts of the zonal boreal forest ecosystem during the late Quaternary.