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High-resolution isotope record of Lake Gerzensee (Switzerland) during the Bølling/Allerød: Precise chronostratigraphy and characterization of rapid climate events

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Synchronization between terrestrial records and the polar ice started by the pioneering work of Siegenthaler, Eicher, Oeschger and Dansgaard in 1984 with the analysis of lake marls in Lake Gerzensee (Switzerland). Here we present a higher resolved stable isotopic record analyzed on authigenic carbonates of Lake Gerzensee covering the Late Glacial to Early Holocene. Combined with sedimentological features, the Gerzensee record provides a basis for the evaluation of environmental forcings and feedbacks of climate change in Central Europe during the last glacial-interglacial transition and enables the detailed comparison of different high-resolution isotopic records in the Atlantic region.

The sediment of Lake Gerzensee comprises mainly shallow water carbonates and some molluscan shell debris, but very little organic matter and detrital material. For this study, four parallel cores were correlated using sedimentological features and pollen assemblages. This core-to-core correlation was further consolidated using oxygen and carbon stable isotopic composition analyzed in authigenic calcite with a sampling resolution of 0.5cm. The final correlation highlights some sedimentological variability and consistent signatures throughout the lake. Stacking of all four parallel dataset cancels out erratic sedimentation features and sampling artifacts. Therefore, the stacked record is most suitable for comparison with other climate records.

Since the sediment does not contain any terrestrial macrofossil plant remains, conventional radiocarbon dating could not be performed. Provided that changes in delta18O in Greenland and Europe occurred simultaneously, the age/depth model was established by wiggle matching the Greenland and Gerzensee isotopic records. The resulting age/depth model was consolidated by the correlation with previously dated markers such as distinct changes in pollen assemblages and the occurrence of the Laacher See Tephra. The resulting isotopic record yields a temporal resolution of about 10 years (Early Holocene and Bølling/Allerød) to about 35 years (Younger Dryas).

The high temporal resolution allows for the reconstruction of abrupt and extreme climatic changes, such as four century-scale cold events during a general cooling trend of the Bølling/Allerød warm period. Some of these small-scale oscillations have been observed in other datasets of the North Atlantic region and central Europe. Comparison of the new Gerzensee record to other marine (e.g. Cariaco basin), terrestrial (e.g. Ammersee), and ice core (e.g. NGRIP) datasets helps to investigate and quantify the isotopic expressions of the cold phases within the Bølling/Allerød warm period. The Late Glacial to early Holocene decadal delta18O record from Gerzensee validates the strong synchronicity of climate in Greenland and Europe with its centennial scale cooling events.

In addition to stable isotope analysis, high-resolution XRF core scanning was performed to gain insights into the elemental composition of the sediment. We developed geochemical signatures of each of the cold events during the Bølling/Allerød warm period (e.g. both low delta13C and delta18O combined with low detrital input during the Gerzensee Oscillation in contrast to both low delta13C and delta18O in combination with high detrital input during the Aegelsee Oscillation). Eventually, comparing delta18O, delta13C, and XRF data allows us to determine the response mechanisms and timing of the sedimentological system to climate change and provides means to develop a better understanding of the causes, mechanisms and impacts of rapid temperature fluctuations.