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Climatic and environmental changes reflected by lake-level fluctuations at Gerzensee from 14,850 to 13,050 yr BP

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ABSTRACT

High-resolution sediment analysis at Gerzensee, Swiss Plateau, focused on the reconstruction of lake-level changes during the last glaciation Greenland Stadial 2a (GS-2a) and a large portion of Lateglacial including the Gerzensee oscillation. The chronology is derived from a comparison of the oxygen-isotope stratigraphy established at Gerzensee with that of the NGRIP ice core. On a multi-millennial scale differences between the lake-level and oxygen-isotope records established from cores GEJ–GEK reflect a complex interplay among climate, vegetation and lake level during retreat of the ice sheet. But on a multi-centennial scale both the lake-level and oxygen-isotope records show a general agreement, i.e. cool periods such as Greenland Stadial GS-2a and Greenland Interstadials-1d and -1b, which coincided with more positive water budgets and, conversely, warm periods (Greenland Interstadials-1e and -1c) with more negative water budget. This is in agreement with the regional pattern of palaeohydrological changes reconstructed from previous studies. Despite possible reduced annual precipitation during GS-2a, the maintenance of relatively high lake-level conditions at Gerzensee at this time could have resulted from reduced evaporation and stronger runoff on bare slopes, whereas during the Lateglacial Interstadial the phases of lake-level lowering may have been associated with summer dryness linked to increasing summer insolation.

1. Introduction

Changes in the composition of terrestrial and aquatic species in response to past climatic oscillations can result from variations in summer and/or winter temperature but they also can be influenced by changes in the hydrological cycle associated with climatic variability. Lake-level records offer highly sensitive archives that document past changes in the water budget during Lateglacial and Holocene (Gaillard and Moulin, 1989; Bohncke and Vandenberghe, 1991; Harrisson and Digerfeldt, 1993; Isarin, 1997).

The aim of the present study is to establish a high-resolution lake-level record covering Greenland Stadial 2a and a large portion of Greenland Interstadial 1 at Gerzensee on the Swiss Plateau. This is a part of an interdisciplinary project focusing on the biotic responses to the early rapid warming around 14,685 yr BP (B. Ammann et al., 2013–this volume-b).

2. Site and methods

Gerzensee is a small lake (27 ha) located on the Swiss Plateau at 603 m asl (Fig. 1). The lake has a maximum depth of 10.7 m and a catchment area of 2.6 km^2. Two cores labelled GEJ and GEK were taken within a square metre in the littoral mire close to the eastern shore (see B. Ammannet al., 2013–this volume-b) and used for a multi-proxy analysis.

The reconstruction of changes in lake level is based on a sedimentological approach (Magny, 1992, 1998, 2007) using the analysis of macroscopic components of lake marl (fraction larger than 0.2 mm). As in most of the lakes in the sub-alpine area and the Jura mountains, Gerzensee is characterised by carbonate sediments composed mainly of concretions of biochemical origin. These concretions can be divided into several morphotypes. Modern analogues based on surface samples taken along transects perpendicular to the shore show that each morphotype has a specific spatial distribution in zones extending from the shore to the profundal zone because of the hydrodynamics and the aquatic vegetation belts. Oncolites and rounded cauliflower-like concretions characterise areas close to the shore. No rounded cauliflower-like forms dominate on the littoral platform; plate and tube-like forms develop on the edge and the slope of the littoral platform and are associated with the *Nuphar-Potamogeton* and Characeae belts, respectively. Broken tubes reflect variable water depth and/or conditions marked by occasional higher hydrodynamics on the shallow part of the littoral platform. In addition to the carbonate concretions, lake marl includes mollusc and ostracod shells. The abundance of mollusc shells increases towards the shore, whereas ostracod remains are relatively rare in the shore areas and show increasing frequencies offshore (Mouthon, 1984). Lithoclasts (rock fragments more than 0.2 mm) reflect detrital influx from the catchment area.

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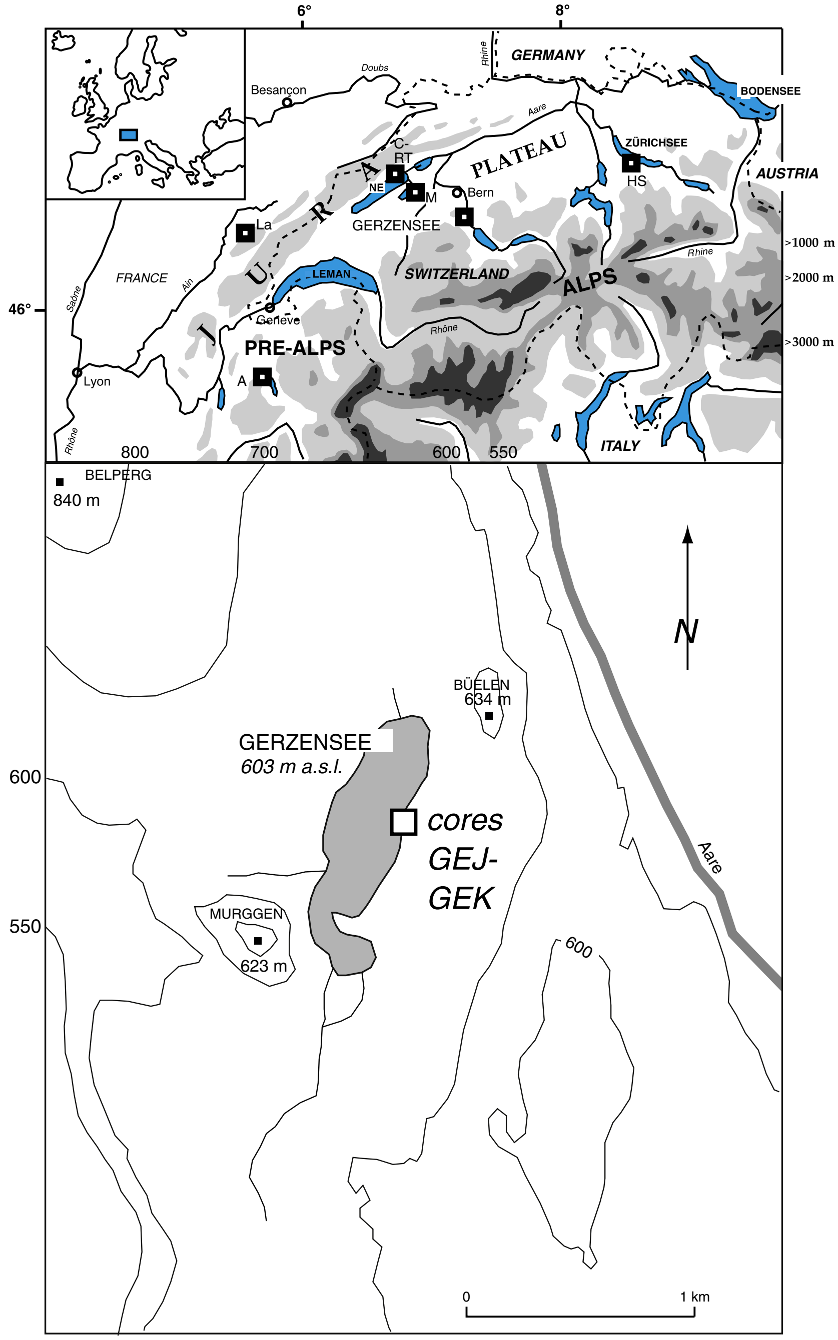

Fig. 1. Upper panel: location of the study site and other sites which provide a lake-level record for the Greenland Interstadial 1. A: Sevrier-Les Charretières, Lake Annecy; C-RT: Hauterive–Champréveyres and Hauterive–Rouges Terres, Lake Neuchâtel; HS: Horgen–Scheller, Zürichsee; M: Montilier–Strandweg, Lake Morat; La: Lake Lautrey. Lower panel: location of the core site at Gerzensee.

The chronology (expressed in yr BP, equivalent to calendar yr BP) is based on correlations between the oxygen-isotope stratigraphy established from cores GEJ–GEK, GEM, GEA–GEB, and GEW and that from Greenland ice cores (GICC-05 time scale, see van Raden et al., 2013–this volume) assuming that the signals in the oxygen-isotope ratios were synchronous on Greenland and in Europe. Sediment analysis for lake-level reconstruction was carried out on contiguous 1-cm samples from the 273–360-cm sequence and 0.5-cm samples from the 360–380-cm sequence. Thus on the basis of the time scale given by correlation between the Gerzensee and Greenland oxygen-isotope profiles, the temporal resolution attains around 22 (15) years for the upper (lower) part of the sediment sequence. The time–depth curve (see van Raden et al., 2013–this volume) suggests a more or less regular sedimentation rate (ca 4–6 cm/100 yr) except for the period around 13,800–13,600 yr BP where it exceeds 14 cm/100 yr. The lithology revealed only homogeneous carbonate lake marl without noteworthy change.

The relative abundance of each macroscopic component of carbonate lake marl is illustrated on the sediment diagram (Fig. 2), where the frequency of each morphotype of carbonate concretion is presented as a percentage relative to the total counted concretions, whereas the frequencies of lithoclasts, mollusc and ostracod shells, and Characeae oogones are presented as a percentage relative to the total counted macroscopic components. The subdivision into sediment zones was made by optimal sum of squares partition (Bennett, 1996) and the number of statistically significant splits was determined with