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An early meromictic stage in Lobsigensee (Switzerland) as evidenced by ostracods and *Chaoborus*

Studies of the late quaternary of Lobsigensee No. 12

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Abstract

Lobsigensee is a small kettle on the western Swiss Plateau in a tectonic depression of the tertiary Molasse. At present its maximum depth is 2.7 m. Analysis of ostracods and other organisms (*Chaoborus*) from a 13 m core indicates that the lake became meromictic during the Bølling and returned again to a holomictic stage during the Boreal when the lake was approximately 10 m deep. The meromictic period is characterized by the disappearance of ostracods – especially of *Cytherissa lacustris* and *Limnocythere sanctipatricii* – and the appearance of *Chaoborus*, whereas the onset of the second holomictic stage is marked by the recolonization of the profundal zone by ostracods not present before in the lake (*Metacypris cordata, Darwinula stevensoni*). A very similar case of 'fossil' meromixis has been found in Kleinsee in Carinthia.

Introduction

Lobsigensee on the western Swiss Plateau (Fig. 1) has recently become an important site for paleolimnological studies (Ammann & Tobolski, 1983; Ammann *et al.*, 1983, 1984, 1985; Hofmann, 1985a; Hofmann, 1985b; Züllig, 1985, etc.). As a result of these investigations it was possible to draw several conclusions concerning the climatic history and its influence on the trophic state of the small lake. It was shown that major steps of warming at the beginning of the Bølling and at the onset of the Holocene resulted in eutrophication and, as indicated by fossil pigments (Züllig, 1985), a meromictic period was therefore postulated for the Boreal. Since ostracods are extremely useful for the recognition of meromixis and eutrophication processes in lakes (Löffler, 1969, 1975, 1977), it was of interest to analyze the development of the ostracod fauna of Lobsigensee and to compare the results with the information from this lake obtained so far.

Material and methods

Lobsigensee is a small (2 ha) kettle with a maximum depth of 2.7 m (during the early Late Glacial it was at least 17 m deep) with a rich macrophytic vegetation (Potamogetonion, Nymphaeion, Phragmition and Alnion glutinosae). From several cores obtained by a modified Livingstone sampler, core 160 a (western margin of the open lake) was used for a.o. diatom, pigment and ostracod analysis. For the inspection of ostracods, 50 ml (at 893 only 10 ml) from sections between 1298 and 90 cm depth were selected and washed through a 50 μm filter. Ostracods and remains of other organisms were counted and the results are presented in Fig. 2a, b, c. It is obvious that due to the procedure used, the figures for *Spongilla*, small diatoms and *Pediastrum* are unrealistic.

Results (Fig. 2a, b, c)

A total of 17 (18?) subfossil species was found. Of these, several are strictly confined to the Dryas 1

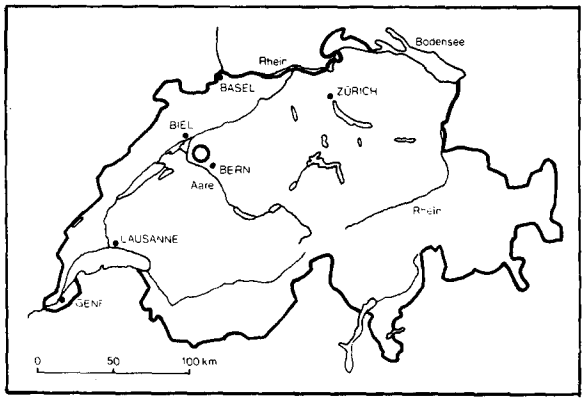


Fig. 1. Geographic location of Lobsigensee (circle).

(*Cytherissa lacustris, Limnocythere sanctiparicii, Leucocythere mirabilis, Ilyocypris sp., Eucypris* cf. *pigra* and *Potamocypris sp.*) and start to disappear and to become extinct before the Bølling. From that time until the middle of the Boreal all ostracods with the exception of species able to swim (*Cypria ophthalmica, Cyclocypris sp.*) are absent. Only during the late Boreal does the colonization of the profundal with ostracods start again. Among the species involved in this recolonization are some candonids (*Candona candida, C. neglecta, C. caudata*) which were present during the Dryas 1 whereas the other species (*Limnocythere inopinata, Metacypris cordata* and *Darwinula stevensoni*) obviously are new immigrants to the lake. Rare species like *Candona fragilis* (at a depth of 90 cm), *Cyprinae sp.* and *Cypridopsis vidua* may also belong to this group. The latter species, however, is likely to be confined to the macrophytic zone, and its shells found for the first time in the profundal and at the end of the Boreal are almost certainly specimens which were moved there by currents.

Other organisms

Studies so far carried out included the investigation of bacteria and algae (fossil pigments, diatoms), *Bosmina,* chydorids, Trichoptera, Coleoptera, chironomids, *Chaoborus* and molluscs. their distribution in the sediment has been partly explained by the climatic history (e.g. chironomids) and partly also by the trophic conditions (e.g. *Bosmina,* chydorids). Among the organisms presented in Fig. 2a, b, c the Oribatei occurred mainly during the time when most of the ostracods were absent. Their presence may be explained by the development of mosses though any information about Musci is still lacking. Of even more interest is the first appearance of fish scales (most likely *Perca fluviatilis*) during the Boreal when the recolonization of the profundal with ostracods took place. *Campylodiscus sp.* and *Spongila* sp. appeared at the same time. In addition, the sudden occurrence of *Chaoborus flavicans* during the Bølling (according to Hofmann, 1985b during the Dryas 3!) soon after most of the ostracods had become extinct is of considerable significance. *Chaoborus flavicans* is well known for its preference for lakes with anoxic deep water or anoxic loose sediment to which the animals migrate during the day. As in Lobsigensee *Chaoborus flavicans* was an early immigrant to small meromictic lakes in Carinthia at the end of the Pleistocene.

Discussion

According to the distribution of ostracods it seems most likely that meromixis in Lobsigensee started during the Bølling or even slightly before. The almost complete extinction of the early ostracod fauna during the late Dryas 1 is paralleled by the disappearance of several cold stenothermic chironomid taxa before and during the Bølling (Hofmann, 1985b). At that time the lake was still about 12 m deep and therefore must have had a cold hypolimnic body of water which enabled the survival of cold stenothermic ostracods and chironomids. The sudden occurrence of *Chaoborus flavicans* during the Bølling suggests a deterioration of the oxygen condition of the profundal zone.

The end of the meromictic stage is marked by the recolonization of the profundal zone by ostracods during the Boreal, when the lake was only about 10.5–11 m deep. Based on fossil pigments a.o. from *Oscillatoria rubescens* Züllig (1985) has given support to this last period of the meromictic stage but he also mentions an earlier step of eutrophication at the beginning of the Bølling. This step, in combination with a change in the thermal conditions from cold monomictic towards dimictic behaviour of Lobsigensee, would account for the onset of meromixis. A further strong argument for the meromixis of Lobsigensee during the latest Pleistocene and Preboreal is the oligotrophic condition in

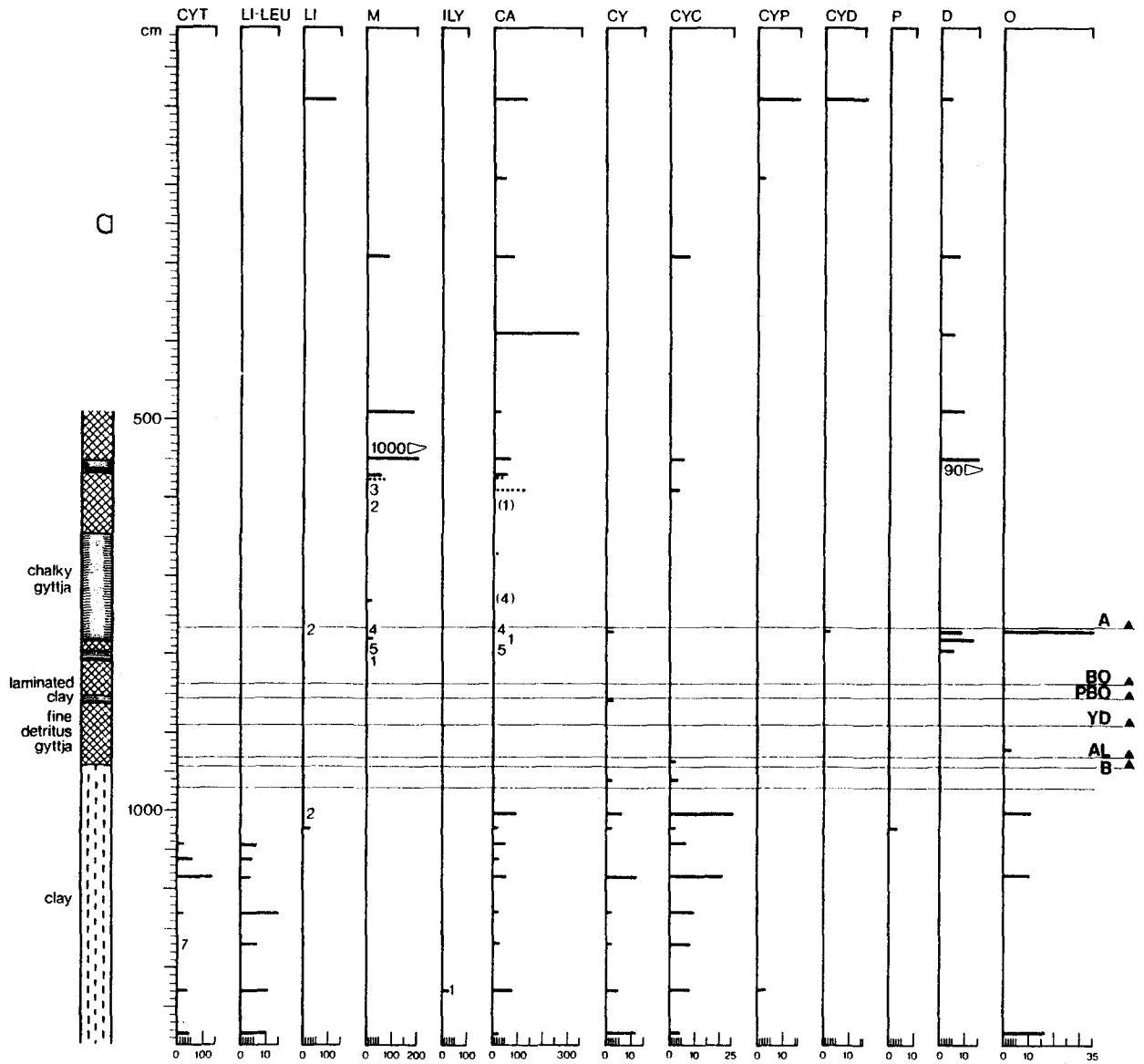


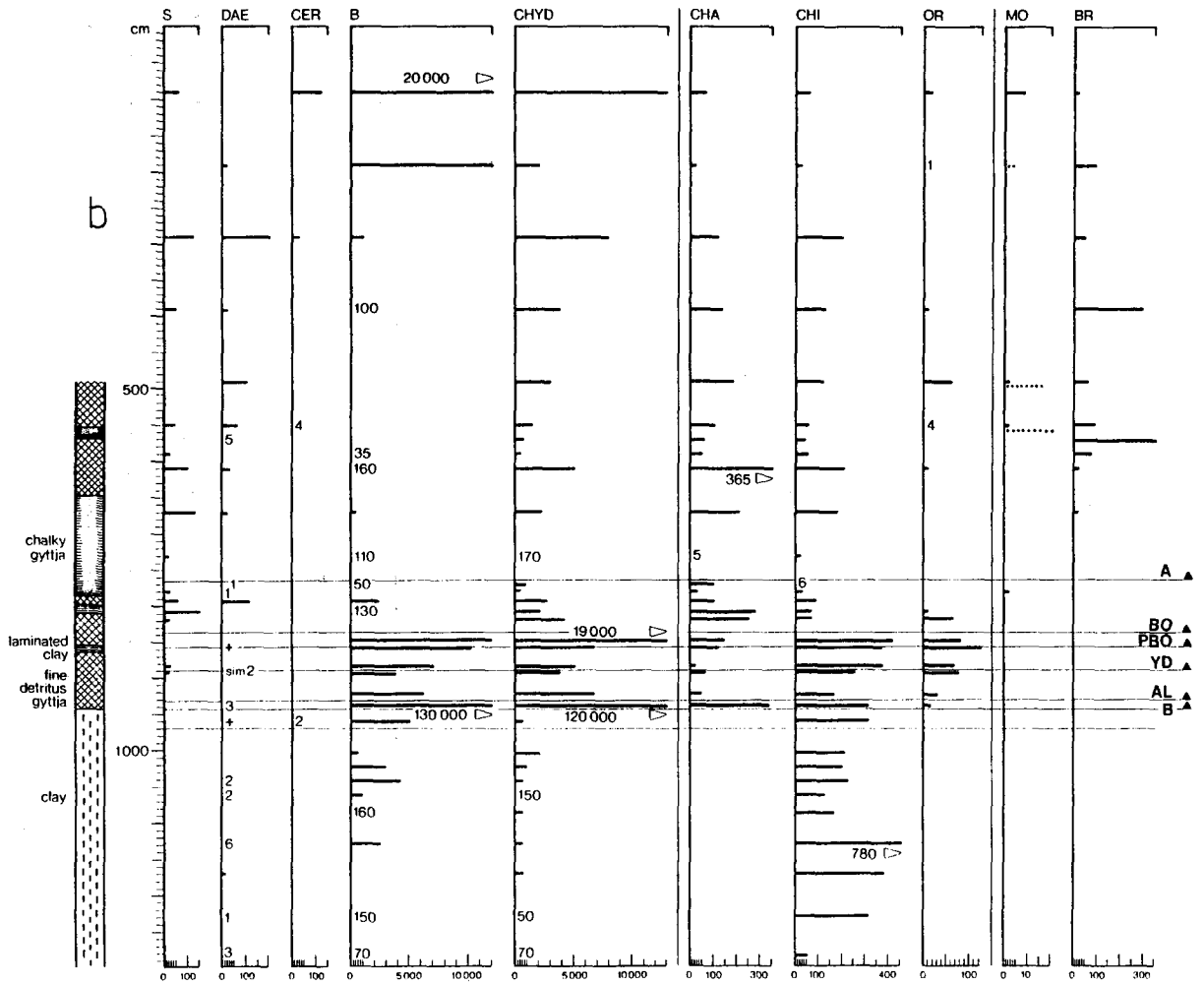
Fig. 2a, b, c. Distribution of the remains of some organisms in core 160 a. To the left the type of sediment is indicated (information available only from 500 cm downward).

B: Bølling, AL: Allerød, YD: Younger Dryas, PBO: Preboreal, BO: Boreal, A: Atlanticum.

(a) Cyt: *Cytherissa lacustris*, Li-Leu: *Limnocythere sanctipatricii – Leucocythere mirabilis*, Li: *Limnocythere* juv. (most likely *L. inopinata* at 90 cm), M: *Metacypris cordata, Ily: Ilyocypris sp.* Ca: *Candona spp.*, Cy: *Cypria ophthalmica*, Cyc: *(C) Cyclocypris sp.*, Cyp: Cypriniae sp., Cyd: *(C) Cypridopsis vidua*, P: *Potamocypris sp.*, D: *Darwinula stevensoni*, O: Fragments of ostracod shells.

(b) S: *Sida crystallina*, Dae: Ephippia of *Daphnia sp.*, Sim: Ephippia of *Simocephalus sp.*, Cer: Ephippia of *Ceriodaphnia*, B: *Bosmina sp.*, Chyd: Chydoridae, Cha: *Chaoborus flavicans*, Chi: Chironomids, head-capsulae, Or: Oribatei, Mo: Fragments of molluscs (dotted lines: *Pisidium sp.*, otherwise gastropods), Br: Bryozoans (*Plumatella*).

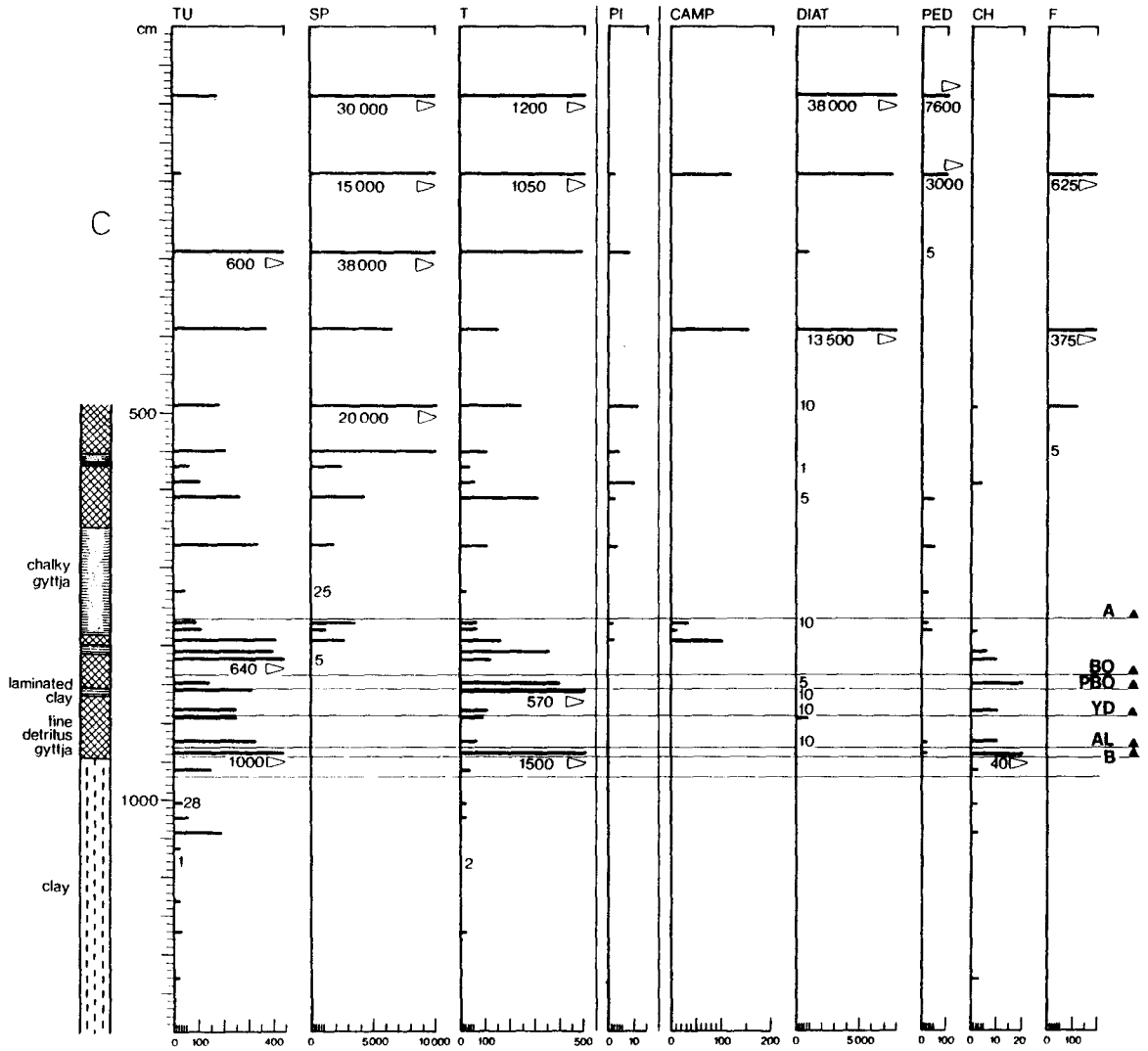
(c) Tu: egg cases of Turbellaria, Sp: Sponges, T: Testacea, Pi: Scales of *Perca fluviatilis*, Camp: *Campylodiscus sp.*, Diat: other diatom species, Ped: *Pediastrum*, Ch: Charales, F: Ferns.



the Younger Dryas proved by pigments (Züllig, 1985).

A striking similar development of circulation patterns was found in Kleinsee (Carinthia), a kettle which at present has a maximum depth of 9.3 m (during the early late Glacial it was at least 16 m deep) and an area of 1.2 ha (Löffler, 1977). As in Lobsigensee a group of ostracod species (*Cytherissa lacustris, Ilyocypris sp.* and *Eucypris sp.*) disappears during the early Bølling, and *Chaoborus* enters the lake – somewhat later namely during the Allerød – when the maximum depth was about 13 m. Recolonization of the profundal zone by ostracods, however, took place only during the Subatlanticum but at a time when Kleinsee, like Lobsigensee, had a depth of approximately 11 m. It is also of interest that species involved in this recolonization are the same in Lobigensee: *Limnocythere inopinata, Metacypris cordata* and *Darwinula stevensoni.*

Finally it may be mentioned that in the lakes of Carinthia which are still meromictic (Goggausee, Klopeiner See and Längsee) very similar events were observed. In all of these cases the disappearance of an early ostracod fauna is followed by the immigration of *Chaoborus.* In small lakes this happened between Bølling and Allerød whereas in lakes with a size class of 1–2 km^2 it took place between Allerød and Preboreal.



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