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Litho- and palynostratigraphy at Lobsigensee: Evidences for trophic changes during the Holocene

Studies in the Late-Quaternary of Lobsigensee No 13

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Abstract

In the pond of Lobsigensee (2 ha, on the Swiss Plateau) lithostratigraphic and palynostratigraphic units for the Late-glacial and the Holocene have been described. During the Late-Glacial the sediment types are mainly controlled by climate (the end of clay deposition coincides with the end of the Oldest Dryas, i.e. with reforestation at the beginning of Bölling) or by facies (lake marl in the littoral, gyttja in the profundal during Bölling and Alleröd). During the Holocene the facies and the changes in the trophic status, partly combined with water level changes, seem to determine the types of sediment. Two phases of natural eutrophication are deduced from laminated sections during the Boreal and the early Older Atlantic. Towards the end of the Younger Atlantic an early example of a probably anthropogenic eutrophication is found in the layers contemporaneous with the neolithic settlement of the Cortaillod culture. Since the Roman colonization the amount of erosional input has markedly increased.

Introduction

At Lobsigensee – a small closed basin on the tertiary Molasse covered by till on the Swiss Plateau – multidisciplinary studies are in progress to elucidate the paleoecology of the lake and its surroundings since the last glaciation. Among other biostratigraphies, pollen stratigraphies have been developed from 12 cores along two transects (see Fig. 1). They reveal 10 local pollen assemblage zones (= local paz) for the Late-Glacial and 20 local paz for the Holocene (Ammann & Tobolski, 1983; Ammann, 1984, 1985). Conclusions can be drawn in terms of regional and local vegetation, climate, lake level changes, trophic status and patterns of pollen deposition within the basin. The present communication shall concentrate on the evidences for changes in the lake level and in the trophic status during the Holocene. Fig. 1a presents the situation of Lobsigensee, covered by Rhone ice during the Last Glaciation, and Fig. 1b the coring sites along the two cross sections LQ and LL.

Description of cross section LQ

The main cross section LQ through the sediments of Lobsigensee is represented in Fig. 2. From the longitudinal cross section LL the most important core LL-160 (see Löffler, 1986; Züllig, 1986, this volume) is projected into LQ. The original sediment description was worked out according to the simplified Troels-Smith-system proposed by Aaby 1979. But for the present synopsis a further reduction of elements was necessary, especially within the symbols for peat and for gyttjas (see caption in Fig. 2); a somewhat more detailed version of the lithostratigraphy is presented in Ammann 1985.

The topmost sediment was often disturbed, either by tillage (cores on land, LQ-20 to LQ-150) or during the coring process under water. All cores were taken by means of two modified Livingstone corers (Merkt & Streif, 1970). In Fig. 2 the columns to the right of the lithostratigraphy show the local paz in Arabic numerals (L1 to L30, see Ammann, 1985) and/or the regional pollen zones according to

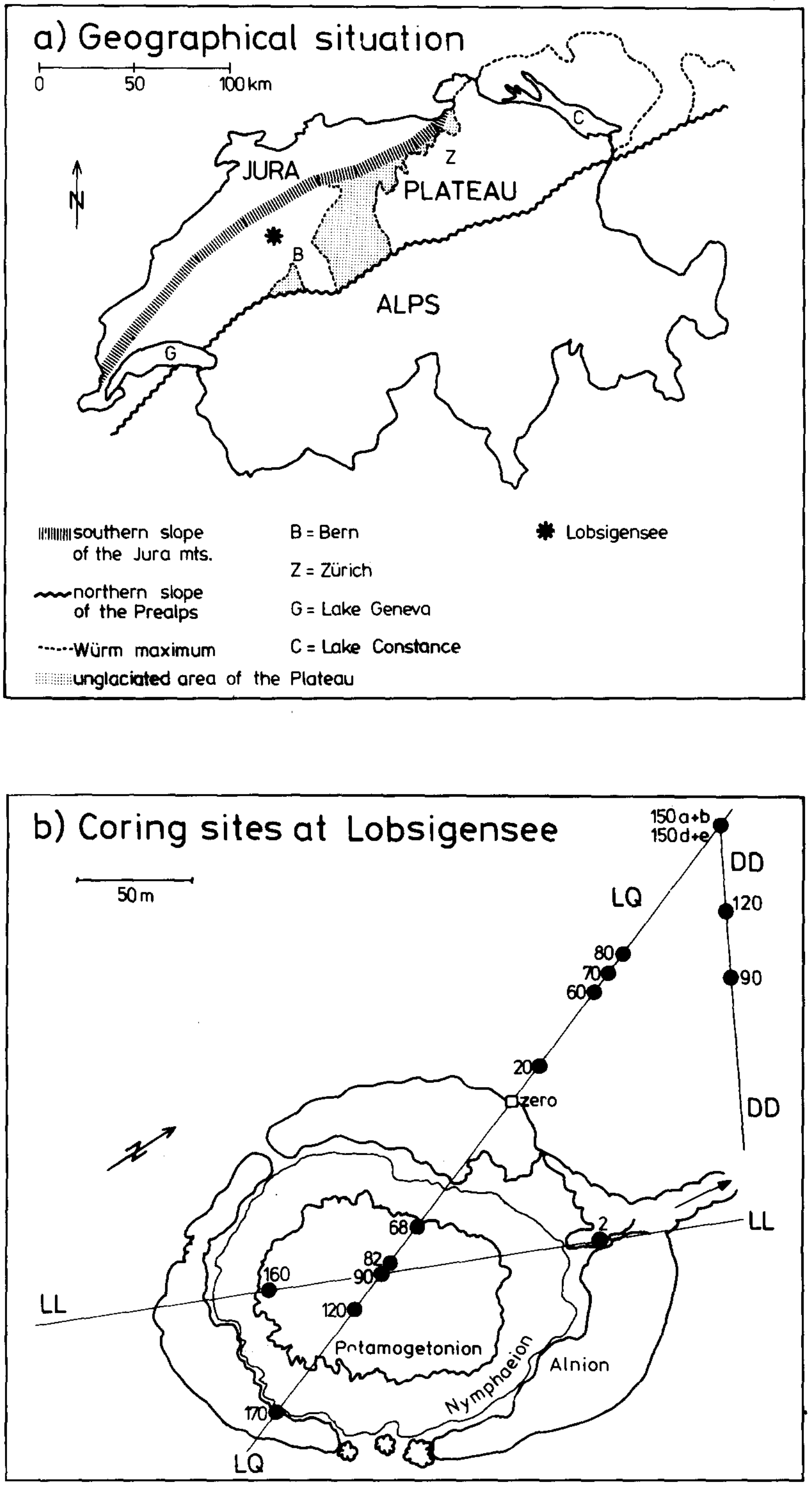


Fig. 1. The site of Lobsigensee, a) Geographical location on the Swiss Plateau. b) Cross sections LQ and LL with sites of cores taken by modified Livingstone samplers. DD = ditch for drainage pipes.

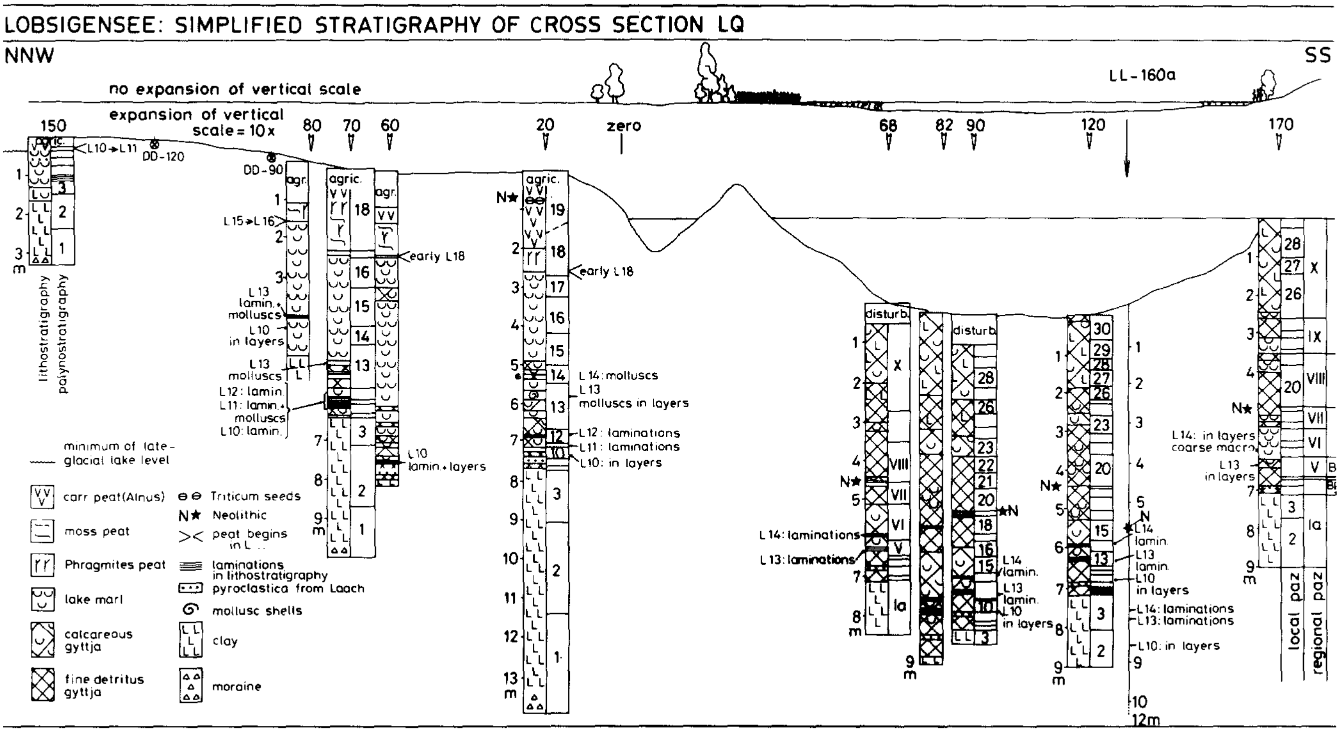


Fig. 2. Simplified litho- and palynostratigraphy of the cross section LQ at Lobsigensee.

Firbas 1949, 1954 in Roman numerals.

As main features we can observe:

– The lake level during the Late-Glacial (local paz L1 to L10) was at least 2 m higher than today. During the Late-Glacial the surface was about 10 ha (today 2 ha), the maximum depth in early Late-Glacial was 17 m (today 2.7 m).

– The SSE-shore is relatively steep, the NNW-shore exhibits a former littoral terrace (LQ-20 to LQ-150); this reflects the general topography and the geology of the gently folded Molasse (Kellerhals & Tröhler, 1981).

– In all cores the clay of the Oldest Dryas was reached (local paz L1 to L3), in some cores even the moraine of the Last Glaciation (Würm), see cores LQ-150, LQ-70 and LQ-20.

– The upper limit of the clay always corresponds to the upper limit of the Oldest Dryas, i.e. the transition to the Bölling. At that time reforestation by juniper and tree-birches took place, soils became stabilized and the inwash of clay stopped.

– The sediment of the Bölling (local paz L4 to L7) and Alleröd (L8 and L9) consists of lake marl in the most littoral cores (LQ-80 and LQ-150) and of gyttja in all the other cores.

– On the littoral terrace hiatuses and 'condensation' of local paz are registered (L4 to L9); these features will be discussed in another paper.

– In general calcareous gyttjas or even lake marl dominate the littoral cores and fine detritus gyttjas dominate the profundal cores.

– During the Younger Dryas (L10) laminations and some alternations of coarser layers are found for the first time. Whereas earlier papers dealt mainly with results from the Late-Glacial and early Holocene sediments (Ammann *et al.,* 1983, 1985) we here want to focus on a prominent feature of the holocene sediment, namely the laminations:

– During the Preboreal (L11) laminations are visible in LQ-20; they are also present over a bed of densely packed mollusc shells in LQ-70.

– During the first part of the Boreal (L12) only two cores show laminated sediments, LQ-70 and LQ-20.

– Nearly all cores have laminated sediments during the second part of the Boreal (L13); in

LQ-20, LQ-70 and LQ-80 they are combined with mollusc beds.

– The next event with laminations occurs during the earliest part of the Older Atlantic (L14), but is registered only in the profundal cores LQ-68 to LQ-170. In the cores of the littoral terrace however the deposit is more or less pure lake marl. The core LQ-20 may be considered as a transition: some bands with more organic material and two layers of molluscs are found in the lake marl. The core LQ-170 at the SSE-end of the transect exhibits instead of laminations some coarse layers of plant macrofossils in the lake marl during L14.

– A narrow but very marked section with laminations is coincident with the local paz L19, marked with an * and N in Fig. 2. It is the sediment deposited during the neolithic settlement of the Cortaillod culture at Lobsigensee. The village of lake dwellers has not yet been excavated but is known from sporadic findings of ceramics and stone axes and from charred grains of wheat as found in LQ-20.

– From archaeological findings (Stöckli, pers. comm.) and two radiocarbon datings (Oeschger *et al.*, 1985) we know that the settlement has an age of about 5000 conventional radiocarbon years.

– The beginning of peat formation is naturally a metachronous process in the basin: in the most littoral core LQ-150 it is synchronous with the transition from Late-Glacial to Holocene i.e. from Younger Dryas to Preboreal (L10 to L11). Towards the lake it becomes younger: in core LQ-80 during the Older Atlantic (L15 to L16), in cores LQ-70, LQ-60 and LQ-20 in the middle of the Younger Atlantic (early L18).

The nature of laminations and their conditions of formation

The laminations found in the above described stratigraphic positions are conspicuous to the eye by their colors: grey-whitish lake marl alternates with dark brown fine detritus gyttja. But the limits of the layers are unsharp and often uneven or slightly undulating; therefore some layers are lenticular rather than horizontally continuous. Counting the layers would be hazardous. Thin sections in araldit (Merkt, 1971) confirm these observations. The thickness of a twin-layer (one organic + one carbonatic layer) varies between 0.3 and 0.9 mm. Most probably the organic layer was deposited during autumn and winter, the carbonatic one during spring and summer (Kelts & Hsü, 1978; Sturm, 1985, 1986); no distinct diatom layers are visible.

Laminations and their formation have been studied in a vast series of lake types (e.g. by Welten, 1944; Tippett, 1964; Simola, 1977; Saarnisto, 1979; Renberg, 1976, 1981; Renberg & Segerström, 1981; Swain, 1978; Tolonen, 1978; Sturm, 1979, 1985, and others). One condition for preservation of laminae of any kind is valid for all lake types, namely the absence of bioturbation. This is usually connected with the lack of oxygen at least during the summer at the bottom of the lake. Anoxis may be due to meromictic or eutrophic conditions. Considering Fig. 2 we can also ask: why does carbonate, which is usually precipitated in the littoral, reach the center of the lake during periods of laminations (e.g. during L13 and L14 in cores LQ-68 to core LQ-120 and LL-160)?

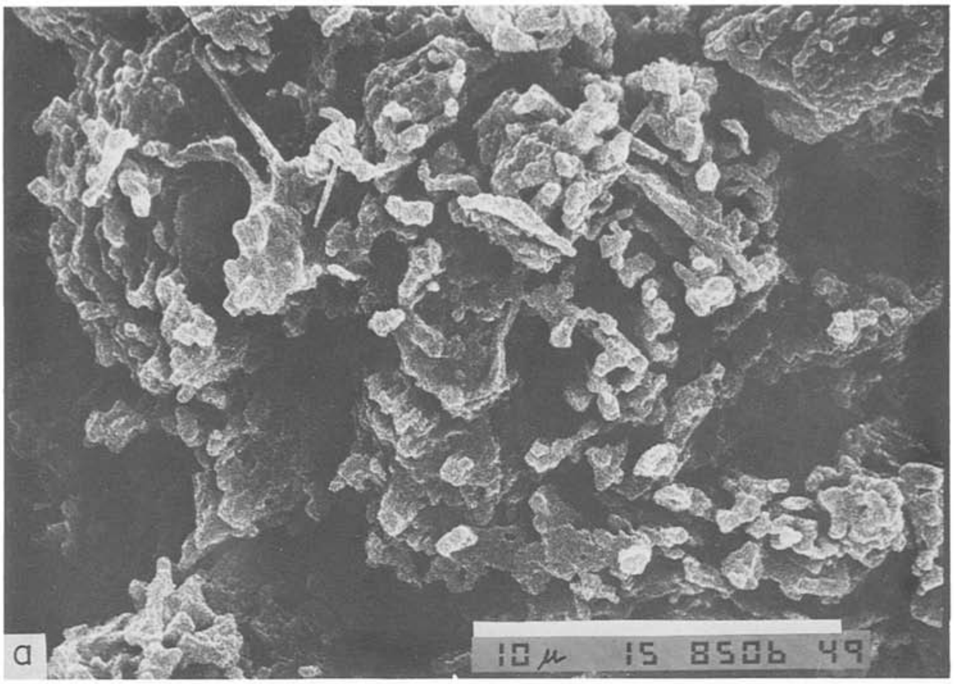
Either or both of the following reasons may apply:

– The littoral influence became marked in the profundal zone because the littoral zone got closer, i.e. the lake level fell.

– The bicarbonate equilibrium is not only controlled by factors such as temperature and pH but also by the phosphorus concentration (Kunz, 1983; Kunz & Stumm, 1984; Sturm, 1985). A pulse of phosphorus input would thus first inhibit the calcite precipitation; after consumption of the phosphates by the phytoplankton in summer the precipitation of large calcite crystals out of the oversaturated solution would follow.

Discussion of the processes at Lobsigensee

The beginning of peat formation does not necessarily point to a falling lake level but can be the result of infilling processes and overgrowth under more or less constant lake level. But at our site the bottom layer of peat gets both younger and deeper towards the lake. Unfortunately the estimation of the water level from the types of peat is not very exact and seasonal water level fluctuations may be important. But generally we can assume that the mean water table was near the transition from Phragmites peat to carr peat (here mainly alder).



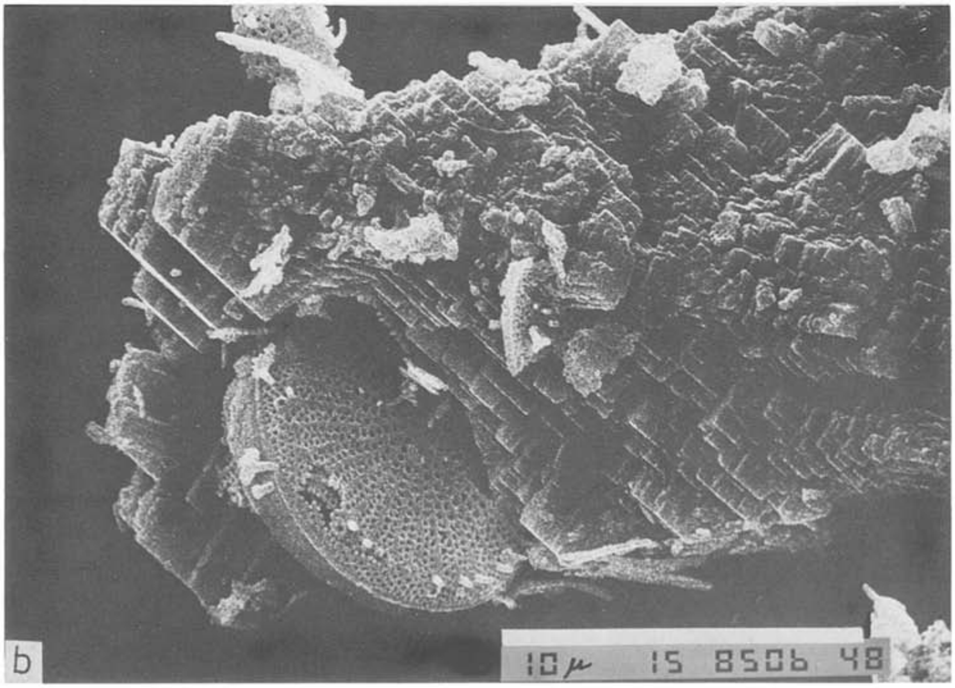


Fig. 3. a) Micritic $CaCO_3$-crystals from the littoral lake marl in core LQ-150a (Lobsigen, local paz L7, Bølling). b) Large, blocky calcite crystals from the profundal core LQ-90 (Lobsigen, local paz L19, Younger Atlantic, neolithic settlement of the Cortaillod culture). A frustule of Stephanodiscus cf. hantzschii functioned as a nucleus. (REM-micrographs taken on Jeol JSM-T 300 at the Systematisch-Geobotanisches Institut Bern).

During April 1981 an artificial ditch for drainage pipes was dug (in Fig. 1b indicated with DD); thus we could sample the transition from lake marl to carr peat in the upper part of the littoral terrace: at point LQ-150 first peat formation at transition L10/L11, at point DD-120 first peat formation during L11 (Preboreal), at point DD-90 first peat formation at transition L11/L12 (PB/BO), at point LQ-80 first peat formation at transition L15/L16 (Older Atlantic), from point LQ-70 to LQ-20 formation in early L18 (Younger Atlantic). This shows that in the early Holocene (Preboreal = L11 and Boreal = L12 and L13) the upper section of the littoral platform became overgrown and thus the volume of the lake became smaller. Remarkable also are the findings of densely packed mollusc layers during L11 (in core LQ-70) and during L13 (in cores LQ-80, LQ-70 and LQ-20) which must be littoral formations. They are possibly remnants of short term fluctuations of unusually low water levels.

As a working hypothesis we therefore suggest: during the climatic warming of the Preboreal and Boreal and with a falling lake level and overgrowth the water body of Lobsigensee became – at least for some periods – small enough to become naturally eutrophic. Eutrophication (or meromixis) is confirmed by Züllig's (1985, 1986 this volume) findings of fossil pigments from *Oscillatoria rubescens* in core LL-160 (laminated part of Boreal) and in core LQ-68 (laminations from early Older Atlantic).

The other marked laminations coincide with the local paz L19. Six holocene pollen diagrams prove, that during L18 the first neolithic settlers were present in the area and that during L19 they lived at the shores of Lobsigensee. As especially noteworthy plant macrofossils Tobolski 1985 recorded the seeds of *Fragaria vesca* and *Papaver somniferum* in L18 of the littoral core LL-2. In core LQ-20 the charred seeds of *Triticum aestivum* have been found in L19. From Fig. 2 we can see that during the zone L18 peat formation started on the lower part of the littoral terrace. According to the stratigraphy of core LQ-20 the lake level was then even lower than today (by about 80 cm).

The size and aspect of the calcite crystals in these neolithic laminations differ distinctly from the ones in ordinary littoral lake marl as Fig. 3 illustrates. Remembering the results presented by Kunz 1983 and Sturm 1985, we propose our second working hypothesis: these large blocky calcite crystals can be a result of a fossil P-input by the neolithic lake dwellers into a lake of a smaller volume and would thus be an example of an early human impact on a lacustrine environment. A reduction in the volume of the water body obviously played a role in the formation of all laminated sections (L11 to L19) as they were preceded by phases of a falling lake level and steps of peat formation on the littoral terrace (during L11 to L18). In addition, the two main steps of eutrophication were caused one by the climatic warming in the early Holocene and the other by an antropogenic phosphorus input during a neolithic phase of settlement. This means that we have an example of a natural and of a more man-made eutrophication respectively.

In all holocene pollen diagrams from Lobsigensee (e.g. Ammann, 1985) two major levels of changes among herbaceous plants are recorded: one at the level of the neolithic settlement (L19) and another at the level of the Roman colonization (L23). Oeschger *et al.* 1985 could show by means of a series of 10 radiocarbon dates through the Holocene that this latter signal is also visible in the age-depth relation: shortly before 2000 B.P. (conventional) the sedimentation rate increases by a factor of 3.7. The increasing portion of inwashed clay in the Roman and post-Roman sediment pinpoint to the same agent – intensified deforestation by man.

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