VEGETATIONAL DEVELOPMENT DURING THE LATE-WURM AT LOBSIGENSEE (SWISS PLATEAU).

STUDIES IN THE LATE QUATERNARY OF LOBSIGENSEE 1.

by

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ABSTRACT

Lobsigensee is a small lake situated northwest of Bern at 514 m asl and was covered by Rhone ice during the Wurm glaciation. Palynological and plant macrofossil studies of a Late-Wurm deposit in the littoral are presented. The stratigraphy of the sediments is from bottom to top: sand, sandy clay, clay, lake marl, peat. The Oldest Dryas consists of three local pollen assemblage zones recording the gradual establishment of a treeless vegetation rich in heliophilous and pioneer species and also containing dwarf shrubs in its third phase. At the transition from clay to lake marl a sharp Juniperus peak initiates the Balling which is mainly dominated by tree-birches. This shift from dwarf birch to tree-birches is confirmed by the macrofossils analyzed. An equivalent of the Older Dryas is not found. The beginning of the Allerod is characterized by the expansion of Pinus and its end by the volcanic ash from Laach. There are slight but consistent indications of a more open vegetation during the Younger Dryas. The transition from lake marl to peat coincides with the boundary between Late-Wurm and Holocene.

As in all ecological investigations, palaeoecological studies try to work on an interdisciplinary basis. In such a "chamber ensemble" palynology has proven to play a strong "thorough-bass continuo": it can provide both the framework of late- and postglacial pollen zones and more detailed information about local and regional vegetation (see GAILLARD, 1983; ELIAS and WILKINSON, 1983; HOFMANN, 1983; CHAIX, 1983; EICHER and SIEGENTHALER, 1983; AMMANN et al., 1983).

A. THE LOCALITY

Lobsigensee (47° 01' 55" N and 7° 17' 57" E, 514 m asl) is a small lake situated on the western Swiss Plateau about 15 km northwest of Bern. It fills the lowest part of a small tectonic depression in the folded tertiary Molasse (Lower Freshwater Molasse, sandstones and marls). During at least the last three glaciations Lobsigensee was covered by the ice of the Rhone glacier; its northeastern lobe extended from Lake Geneva to the area of Solothurn during the Wurm maximum (Fig. 1). The date of the last deglaciation is not known but it was considerably before 13 5000 B.P. and it could well had been around 16 000 B.P. The area is covered by till of the Wurm glaciation; moraines are mapped on the hills NW and SE of the lake (KELLERHALS and TRÖHLER, 1991). The actual vegetation consists of floating-leaved aquatics (Nymphaeion) and reeds (Phragmition) in the lake, a narrow belt of a riparian forest (Alnion glutinosae) around it and intensively cultivated fields in its surroundings. The original vegetation before agriculture was mainly beach forest (Asterulo-Pagetum; on poor soils Luzulo-Pagetum s.l., and on dry chalky soils Carici-Pagetum, HEGG, 1980). The slopes of the Jura mountains are 17 km distant, the northern Préalpes are about 40 km away. Lobsigensee is a closed basin with a modern surface of 2 ha and a maximum depth of 2,5 m. In the early Late-Glacial its surface was at least 10 ha and its maximum depth at
Fig. 1

The climate. C. The site "150" is the most littoral point of the cross section LQI. D. Sampling was done by coring and by digging a pit.

A. Geographical situation

B. Climate

C. Cross sections at Lobsigensee

D. Sampling site 150
least 17 m. Today the ratio of lake surface to drainage area is about 1:50. The climate of the region is represented in Fig. 1.

B. METHODS

Since Lobsigensee was chosen as a primary reference site in the Swiss contribution (LANG, 1983) to IGCP 158b, we followed the guidebook (BERGLUND ed., 1975, 1982) in many respects. The topic of the present paper is only the site called "150", the most littoral point of the crosssection through the basin (Fig. 1). The twin cores 150a-b were taken with a Livingstone sampler modified according to Streif (MERKST and STREIF, 1970). For the study of the fossil insects (ELIAS and WILKINSON, 1983) large samples were needed which were obtained by digging a pit (Fig. 1). From its open wall, material for a second pollen profile 150e was taken in metal boxes about 70 cm distant from the core 150a. Subsamples of known volume (1-4 cm³) were prepared together with Lycopodium pellets (STOCKMARR, 1971) with HCI, hot HF, acetolysis and KOH, and mounted in glycerin. For the profile 150e (and its basal completion "200") a percentage diagram was drawn and for 150a-b a diagram with concentrations and percentages was drawn. Two columns in Fig. 2 represent cumulative area diagrams which include and exclude Cyperaceae. These only show marked differences in the lowest pollen assemblage zone L2 with its high percentages of Cyperaceae. This cumulative area diagram will be more informative when Betula nana is recorded quantitatively; in the current diagram dwarf birch is still included in the sum of the trees (see GAILLARD, 1983). The black dots represent single grains. Pollen assemblage zones and their boundaries are defined according to the percentage diagrams; only the profile L2 = first grains of Juniperus and Hippophaë appear. The lower boundary of L 2 was only reached in the profile 150a-b (Fig. 3).

Contact L 2/L 3 : rise of Betula above 15 % or from 5-12 % (1-9 %) to 19-35 % (24-33 %) fall of Cyperaceae below 20 % or from 20-33 % (10-48 %) to 8-20 % (9-17 %)

L 3 = Artemisia-Betula nana -paz : Betula shows a plateau at 18-35 % (for its attribution to B. nana see the chapter on plant macrofossils and GAILLARD, 1983). Artemisia is at 2-5 %, Selaginella selaginoides, Botrychium, Centaurea scabiosa -type, Rumex / Oxystis and Myrio­phyllum spicatum show for the first time continuous curves.

Contact L 3/L 4 : rise of Juniperus above 10 % or from 0.2-2 % (0.5-4 %) to 11-50 % (15-60 %) fall in many NAP, sum NAP below 50 % or from 55-74 % (58-67 %) to 11-42 % (13-46 %)

L 4 = Juniperus-Hippophaë -paz : Juniperus shows a remarkable peak in the pollen curve, its stomata occur as well. Hippophaë reaches its maximum. The fall in NAP is especially marked among heliophytic taxa: Ephedra, Artemisia, Helianthemum, Gypsophila, Lithospermum, Selaginella selaginoides. Cyperaceae decrease as well.

Contact L 4/L 5 : fall in Juniperus below 15 % or from 11-50 % (15-60 %) to 0.5-13 % (0.2-17 %) rise in Betula above 60 % or from 13-23 % (16-26 %) to 67-88 % (66-92 %)

L 5 = first Betula alba -paz : Betula is most abundant (attribution to the tree-birches see chapter on plant macrofossils and GAILLARD, 1983), while Juniperus is gradually decreasing to even below 1 %. A second fall of NAP concerns again mainly the heliophytic taxa: end of the continuous curves for Caryophyllaceae, Saxifraga oppositifolia-type and Selaginella selaginoides.

Contact L 5/L 6 : Betula decreases slightly from 67-88 % (66-92 %) to 60-77 % (62-67 %) Salix increases above 3.5 % or from 1.5-3.5 % (1.3-3.5 %) to 3.5-6.5 % (3.5-7.5 %)

NAP increases above 15 % or from 8-12 % (5-15 %) to 16-23 % (16-27 %)

L 6 = Betula-Salix-Artemisia -paz : Betula percentages are somewhat reduced while Artemisia shows an increase and Salix gets its maximum values. L 6 is in the following also termed "Betula -depression".

Contact L 6/L 7 : Betula increases slightly from 66-77 % (62-67 %) to 70-87 % (72-85 %) Salix decreases below 3 % or from 3-6.5 % (3.5-7.5 %) to 0.7-3.1 % (0.6-2.6 %)

NAP decreases below 15 % or from 16-23 % (16-27 %) to 7-13 % (8-14 %)

L 7 = second Betula alba -paz : Tree-birches again dominate; Salix, Artemisia and Gramineae return to values similar to L 5.

Contact L 7/L 8 : beginning of the rise of Pinus (above 5 %)

L 8 = Betula-Pinus -paz : in pollen percentages and concentrations L 8 is a transitional pollen assemblage zone: the curve of Pinus rises slight before the beginning but gradually becomes steeper and the curve of Betula falls. Towards the end of this paz the two curves cross each other. But we prefer not to use this crossing as a link between two pollen zones because it is affected by facial differences due to differential flotation of Pinus pollen. In the upper half of L 8 NAP decreases a last time.

Contact L 8/L 9 : end of the rise of Pinus (above 80 %)
Fig. 2  Lobsigensee: diagram of pollen percentages from 150e (open pit).

LOBSIGENSEE  514 m asl  (Swiss Plateau)  LOI 150e and LOI 200

LOBSIGENSEE  514 m asl  (Swiss Plateau)  LOI 150e and LOI 200

[Diagram showing pollen percentages and stratigraphy]
## 1. Vegetational development during the Late Würm...

### Sampling at open pit April 13, 1981

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<thead>
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<th>Unit</th>
<th>Helophytes</th>
<th>Various Ecologies</th>
<th>Waris-Organisms</th>
<th>Moist Habitat</th>
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### Table

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<td>L10</td>
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### Diagram

- Analyzed by Ammann 1987

- Depth in cm

- Various Helophytes

- Various Ecology

- Waris-Organisms

- Moist Habitat
end of the fall of Betula (4 20%).

L 9 = Pinus-Betula-paz : Pinus is dominant in this paz with 76-91 % (70-81 %), Betula is subdominant with 8-22 % (17-28 %), NAP are at their minimum with 1-4 % (1-2 %).

Contact L 9/L 10 : Artemisia increases slightly from 0-2-12 % (0-1-0-5 %) to 1-6 % (0-2-6 %) Gramineae increase slightly from 0-3-12 % (0-3-0-6 %) to 1-5 % (0-3-4 %).

L 10 = Pinus-Gramineae-Artemisia-paz : while the Pinus-dominance continues, many NAP, especially Gramineae and Artemisia, increase. Both Sphagnum-types, Hippophaë and Juniperus are more frequent. The upper boundary of L 10 was not recorded in 150a, but in the cores 150a + b (see below).

2. THE PERCENTAGE AND CONCENTRATION DIAGRAM 150a + b

The stratigraphy of the cores 150a-b is very similar to the one from 150a + 200. The surface of the ground served as zero-level. The twin cores a and b were taken with overlapping 1m-sections by means of a modified Livingstone sampler. In Fig. 3, in the column "samples", black dots mark the samples used for the diagram, circles mark the samples analyzed but used only for correlation between the twin cores. Pollen analysis showed a difference in levels of 10 cm between core a and core b at the upper junction; we kept the original depths and therefore the sample 88 cm is followed by the sample 75 cm (instead of 85 cm).

Profile 150a+b: 0-25 cm peaty soil, disturbed by tillage 25-36 cm dark brown carr peat (Alnus mainly) with Phragmites, heavily decomposed T1/2, Th2 Phragmites 3 36-127 cm lake marl with plant remains, whitish, yellowish or pink Lc4, Ld-

127-130 cm transition from lake marl to clay (olive-gray) (As+Ag)2, Lc2 130-162 cm clay (blue-gray) with some carbonate (As+Ag)3, Lc1, Ga-

162-286 cm clay with some sand (especially 220-230 cm) (As+Ag)3, Ga1 268-330 cm clay (0-3-0-5 cm)

More detailed stratigraphic description will be given in an other paper comparing all the cores on the cross-section through the lake (AMNH).

Among the genera of the mixed oak forest increases from <1 % to 3-7 %

L 1 = Artemisia-Pinus-paz : Artemisia (10-23%) and Helianthemum (7-34 %) play a great role among the NAP (36-82 %), whereas Pinus (10-52 %) and Betula (below 12 % and gradually decreasing) make up most of the amazing high percentages of AP (18-64 %). Single grains of Quercus, Ulmus and Abies are indicators of reworked material. Water plants are lacking. Pollen concentrations are very low but gradually increasing (70-1100 grains/cm3).

Contact L 1/L 2 : Pinus percentages decrease below 10 % or from 10-52 % to 3-9 % NAP increase above 85 % or from 35-82 % to 85-92 %, beginning of the Salix curve, pollen concentrations increasing and passing 1200 grains/cm3.

L 2 = Artemisia-Helianthemum - Cyperaceae-paz : concentrations in all NAP increase (e.g. Artemisia, Helianthemum, Chenopodiaceae, Gramineae, Cyperaceae, Thalictrum). Sphæra fragilis-type and E. distachya-type are frequent.

L 3 = Artemisia-Betula nana - paz : at the contact L 2/L 3 the total pollen concentration is about constant, but Betula concentrations are increasing by a factor of 3. During the first half of L 3 the concentrations of most AP and NAP are rising.

L 4 = Juniperus-Hippophaë-paz : the concentrations of the pollen sum are increasing mainly due to a dramatic increase in Juniperus pollen. At the contact L 3/L 4 the concentrations of AP excluding Juniperus are only slightly increasing. At this transition the concentrations of the sum of NAP are about constant, while their percentages show a marked fall all through L 4; this holds true for Thalictrum and Cyperaceae and among AP for Salix, whereas for Artemisia, Helianthemum and Chenopodiaceae percentages as well as concentrations decrease. The contact L 3/L 4 is the only one in which changes in percentages and concentrations may not go in the same direction in the two samples with the Juniperus-maximum we can even find taxa with falling percentages and rising concentrations, e.g. Betula and Gramineae.

L 5 to L 10 : The pollen concentrations generally confirm the percentage curves. Considerable variation of concentrations of subsequent samples occurs in the dominant Betula (and therefore in the pollen sum) during L 6 and 7. Possible reasons for these variations are:

- real changes in vegetation (accurately reflected by changes in influx)
- sedimentary changes in the littoral lake marl artefacts during preparation (for instance differential loss of Lycopodium spores containing air bubbles).

Therefore the Betula depression of L6 is not proven by the concentration diagram.

Contact L 10/L 11 : Betula increases above 16 % or from 7-16 % to 16-23 % NAP decrease from 1-12 % to 1-6 %

L 11 = Pinus-Betula - thermophilous-paz : While the dominance of Pinus continues, Betula shows a small but distinct peak. Most NAP but especially Artemisia, Gramineae and Chenopodiaceae decrease; with the first or the second sample of L 11 the following taxa disappear: Juniperus, Sphæra, Helianthemum and Thalictrum. Instead, new taxa appear in this paz : Corylus, Alnus, Quercus, Ulmus. They occur in small quantities but rather regularly. With the transition from lake marl to peat all pollen concentrations increase very distinctly.

Contact L 11/L 12 : Pinus decreases below 60 % or from 73-80 % to 3-11 %

Corylus increases above 10 % or from 0-3 % to 13-47 %, mixed oak forest increases from <1 % to 3-7 %

L 12 = Corylus-Quercus mixtum - paz : The pollen spectra are dominated by Corylus. Among the genera of the mixed oak forest Ulmus is the most important (2-5 %), while Quercus and Tilia are below or around 1 %, Acer and Hedera are found as single grains, Fraxinus is still lacking.

3. THE PLANT MACROFOSSILS (K.T.)

The littoral lake marl at Lobsgensee is rather poor in plant macrofossils as compared with laterglacial deposits of the profound zone. Studies of the two profiles under consideration revealed merely the presence of a few fruits, seeds, scales etc. The list is presented in Fig. 4. Betula nana occurs mainly in the pollen zones L 2 and L 3 and is sporadically found in L 4 to L 6. The first fossil finds of tree-birches are present in L 2 and L 3. Wingless nutlets are undoubtedly derived from tree-birches but additional biometric techniques would be required to determine their taxonomic identity. Zone L 3 contains Betula pubescens fruits, typically with widely open upper parts of wings that protrude above the nutlet apex only to a small extent, as well as larger-sized nutlets with similar wings which are recognized as Betula torquata-type (BIŁOZOREWSKA and TRUČAŇOVICZWA, 1980). Tree-birches remain dominant in the pollen zones.

Fig. 3 Lobsgensee : Diagram of pollen concentrations and percentages from the cores 150a+b.
LOBSENSEE (Swiss Plateau)

LO1 - LO5 cm

pollen % and concentration (grains/cm³)

- LOBSENSEE
- (Swiss Plateau)
- LO1 - LO5 cm
- pollen % and concentration (grains/cm³)

[Chart with data and graph elements]
1. Vegetational development during the Late Würm ...

LS and L 6. It is also there that a greater number of Betula tortuosa-type members are found. The significance of tree-birches diminishes markedly in successive pollen zones. The uppermost finds come from a sample with Pinus silvestris remains.

It may be inferred that before the Juniperus peak of L 4, Betula nana was abundant and Betula sectio albae (tree-birches) was present; after L 4 dwarf birch disappeared, whereas tree-birches developed markedly. This is a confirmation of WELTEN's (1944), GAILLARD's (1981, 1983), LANG's (1952) and MIELKE and MÜLLER's (1981) results. Saladinella selaginoides were found in L 3 as the microspores in the pollen diagram (Fig. 2). The frequency occurrence of Chara decreases rapidly in L 3. This may be a local effect, i.e. changes in the vegetational belts during sediment accumulation, or due to eutrophication. Plant macrofossils from other cores along the cross-section through the lake will be discussed in another paper.

LOBSIGENSEE: PLANT MACROFOSSILS ANALYSIS: K. TOBOLSKI

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<td>SELAGINELLA SELAGINOIDEA</td>
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Fig. 4 Lobsigensee: plant macrofossils from selected samples.
**Fig. 5** Tentative chronology of the Late Würm: review of pertinent radiocarbon dates from the Swiss Plateau and from Schleinsee.

**REVIEW OF SOME NOT CALIBRATED 14C-DATES FROM LATE-WURM SITES IN THE NORTHERN ALPINE FORELAND**

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*sample completed with "dead carbon"
D. DISCUSSION
1. DATING THE ZONES
Gyttja and carbonate samples from profundal and littoral profiles of Lobsigensee have been submitted for dating, but at present we can only compare our diagrams with dated profiles of the area. Fortunately there are quite a few of them available, although their dates are not always without contradictions (WELTEN, 1972, 1982; GAILLARD, 1981). As a check point, we have the date of the volcanic ash from Laach/Eifel (van den Bogaard, 1983), in 150e at 36.5–38 cm and in 150b at 70–74 cm (corresponding to 80–64 cm in 150 a). This eruption is generally dated at 11 000 B.P.

Fig. 5 gives a review of the local and regional pollen zones, of some pertinent 14C-dates and of the attribution of the pollen zones to chronozones. For Lobsigensee we are using the chronozones proposed by WELTEN (1982).

In the following discussion we mainly compare our finds with the lowland sites between Lake Geneva and Lake Constance. Alpine sites are noted here considered because of differences in vegetational history controlled by differences in altitude (Zoller, 1968; Welten, 1972, 1982; HEEB and WELTEN, 1972; KUTTEL, 1974, 1979); these will be described for the Swiss contribution to IGCP 155b in a future synthesis by Lang et al. (in prep.).

2. THE OLDEST DRYAS (L 1 + L 2 + L 3)
Although we can mostly follow the nordic proposal for the Late-Weichselian chronozones (MANGERUD et al., 1974) in the northern alpine foreland (WELTEN, 1982) we choose to keep the Oldest Dryas (IVERSEN, 1964) – before the Bölling (before 13 000 B.P.) – an often long sequence of several (2-6) pollen assemblage zones, has observed (WELTEN, 1972, 1982 at Murifeld, WEGMULLER, 1977; de Coinsin, 1981; MÜLLER, 1982, MIELEK and MÜLLER, 1981 at Schleissenn, ROSCH, 1982 at Nussbaurnseen, KUTTEL, 1982, 1983 at Uffikon) as summarized in Fig. 6. The stippled horizontal lines indicate that we can by no means take these subdivisions of the Oldest Dryas as synchronous but only as a comparable pollen assemblage zones.

During L 1 = Artemisia-Pinus-paz the sources from long distance transport (especially Pinus and Betula) and from redeposition of secondary pollen were important but their quantitative relationship to the local pollen pool cannot be determined. Neither algae nor higher water plants are found in this periglacial lake. Comparably finds at the bases of Interglacial diagrams were presented by WELTEN (1944, 1952, 1982), AMMANN-MOISER (1975), (GAILLARD, 1981), KUTTEL (1982, 1983), ROSCH (1982).

During L 2 = Artemisia-Melianthomum –Cyperaceae-paz flora and vegetation became gradually richer: besides increasing NAP (percentages, concentrations, number of taxa) and besides the first plants (Potamogeton incl. Coleogeton, some Najas, a few Cyperaceae, a few Poaceae, some Arctostaphylos, some Myricaceae) and algae (mainly Pediastrum cf. integrum, some P. boryanum –types) the first grains of shrubs are found; but without macrofossils we can not decide whether single specimens of Salix, Juniperus and Hippophaë are present or whether we only register long distance transport of those genera immigrating into the wider area.

During L 3 = Artemisia-Betula nana –paz these three genera and especially Betula nana were growing around Lobsigensee, for plant macrofossils are found except for Hippophaë. Sporadically fruits of Betula alba were found as well (see preceding chapter). At Vidy/Lausanne WEBER, 1980a found in corresponding layers of Salix; he could attribute them to several species, dwarf shrubs as well as taller shrubs, but taxa of NAP still prevailed (often more than 20); alpine elements (e.g. Saxifraga oppositifolia-type, Plantago montana, P. alpina, Rumex/Oxyria) and "steppic" elements (e.g. Euphorbia distachya –type, K. fragilis-type) form a pattern of communities not existing today (IVERSEN, 1954; FRENZEL, 1966, pp. 230; GAILLARD, 1981 in her chapter "flore tardiglaciaire et phytogéographique"). In L 3 less sand and more carbonate are deposited than before. We can assume, that the latter is gradually of less detritic and more biogenic origin (see curve of Potamogeton). This means that the productivity of the lake has increased and the gradually denser vegetation cover around it is responsible for less erosional in-wash of sand, silt and clay. Our L 3 is comparable to the "Murifeld-Steppe phase" of WELTEN (1972, 1982), but it is not comparable with the lag of van der HAMMEN and VOGEL (1986) which designated a cooler phase.

The chronology of the Oldest Dryas is a delicate matter due to the scarcity of radiocarbon dates. Its lower boundary has not been dated in the northern alpine foreland. As WELTEN (1970) pointed out for the pollen zone L 1: "The lower limit of Oldest Dryas in our diagrams was always thought of as the practical limit of the boring system employed." So in many cases in our area the lower limit is given by the till of the last phase of Wurm glaciation (about 20 000 B.P.). But according to van der HAMMEN (1951) only later – palynostratigraphically at our transition L 1/L 2 – with the rise of Artemisia the boundary between Pleniglacial and Lateglacial is to be found.

The upper boundary of the chronozones of Oldest Dryas could be at 13 300 B.P. as indicated by the beginning of the pollen zone of Bölling (WELTEN, 1972, 1982 from Murifeld). 13 300 B.P. is 13 000 B.P. as defined as the beginning of the chronzone of Bölling (MANGERUD et al., 1974, WELTEN, 1982). But we must also consider the dates from Schleissenn (MIELEK and MÜLLER, 1981) where organic material of limnic and terrestrial origin was 14C-dated separately (Fig. 5): from limnic material a date for the Juniperus peak very similar to the one from Murifeld was measured at 13 495 ± 250 B.P. (corresponding to our L 4); however a comparable date of 13 325 ± 120 B.P. was obtained from terres­trial macrofossils (Betula nana, Salix sp, and Hippophaë) which marks there the rise of the Betula nana curve during the Oldest Dryas (corresponding to our transition from L 2 to L 3). The limnic and the terrestrial series of radiocarbon dates join at about 12 400 B.P. during the expansion of Pinus (and with a Betula peak interpreted as Older Dryas). SHOTTON (1972) has demonstrated two series of radiocarbon dates from samples of limnic and terrestrial origin from IVERSEN'S (1942) classical site at Nørre Lyngby: of the two almost linear series the limnic one is quite different than the terrestrial one. Several questions arise: are the available radiocarbon dates good enough (see de BEAU­LIEU, 1977, pp. 195) as a basis for long distance corre­lations? Do radiocarbon dates from lakes, as for instance at least 13 500 to 13 000 B.P. and recorded world wide (van der HAMMEN and VOGEL, 1966; COOPE and BROPHY, 1972; PENNINGTON, 1975, 1977; COOPE, 1977; RUDDIMAN et al., 1979, 1979, 1979; BERGLUND and LOWE, 1977; RUDDIMAN and McIntyre, 1981 and others) the date of 13 300 B.P. appears rather often; if this is meaningful, is this event reflected in our area by the expansion of Betula nana (as dated with terrestrial material at Schleissenn) or by the expansion of Juniperus or by the rise of the NAO-paz (as dated by limnic material at Schleissenn and at Murifeld)? How does our Artemisia - Betula alba-paz and Juniperus-Hippophaë-paz (L 3 and L 4) correlate with the Susac-interstadial (van der HAMMEN and VOGEL, 1966) or its equivalents (DREIMANIS, 1966; MENKE, 1968; SEREBRJANNYY and RAUKAS, 1970; BERGLUND, 1972) which ended at about 13 000 B.P.? According to van der HAMMEN and VOGEL (1966), MENKE (1968), SEREBRJANNYY and RAUKAS (1970) demonstrated a climatic regression between the Pre-Bölling and the Bölling­interstadial (Susac element, Betula nana and many others) (see Fig. 4). MILODORF - GRÖMITS - Bölling, but a new corre­lation was proposed by USINGER (1975) and Rauhns - Lug - Bölling respectively. In our diagrams, however, the L 3 and L 4 are just steps during a progressive vegetational development most probably controlled by a warming cli­
### Local Pollen Assemblage Zones in the Oldest Dryas

<table>
<thead>
<tr>
<th>Lobsigensee</th>
<th>Schleinsee</th>
<th>Murfeld</th>
<th>St. Laurent</th>
<th>Villarimboüd</th>
<th>Uffikon/Luzern</th>
<th>Nußbaumerseen</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3</td>
<td>Ia3</td>
<td>Ia2</td>
<td>Ia3</td>
<td>Vill 3</td>
<td>b2</td>
<td></td>
</tr>
<tr>
<td>Artemisia - Betula nana-paz</td>
<td>Betula nana: pollen and macrofossils</td>
<td>Murfeld-Steppenphase</td>
<td>toundra à arbustes</td>
<td>à Helianthemum</td>
<td>Betula nana zone</td>
<td>Zwergstrau-Rasen-phase mit Gebüschausbreitung</td>
</tr>
<tr>
<td>L2</td>
<td>Ia2</td>
<td>Ia1</td>
<td>Ia2</td>
<td>Vill 2</td>
<td>a4</td>
<td></td>
</tr>
<tr>
<td>Artemisia - Helianthemum - Cyperaceae-paz</td>
<td>Gramineae, Cyperaceae, Artemisia Helianthemum</td>
<td>Pionierphase</td>
<td>toundra &quot;dense&quot;</td>
<td>zone à Artemisia et Chenopodiaceae</td>
<td>Artemisia-Chenopodiaceae zone</td>
<td>Phase geschlossener Rasen</td>
</tr>
<tr>
<td>L1</td>
<td>Ia1</td>
<td>Ia1</td>
<td>Ia1</td>
<td>Vill 1</td>
<td>a3</td>
<td></td>
</tr>
<tr>
<td>Artemisia - Pinus - paz</td>
<td>many secondary pollen</td>
<td>Pionierphase</td>
<td>toundra &quot;maigre&quot;</td>
<td>Zone à Artemisia et Saxifraga oppositifolia</td>
<td>Thalictrum-Cyperaceae zone</td>
<td>Gräser-Kräuterphase</td>
</tr>
</tbody>
</table>

Note: The zones describe local successions, syndromes between the oldest Dryas (northern alpine foreland). The zones describe local successions, syndromes between the oldest Dryas (northern alpine foreland).
mate, developing soils and immigrating species. For Toublére de Coisin WEGMÜLLER, (1977) discussed a stagnation in the development just before the beginning of the juniper expansion. For Gerzensee and Faulensee EICHENGERTHALER, (1976) show a pronounced decrease in \( \Delta^{18}O \); but this minimum is synchronous with the steep rise of juniper. Also VERBRUGGEN (1979) observed a short stagnation or regression in the AP between \( \alpha \) and \( \beta \). Our decrease of NAP during L 4 can not be taken as a sign for a cooling climate because it happens during the increase of juniper and because it is an artefact due to the calculation of percentages: the concentrations of Betula increase steadily.

3. THE BÖLLING

The changes at the transition from L 3 to L 4 are very marked: pollen concentrations rise rapidly, pollen spectra change distinctly, the sediment shifts from clay to lake marl. The frequencies of \( Paeospermum \) are dropping. Related faunal changes are presented by CHAIK (1983) and by HOFMANN (1983). The juniper peak of L 4 = Juniperus - \( \varphi \)ppopho\- \( \varphi \)s is both of stratigraphic and ecological interest. Its wide spread occurrence at the beginning of reforestation is clearly throughout Europe and in the Netherlands. Bölling to the Boreal period respectively) was compiled by de BEAULIEU (1977). The relationship between ecology and pollen production discussed by IVERSEN (1953), BERTSCH (1961 b), VASARI (1968), RIKS (1973), BERGLUND (1966) and de BEAULIEU (1977) was partly confirmed by the finds of plant macrofossils by WEBER (1960) in the area of Vidy/Lausanne Juniperus communis and/or its subspecies nana WEBER (1979). The same was already present during the upper part of the Oldest Dryas, when its pollen production was still poor. The climatic change at the beginning of Bölling (around 14000 B.P.) favored several shrubs, but the more pronounced pollen production of juniper (IVERSEN, 1954) sharpened the rise of its pollen curve most distinctly (percentages and concentrations). Most probably the pollen production of Juniperus and Hippophae was still lower than in L 5. Unfortunately Betula concentrations fluctuate for two reasons: for one thing the pollen analysis for L 5 is missing. The second pollen type could as well be indicators for Betula (visible in percentages). She concludes for this phase: "L'interprétation de l'analyse pollinique en termes de végétation, de même que les valeurs polliniques absolues n'apporte aucune preuve d'un renforcement climatique", mais évocait plutôt une stabilisation des températures". For the period comparable to L 5, WELTEN (1982) writes: "Das relativ günsti- gen Charakter des Klimas der Aelteren Dryas unterstreicht die Tatsache der Entwicklung der Föhre vor dem endgli- tischen Rückgang der Artemisia- und Mineralpara- ke-Werte". Could the Betula depression be the record of drier conditions? Northern Artemisia and Salix are identifiable to species, but the first two pollen types could as well be indicators for steppic conditions (MENENDEZ AMOR and FLORSCHUTZ, 1963). LANDOLT, 1977, p. 160. Sanguisorba officinalis was found several times in L 6. Filippendula ulmaria and Sanguisorba officinalis present during the first and the second Betula dominance were not found in the Betula depression of L 6. As a whole the hints for dry conditions during this period are rather weak in our diagrams. A detailed discussion of arguments for a possibly dry Old Dryas in northeast Europe was given by KOLS- TRUP, 1982. In addition it is striking, that during the Older Dryas tree-birches were expanding into the area of Schleswig-Holstein glaciated during Weichselian (i.e. a contrast to a supposed cooling climate) as demonstrated by UISINGER, 1978, but the other hypothesis is strongly felt in diagrams from the central German dry area (MÜLLER, 1953: Gaalsteben und river system in precipitation < 500 mm/year). For western Belgium VER- BRUGGEN (1979) discussed a possible role of RUDIMAN and MCINTYRE (1981b, a) emphasize the importance of moisture conditions during deglaciation. For Logisensee ELIAS and WILKINSON (1983) demonstrate a special shift during L 6 which can not be interpreted of this period as a colder episode, but it does not directly support the interpretation as a drier one. The L 7 = second Betula alba-\( \varphi \)ps in most features resembles the first one (L 5). Towards the percentages of Pinus start to rise. Provided our correla-
tion between the transitional phase L 8 and the early Alleröd is correct (see below), the existence of this second Betula alba dominance is an argument against the correlation of the Betula depression to the Older Dryas. In this latter, if it is correct, it is immediately shown for the Alleröd. The classical "birch zone" (Birkenzeit, FIR-

Bas, 1935) recorded in our assemblage zones L 5 to L 8 is characterized by several fluctuations of Betula in most of the localities mentioned in Fig. 1 but also by SCHMEIOL (1971) and BEUG (1976). At Lansersee/Innabruck, on the contrary, the Betula peak in the percentage diagram after 12 250 B.P., does not take place in the concentration diagram - reforestation after the Juniperus-hippophæa-Salix-peak is accomplished by Pinus during the Bölling (Bortenschlager, 1980). The notion "Bölling" was extended from its original biostratigraphic meaning (Iversen, 1942, 1946, 1954, 1973) backwards by van der Hammem and Vogel (1966) as a Bölling sen-

su latu comprehending the Susasch interstrial, the Earliest Dryas and the Böllingلات (about 13 700 to 12 000 B.P.). As a chronzone for Northern the Bölling was established by Mangerud et al. (1974) comprising the period 13 000 to 12 000 B.P., based on many pollen diagrams (Welen, 1982; de Beaulieu, 1977; L. Bortenschlager, 1976; S. B. Bortenschlager, 1980; Quédal, 1981 and others) and on studies of oxygen isotopes (Eicher and Siegen-

Thaler, 1976; Eicher et al., 1981) Welen (1982, p. 96) proposed to include in a pollen zone Bölling sensu lato comprehending the

zone L 8 is characterized by several fluctuations of Pinus (Gaillard, 1981; Welten, 1976, 1982; Rošch, 1982) and can be used as the beginning of the Alleröd chronzone (omitting the Older Dryas, according to Welten, 1982).

Our Alleröd at Lobisengen consists of the two local pollen assemblage zones L 8 = Betula-Pinus-paz and L 9 = Pinus-Betula-paz. While during L 8 the NAP play a still rather important role, they all show tapering curves at the transition L 8 to L 9. Oryas, Juniperus, Hippophæa, Alnus, Quercus, then

W开门 and Welten (1980) have been a dramatic event for the northern alpine foreland, as a major biostratigraphic period of the Alleröd. The classical

the Alleröd? For the northern alpine foreland as a major biostratigraphic period of the Alleröd. The classical

corpus of the period of 12 000 B.P. (Gaillard, 1981; Welten, 1976, 1982; Rošch, 1982) and can be used as the beginning of the Alleröd chronzone (omitting the Older Dryas, according to Welten, 1982).

The development of the Bölling was dated (1982) by analyzing the stratigraphic succession of the Holocene pollen zone to the Alleröd chronzone. In the Alleröd period, the Bölling was proposed to be included in the chronzone L 9 as an alternative to L 6. While L 8 is not a regression period either, but just the final phase of heliophilous vegetation, independent from the ratio of Betula to Pinus (littoral or profundal profiles) all NAP are at their minimum during L 9 as percentages and as concentrations. This means that for our area the greatest density of the forest during the Lateglacial existed from about 11 000 to 10 800 B.P., but the transition from L 9 to L 10 + b van den Boogaard (1983) identified the remnants of the volcanic eruption in Laach/Eifel (Middle Laacher See, glass, titanugina and kaersutite hornblende), which was repeatedly dated at around 11 000 B.P. (see also Fig. 5).

5. THE YOUNGER DRYAS (ABOUT L 10)

Based on the volcanic ash from Laach and on comparison with other data in the area we may assign the slight but consistent decrease in AP and increase in NAP to the younger Dryas (L 9 to L 8). For the forest formation from L 8 to L 7 this chronzone YD is about 200 years older than the beginning of the pollen zone III or the local paz L 10 (see Fig. 5). At the transition L 9 to L 10 not only Artemisia, Gramineae and sphaerae increase but also the shrubs Juniperus and Hippophæa. In contrast to the more sensitive regions near the alpine timberline the densely forested lowlands only slightly reflect this climatic change. Whether it was a general breaking-up of the forest or a marginal retreat along ecotones, it can not have been a dramatic event (Watts, 1980). In our diagrams there are no indications for subdivisions of this zone.

6. THE EARLY POSTGLACIAL (L 11 AND L 12)

In 150a + b the transition from Lake marl to peat is palynostratigraphically characterized by the first grains of Alinus, Quercus, then Corylus, Oulmus and Tilia and a new increase of Betula. This transition is dated at about 10 000 B.P. (see Fig. 5; Gaillard, 1981; Welten, 1982). It marks the boundary between the chronozones of Younger Dryas and Preboreal and between the Late-Wurm and the Holocene. The explosive increase in pollen concentrations may be partly due to the change in sedimentation rate (the Preboreal in 4 cm). The following decrease in Pinus and sharp increase in Corylus can be attributed to the early Boreal. 
E. CONCLUSIONS

1. THE VEGETATIONAL DEVELOPMENT

- The term Oldest Dryas is used here sensu WELTEN (1979) as the pollen zone between the (metachronous) deglaciation and the beginning of the Bölling pollen zone (and chronzone). Three pollen assemblage zones reflect the local and regional succession: at the base a sediment with very low pollen concentrations and high proportions of reworked pollen and spores indicates poorly colonized open ground after the ice retreat (L 1 = Artemisia-Pinus-paz). The L 2 = Artemisia-Helianthemum-Cyperaceae-paz is a record of a treeless vegetation rich in heliophilous and pioneer species; the first water plants colonized the lake. The expansion of Betula nana and additional herbs and shrubs characterize the L 3 = Artemisia-Betula nana-paz. Its possible relationship to Pre-Bölling interstadials of many authors is not yet clear.

- As Bölling-complex (pollen zone) according to WELTEN (1982) we term the sequence of local pollen assemblage zones from the expansion of Juniperus to the expansion of Pines. As a chronozone the Bölling sensu WELTEN (1982) lasted from 13,000 to 12,000 B.P. It was initiated by a Juniperus-Hippophae-Salix-scrub (L 4 = Juniperus-Hippophae-paz) beginning the reforestation by Betula alba (L 5 = first Betula alba-paz). A depression in the birch curve (L 6 = Betula-Salix-Artemisia-paz) is comparable to what was often correlated with the Older Dryas pollen zone. There are no indications for cooling climate and very little for a drier one.

- The Olderöd pollen zone comprises the Pines expansion (L 8 = Betula-Pinus-paz) and the Pines dominance until shortly after the eruption of the Laacher See (L 9 = Pines-paz) as a chronozone the Olderöd sensu WELTEN (1982) lasted from 12,000 to 11,000 B.P. The crossing level of the percentage curve of Betula and Pines is rejected as a criterion for the opening of the Olderöd pollen zone.

- During the Younger Dryas (recorded in L 10 = Pines-Graminea-Artemisia-paz) the Swiss Plateau was largely covered by pine forests. The reappearance of species of open Vegetation points to a somewhat cooler climate (pollen zone 10 800 to 10 300 B.P., chronzone 11 000 to 10 000 B.P.).

- The early Holocene is reflected by the immigration of deciduous trees during the Preboreal (L 11 = Pines-Betula-thermophilus-paz) and their expansion during the Boreal (L 12 = Corylus-Quercetum mixtum-paz).

2. THE CLIMATIC INTERPRETATION

The vegetational development during Late-Würm at Lobsigensee is a sequence of mainly progressive types of vegetation, the only tangible regression being the Younger Dryas. Fluctuations during the Betula-phase of the Bölling can not be attributed to a cooler climate as postulated for the Older Dryas. A climatic deterioration just before the Bölling points not to be the case. Essential for future work will be all attempts to separate temperature and moisture indications; this will be crucial for understanding events like the main ice retreat from the northern alpine foreland during the Oldest Dryas.

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