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VEGETATIONAL DEVELOPMENT DURING THE LATE-WÜRM AT LOBSIGENSEE (SWISS PLATEAU). STUDIES IN THE LATE QUATERNARY OF LOBSIGENSEE 1.

by

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ABSTRACT

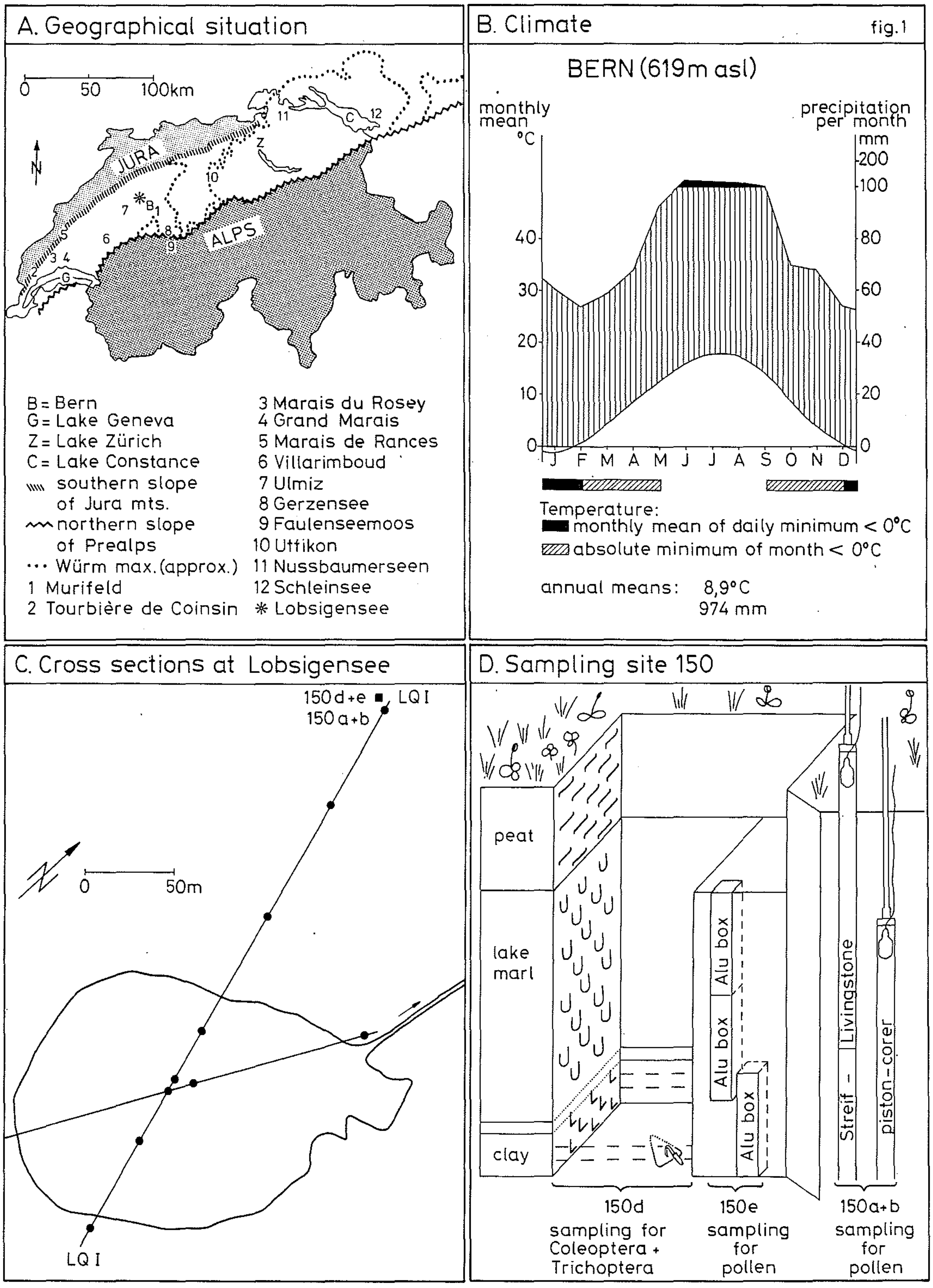
Lobsigensee is a small lake situated northwest of Bern at 514 m asl and was covered by Rhone ice during the Würm glaciation. Palynological and plant macrofossil studies of a Late-Würm deposit in the littoral are presented. The stratigraphy of the sediments is from bottom to top : sand, sandy clay, clay, 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 Bölling 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 Alleröd 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-Würm 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 (47⁰ 01' 55" N and 7⁰ 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 Würm 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 been around 16 000 B.P. The area is covered by till of the Würm glaciation : moraines are mapped on the hills NW and SE of the lake (KELLERHALS and TRÖHLER, 1981). 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 beech forest (*Asperulo-Fagetum* .; on poor soils *Luzulo-Fagetum* s.l. and on dry chalky soils *Carici-Fagetum* , 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 locality of Lobsigensee. A. Its geographical situation, the localities of comparable pollen diagrams are : 1 = Murifeld (WELTEN, 1972, 1982), 2 = Tourbière de Coinsin (WEGMÜLLER, 1966, 1977), 3 = Marais du Rosey, 4 = Grand Marais, 5 = Marais de Rances, 6 = Villarimboud (3-6 by GAILLARD 1981), 7 = Ulmiz (SLOTBOOM and van der MEER 1980), 8 = Gerzensee (EICHER and SIEGENTHALER 1976), 9 = Faulenseemoos (WELTEN 1944, 1982, EICHER and SIEGENTHALER 1976), 10 = Uffikon (KÜTTEL 1982, 1983), 11 = Nussbaumerseen (RÖSCH 1982), 12 = Schleinsee (LANG 1952, MÜLLER 1962, MIELKE and MÜLLER 1981). B. 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.



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. 1979, 1982) in many respects. The topic of the present paper is only the site called "150", the most littoral point of the crossection through the basin (Fig. 1). The twin cores 150a+b were taken with a Livingstone sampler modified according to Streif (MERKT 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 cm^3) were prepared together with *Lycopodium* pellets (STOCKMARR, 1971) with HCl, 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 when we are able to calculate influx will we overcome the problems introduced into concentration diagrams by changes in sediment.

C. RESULTS

1. THE PERCENTAGE DIAGRAM 150e + 200

The stratigraphy of the wall in the open pit was relatively simple. The sharp contact between the superficial peat (40cm thick, in its upper part disturbed by tillage) and the lake marl served as zero level.

Profile 150e	: 0-89 cm	**lake marl** (yellowish), fragments of mollusc shells and some roots penetrating from above (*Alnus* carr). Lc4, Tl 1+, part. test. moll. +
	89-93 cm	**transition** from lake marl to clay (olive-gray) (As+Ag)2, Lc2
	93-110 cm	**clay** (blue-gray) with some carbonate (As+Ag)3, Lc 1 (at 105-110cm also Ga+)
Profile 200	: 110-128 cm	**clay** (blue-gray) with some sand (As+Ag)3, Ga1, Lc+
	128-149 cm	**sandy clay** (As+Ag)3, Ga1, Gs+
	149-151 cm	**sand** with some cobbles (partly alpine ones) Ag1, Gs2, Gg(maj)1

The **local pollen assemblage zones** (paz) L 2 to L 10 are shown in Fig. 2. L 1 is only recorded in 150a+b. In the following description we add to the local paz Ln a short designation with the most important pollen types. In order to facilitate comparison we use the names employed by GAILLARD (1981) for the regional pollen zones whenever possible. Percentages given in () concern the diagram of 150a+b (Fig. 3).

L 2 = ***Artemisia-Helianthemum* -Cyperaceae-paz** : Arboreal pollen AP are only 10-19 % (7-16 %). Most abundant are *Artemisia* with 15-27 % (11-44 %), Cyperaceae with 20-33 % (1-48 %) and Gramineae (around 20 %); also very important are *Helianthemum*, Chenopodiaceae, Caryophyllaceae (especially *Gypsophila*-type) and Brassicaceae. *Salix*, *Thalictrum* and Rubiaceae are present. *Potamogeton* (especially *Coleogeton*) is regularly found. In the upper half of L 2 *Ephedra distachya* -type and the first grains of *Juniperus* and *Hippophae* 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 18-35 % (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). *Salix* is at 2-5 %. *Selaginella selaginoides*, *Botrychium*, *Centaurea scabiosa* -type, *Rumex / Oxyria* and *Myriophyllum spicatum* show for the first time continuous curves.

Contact L 3/L4 : rise of *Juniperus* above 10% or from 0.2-2 % (0.5-4 %) to 11-59% (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 occurr as well. *Hippophaë* reaches its maximum. The fall in NAP is especially marked among heliophilous taxa : *Ephedra*, *Artemisia*, *Helianthemum*, *Gypsophila*-type, *Thalictrum*, *Selaginella selaginoides*. Cyperaceae decrease as well.

Contact L 4/L5 : fall in *Juniperus* below 15 % or from 11-59 % (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 GAILLLARD, 1983), while *Juniperus* is gradually decreasing to even below 1 %. A second fall of NAP concerns again mainly the heliophilous 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 68-77 %) (62-67 %)
Salix increases above 3,5 % or from 1.5-3.5 % (1-3,5 %) to 3-6.5 % (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* and Gramineae 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 68-77 % (62-67 %) to 70-87 % (78-85 %)
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 %)

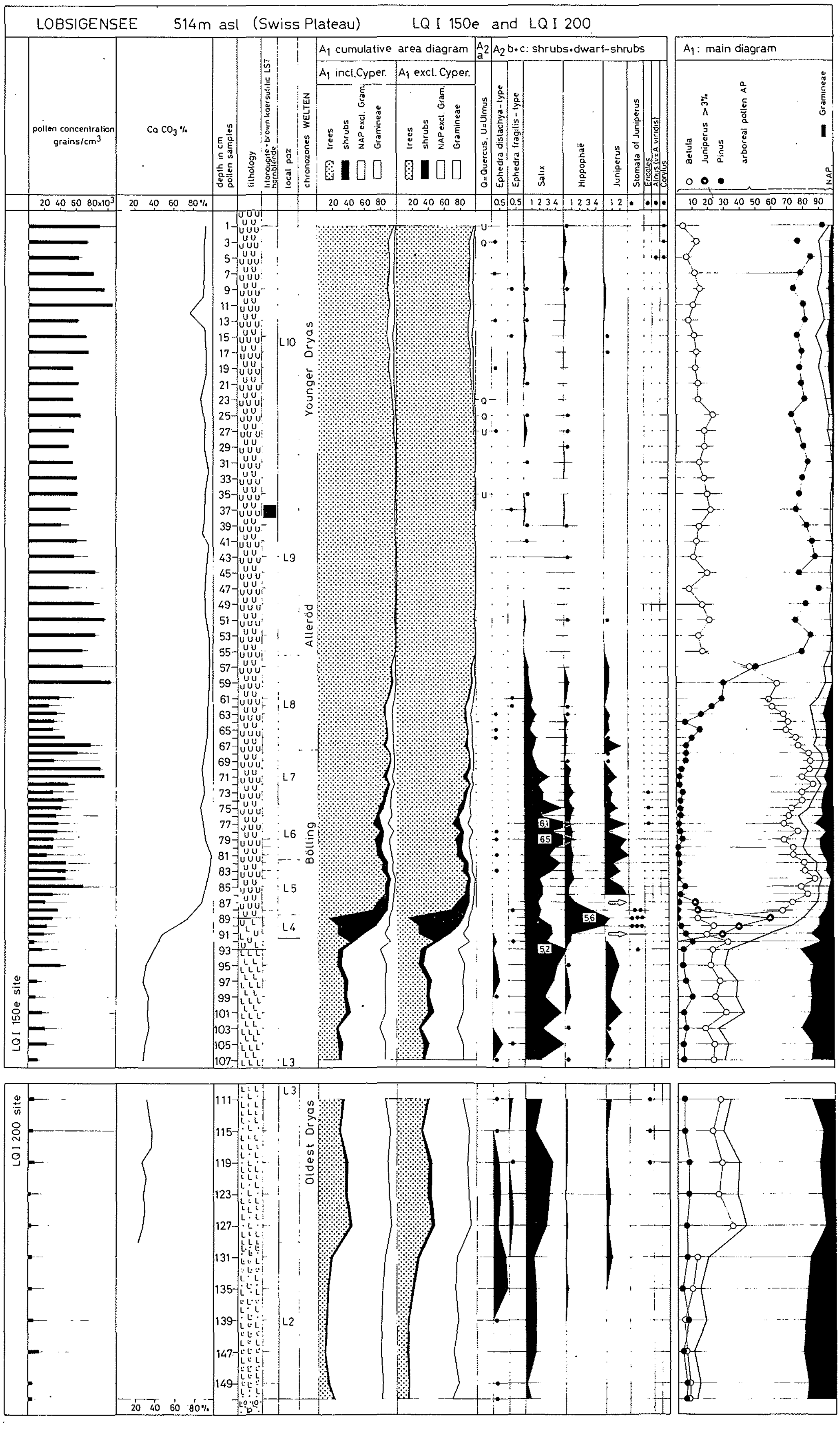
L 7 = **second *Betula alba* -paz** : Tree-birches again dominate; *Salix*, *Artemisia* and Gramineae return to values similar to L 5.

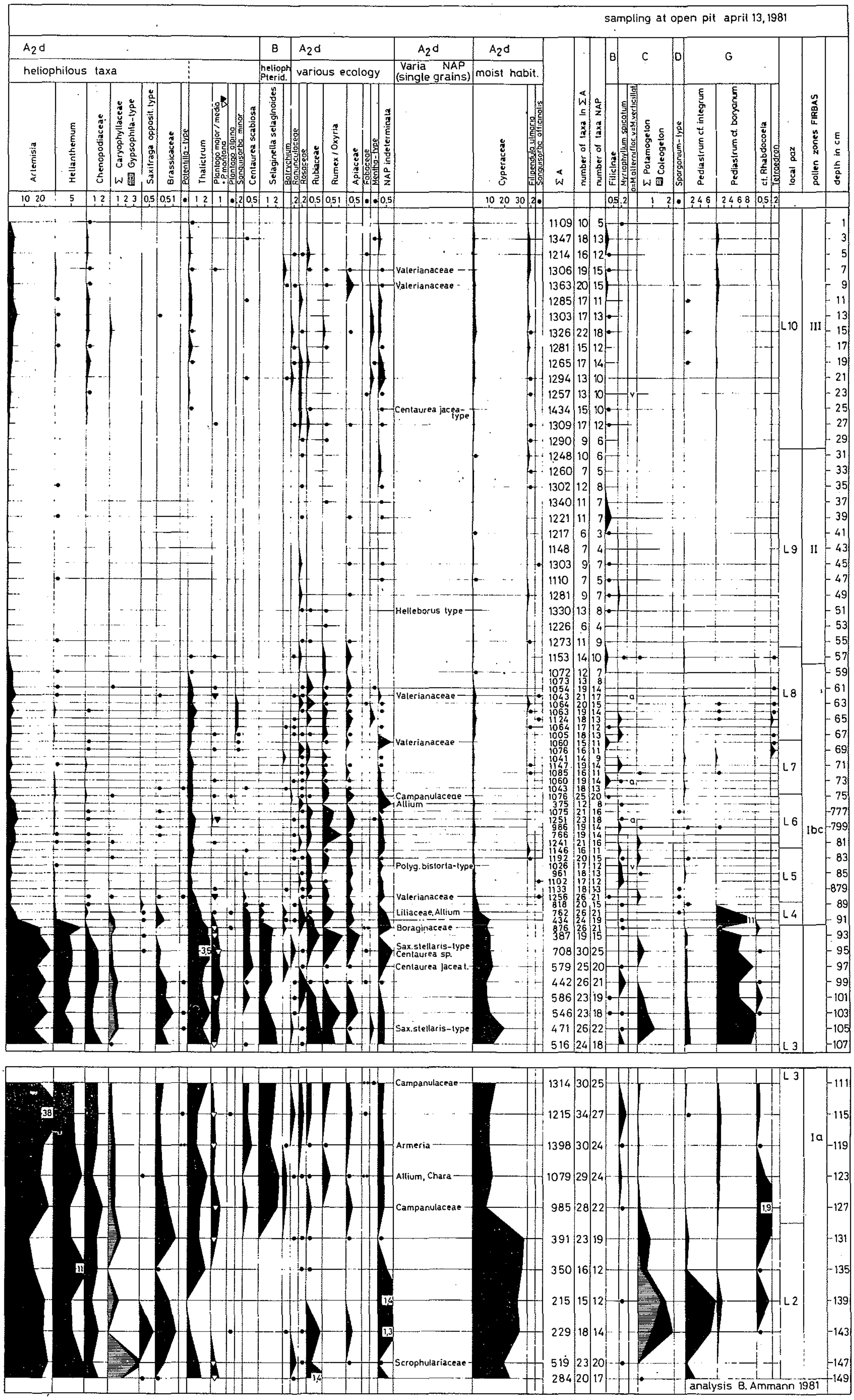
Contact L 7/L 8 : beginning of the rise of *Pinus* (above 5 %)
beginning of the fall of *Betula* (below 80 %)

L 8 = ***Betula-Pinus* -paz** : in pollen percentages and concentrations L 8 is a transitional pollen assemblage zone : the curve of *Pinus* rises slowly in 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 limit 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* ($\geq$ 80 %)

Fig. 2 Lobsigensee : diagram of pollen percentages from 150e (open pit).




sampling at open pit april 13, 1981
A2d
heliophilous taxa
B
heliophil. Pterid.
A2d
various ecology
A2d
Varia NAP (single grains)
A2d
moist habit.
B
C
D
G
Artemisia
Helianthemum
Chenopodiaceae
Σ Caryophyllaceae
Gypsophila-type
Saxifraga opposit. type
Brassicaceae
Potentilla-type
Thalictrum
Plantago major / media + P. montana
Plantago alpina
Sanguisorba minor
Centaurea scabiosa
Selaginella selaginoides
Botrychium
Ranunculaceae
Rosaceae
Rubiaceae
Rumex / Oxyria
Apiaceae
Fabaceae
Mentha-type
NAP indeterminata
Cyperaceae
Filipendula ulmaria
Sanguisorba officinalis
Σ A
number of taxa in Σ A
number of taxa NAP
Filicinae
Myriophyllum spicatum
a = M. alterniflorum
v = M. verticillatum
Σ Potamogeton
Coleogeton
Sparganium-type
Pediastrum cf. integrum
Pediastrum cf. boryanum
cf. Rhabdocoela
Tetraedron
local paz
pollen zones FIRBAS
depth in cm
Valerianaceae
Centaurea jacea-type
Helleborus type
Campanulaceae
Allium
Polyg. bistorta-type
Liliaceae, Allium
Boraginaceae
Sax. stellaris-type
Centaurea sp.
Centaurea jacea t.
Armeria
Allium, Chara
Scrophulariaceae
L10
L9
L8
L7
L6
L5
L4
L3
L2
III
II
Ibc
Ia
analysis B. Ammann 1981

end of the fall of *Betula* (≤ 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 0.2-1.2 % (0.1-0.5 %) to 1-6 % (0.2-6 %)
Gramineae increase slightly from 0.3-1.2 % (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 *Ephedra*-types, *Hippophaë* and *Juniperus* are more frequent. The upper boundary of L 10 was not recorded in 150e, but in the cores 150 a + 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 150e + 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
  Tl3 2, Th3 *Phragmitis* 2
- 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+
- 162-268 cm **clay** with some sand (especially 220-230 cm)
  (As+Ag)3, Ga1
- 268-330 cm **sandy clay**
  (As+Ag)3, Ga1, Gs+

More detailed stratigraphic description will be given in an other paper comparing all the cores on the cross section through the lake (AMMANN, in prep.). The **local pollen assemblages zones** L 1 to L 10 are shown in Fig. 3.

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 amazingly 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 (70-1160 grains/cm^3).

Contact L 1/L 2 : *Pinus* percentages decrease below 10 % or from 10-52 % to 3-9 %
NAP increase above 85 % or from 36-82 % to 85-92 %, beginning of the *Salix* curve
pollen concentrations increasing and passing 1200 grains/cm^3

L 2 to L 10 were already described above with the percentages in () for 150 a+b. In the following only the properties of the paz in pollen concentration are discussed.

L 2 = ***Artemisia-Helianthemum*** **- Cyperaceae-paz** : concentrations in all NAP increase (e.g. *Artemisia* , *Helianthemum* , Chenopodiaceae, Gramineae, Cyperaceae, *Thalictrum*). *Ephedra 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-Hipphophaë*** **-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 between subsequent samples occurs in the dominant *Betula* (and therefore in the pollen sum) during L 6 and L 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*, *Ephedra*, *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 31-58 %
Corylus increases above 10 % or from 0-3 % to 13-47 %, mixed oak forest increases from < 1 % to 3-7 %

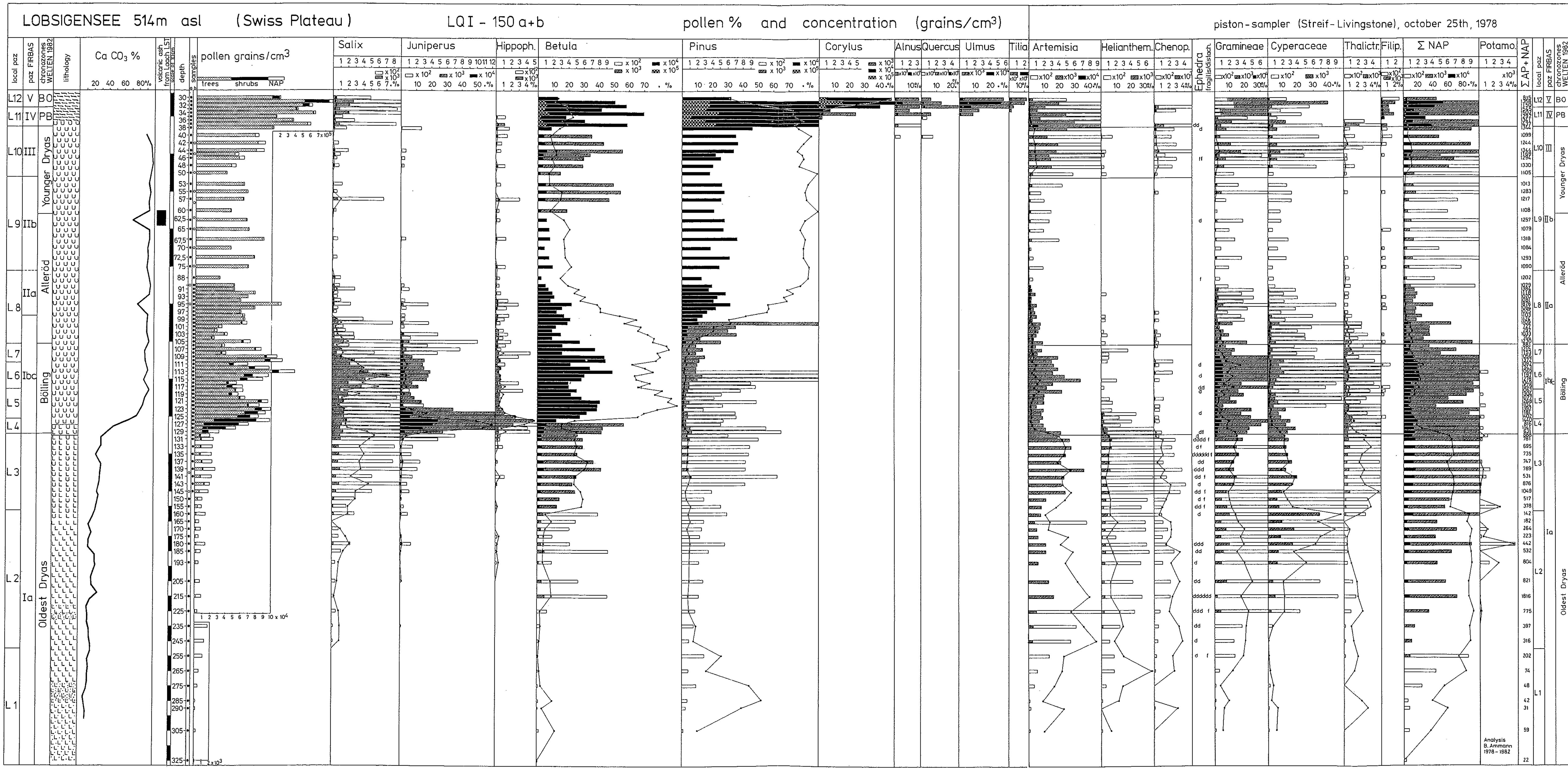
L 12 = ***Corylus-Quercetum mixtum*** **-paz** : The pollen spectra are dominated by *Corylus*. Among the genera of the mixed oak forest *Ulmus* is the most important (2-6 %), while *Quercus* and *Tilia* are below or around 1 %; *Acer* and *Hedera* are found as single grains, *Fraxinus* is still lacking.

3. THE PLANT MACROFOSSILS (K.T.)

The littoral lake marl at Lobsigensee is rather poor in plant macrofossils as compared with lateglacial deposits of the profundal 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 tortuosa*-type (BIAŁOBRZESKA and TRUCHANOWICZOWNA, 1960). Tree-birches remain dominant in the pollen zones

Fig. 3 Lobsigensee : Diagram of pollen concentrations and percentages from the cores 150 a+b.



LOBSIGENSEE 514m asl (Swiss Plateau)
LQI - 150 a+b
pollen % and concentration (grains/cm3)
piston-sampler (Streif-Livingstone), october 25th, 1978
local paz
paz FIRBAS
chronozones WELTEN 1982
lithology
Ca CO3 %
volcanic ash from Laach LST
depth
samples
pollen grains/cm3
trees
shrubs
NAP
Salix
Juniperus
Hippoph.
Betula
Pinus
Corylus
Alnus
Quercus
Ulmus
Tilia
Artemisia
Helianthem.
Chenop.
Ephedra fragilis/distach.
Gramineae
Cyperaceae
Thalictr.
Filip.
Σ NAP
Potamo.
Σ AP+NAP
Younger Dryas
Alleröd
Bölling
Oldest Dryas
BO
PB
Analysis B. Ammann 1978 - 1982

L5 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. *Selaginella 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.

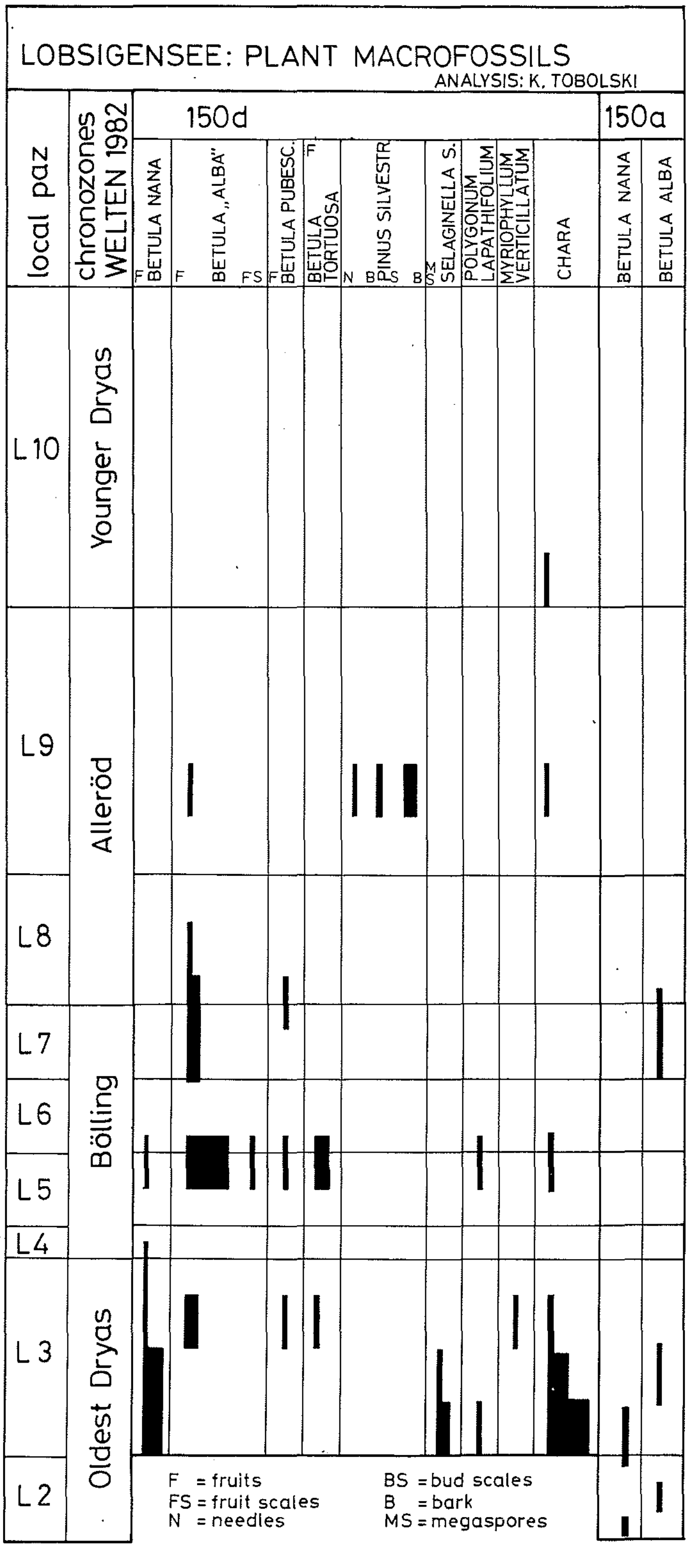
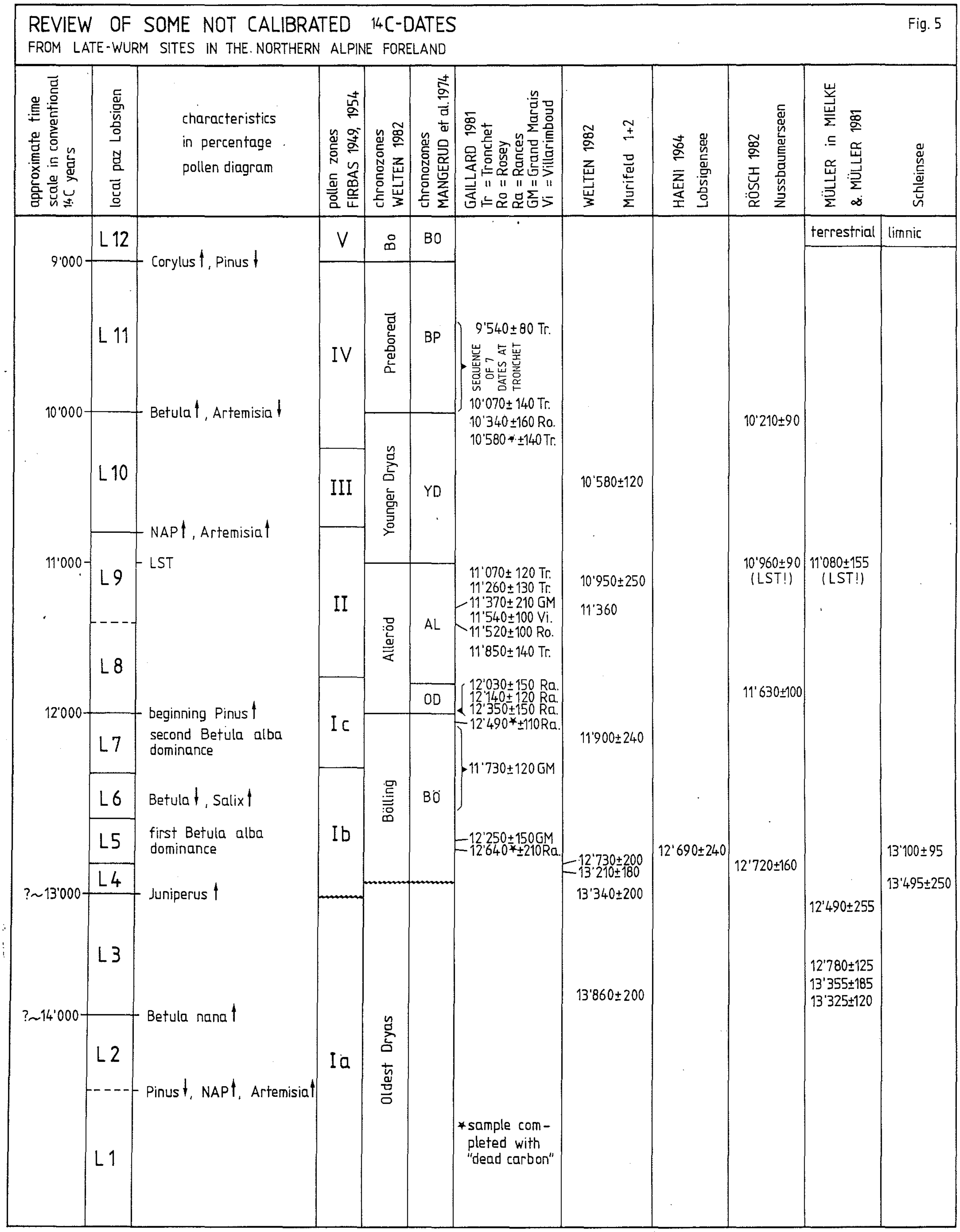


Fig. 4 Lobsigensee : plant macrofossils from selected samples.

Fig. 5 Tentative chronology of the Late Würm : review of pertinent radiocarbon dates from the Swiss Plateau and from Schleinsee.



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 finds 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 60-64 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 ^{14}C-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 note here considered because of differences in vegetational history controlled by differences in altitude (ZOLLER, 1968; WELTEN, 1972, 1982; HEEB and WELTEN, 1972; KÜTTEL, 1974, 1979); these will be described for the Swiss contribution to IGCP 158b 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 need to keep the Oldest Dryas (IVERSEN, 1954) : before the Bölling (before 13 000 B.P.) an often long sequence of several (2-6) pollen assemblage zones is observed (WELTEN, 1972, 1982 at Murifeld, WEGMÜLLER, 1977 at Tourbière de Coinsin, GAILLARD, 1981 at 8 localities, MÜLLER, 1962, MIELKE and MÜLLER, 1981 at Schleinsee, RÖSCH, 1982 at Nussbaumerseen, KÜTTEL, 1982, 1983 at Uffikon) as summarized in Fig. 6. The stippeled 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 production can not be determined. Neither algae nor higher water plants are found in this periglacial lake. Comparable finds at the bases of lateglacial diagrams were presented by WELTEN (1944, 1952, 1982), AMMANN-MOSER (1975), GAILLARD (1981), KÜTTEL (1982, 1983), RÖSCH (1982).

During L 2 = *Artemisia-Helianthemum* -Cyperaceae-paz flora and vegetation became gradually richer : besides increasing NAP (percentages, concentrations, number of taxa) and besides the first water plants (*Potamogeton* incl. *Coleogeton* , some *Myriophyllum*) 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* were 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 preceeding chapter). At Vidy/Lausanne WEBER, 1980a found in corresponding layers leaves of *Salix*; he could attribute them to several species, dwarf shrubs as well as taller shrubs. But taxa of NAP still prevail in L 3 (often more than 20); alpine elements (e.g. *Saxifraga oppositifolia*-type, *Plantago montana* , *P. alpina*, *Rumex* / *Oxyria*) and "steppic" elements (e.g. *Ephedra distachya* -type, *E. fragilis*-type) form a pattern of communities not existing today (IVERSEN, 1954; FRENZEL, 1968, pp. 230; GAILLARD, 1981 in her chapter "flore tardiglaciaire et phytogéographie"). 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-Steppenphase" of WELTEN (1972, 1982), but it is not comparable with the Ia$_3$ of van der HAMMEN and VOGEL (1966) 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 (1979) pointed out for the pollen zone Ia : "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 Würm 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 chronozone of Oldest Dryas could be at 13 300 B.P. as indicated by the beginning of the pollen zone of Bölling (WELTEN, 1972, 1982 for Murifeld : 13 340 ± 200 B.P.) or at 13 000 B.P. as defined as the beginning of the chronozone of Bölling (MANGERUD *et al.*, 1974, WELTEN, 1982). But we must also consider the dates from Schleinsee (MIELKE and MULLER, 1981) where organic material of limnic and terrestrial origin was ^{14}C-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 *Dryas octopetala*) 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 approximately 1 700 years older 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 ? During the rise in temperature lasting from 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.*, 1977; BERGLUND, 1979b; WATTS, 1980; GRAY 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 Schleinsee) or by the expansion of *Juniperus* (as dated by limnic material at Schleinsee and at Murifeld) ? How does our *Artemisia - Betula nana* -paz and *Juniperus - Hippophaë*-paz (L 3 and L 4) correlate with the Susacà-interstadial (van der HAMMEN and VOGEL, 1966) or its equivalents (DREIMANIS, 1966; MENKE, 1968; SEREBRJANNYJ and RAUKAS, 1970; BERGLUND, 1979b) which ended at about 13 000 B.P. ? According to the terrestrial radiocarbon samples, this is in the dwarf birch phase (L 3), but according to the limnic series, the juniper (and the first tree-birch ?) phase L 4 (and L 5 ?) would correspond to those pre-Bölling interstadials. Van der HAMMEN and VOGEL (1966), MENKE (1968), SEREBRJANNYJ and RAUKAS (1970) demonstrated a climatic regression between the Pre-Bölling and the Bölling-interstadial (Susacà - Earliest Dryas s. str. - Bölling s.str.; Meiendorf - Grömitz - Bölling, but a new correlation was proposed by USINGER (1975); Raunis - Luga - 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

figure 6

<table>
<tr><th rowspan="2">LOBSIGENSEE
local paz</th><th colspan="2">SCHLEINSEE</th><th rowspan="2">MURIFELD
Welten 1972, 1982</th><th rowspan="2">ST. LAURENT
Gaillard 1978
Gaillard and Weber 1978</th><th rowspan="2" colspan="2">VILLARIMBOUD
and other sites on the western Swiss Plateau
Gaillard 1981</th><th rowspan="2">UFFIKON/LUZERN
Küttel 1982
Küttel 1983</th><th rowspan="2">NUSSBAUMERSEEN
Rösch 1982</th></tr>
<tr><th>Lang 1952</th><th>Müller 1962, 1981</th></tr>
<tr><td rowspan="2">L3
Artemisia-
Betula nana-paz</td><td rowspan="2">Zwergbirkenphase</td><td rowspan="2">Ia3
Betula nana: pollen and macrofossils</td><td rowspan="2">Ia2
Murifeld-Steppenphase
Gramineen-Artemisia-
Ephedra-Steppenphase
(Dauerphase)</td><td rowspan="2">Ia3
toundra à arbustes</td><td rowspan="2">Vill 3
zone à Artemisia et Betula nana</td><td>Vill 3_2
à Helianthemum</td><td rowspan="2">Betula nana zone</td><td>b2
Zwergstrauch-Rasen-phase mit Gebüschausbreitung</td></tr>
<tr><td>Vill 3_1
Thalictrum
Selaginella</td><td>b1
Zwergstrauch-Rasenphase</td></tr>
<tr><td rowspan="3">L2
Artemisia-
Helianthemum-
Cyperaceae-paz</td><td rowspan="3">Pionierphase</td><td rowspan="3">Ia2
Gramineae,
Cyperaceae,
Artemisia
Helianthemum</td><td rowspan="3">Ia1
Pionierphase</td><td rowspan="3">Ia2
toundra "dense"</td><td colspan="2">Vill 2
zone à Artemisia et Chenopodiaceae</td><td>Artemisia-
Chenopodiaceae zone</td><td>a4
Phase geschlossener Rasen</td></tr>
<tr><td colspan="2" rowspan="2">Vill 1
Zone à Artemisia et Saxifraga oppositifolia</td><td rowspan="2">Thalictrum-
Cyperaceae zone</td><td>a 3
Gräser-Kräuterphase</td></tr>
<tr><td>a 2
Pionierphase</td></tr>
<tr><td>L 1
Artemisia-
Pinus - paz</td><td></td><td>Ia1
many secondary pollen</td><td></td><td>Ia1
toundra "maigre"</td><td colspan="2">bases of cores at 6 sites: low pollen concentrations, high Pinus - %</td><td>many secondary pollen (open ground)</td><td>a 1
vegetationsarme Phase</td></tr>
</table>

Fig. 6 Pollen assemblage zones within the Oldest Dryas (northern alpine foreland) : the zones describe local successions, synchronism between leveled phases is not assumed.

mate, developing soils and immigrating species. For Tourbière de Coinsin WEGMÜLLER (1977) discussed a stagnation in the development just before the beginning of the juniper expansion. For Gerzensee and Faulensee EICHER and SIEGENTHALER (1976) show a short term 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 Ia and Ib. Our decrease of *Betula* 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 *Pediastrum* are dropping. Related faunal changes are presented by CHAIX (1983) and by HOFMANN (1983). The juniper peak of **L 4 = *Juniperus-Hippophaë*-paz** is both of stratigraphic and ecological interest. Its wide spread occurrence at the beginning of reforestation nearly throughout Europe (and from the 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 a, b), VASARI and VASARI (1968), BIRKS (1973), BERGLUND (1966) and de BEAULIEU (1977) was partly confirmed by the finds of plant macrofossils by WEBER (1980b) : in the area of Vidy/Lausanne *Juniperus communis* (and/or its subspecies *nana*, WEBER (1979, 1980a) 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 13 000 B.P.) favored several shrubs, but the enhanced pollen production of juniper (IVERSEN, 1954) sharpened the rise of its pollen curve most distinctly (percentages and concentrations). Most probably the pollen production of either *J. communis* ssp. *communis* or *J. communis* ssp. *nana* was improved and the taller habitus described by the authors mentioned does not involve a "transformation" from the ssp. *nana* to the ssp. *communis* (ZOLLER, pers. comm.). *Hippophaë rhamnoides* expanded more or less synchronously with juniper (BERTSCH, 1961 b; WELTEN, 1972, 1982; KÜTTEL, 1979; GAILLARD, 1981; ROSCH, 1982 and others) but has a rather poor pollen production. The capacity of *Hippophaë* to colonize poor soils is also certainly due to the symbiontic actinomycetes in its root nodules (BOND *et al.*, 1954;BAUMEISTER and KAUSCH, 1974). The expansion of *Juniperus* and *Hippophaë* is an indication for both rising summer temperatures and more stabilized soils and can be understood as a successional phase introducing reforestation (BERGLUND, 1966; WELTEN, 1972, 1982; REYNAUD, 1976; I. BORTENSCHLAGER, 1976; S. BORTENSCHLAGER, 1980; de BEAULIEU, 1977; GAILLARD, 1981 and others). The concentration diagram (Fig. 3) and the pollen size measurements (GAILLARD, 1983) show that the tree-birches were expanding simultaneously with *Juniperus* and *Hippophaë*. Interestingly enough, in our Fig. 3 the sum of NAP decreases strongly during L 4 as percentages but the concentration values are more or less constant. Provided the sedimentation rate would be constant, this would mean that the herb vegetation would only later decline due to the developing forest but not yet by the juniper scrub. Changes in sediment during the juniper phase are a wide spread phenomenon. Thus it is during the transition from L 4 to L 5 that reforestation took place at Lobsigensee. The shift from prevailing dwarf birch to prevailing tree-birches (see chapter on plant macrofossils and GAILLARD, 1983) must have reinforced the impression of this environmental change for any palaeolithic hunters of the area. To estimate the rate of change we will need series of dates with high resolution or annually laminated sediments.

During this **first *Betula alba*-paz of L 5** the heliophilous pioneers *Juniperus*, *Hippophaë* and many NAP were shaded out. The NAP concentration is slightly decreasing as well. The sediment is now lake marl in the littoral ($CaCO_3 > 80$ %) and a fine detritus gyttja in the profundal. From this pollen zone HÄNI, 1964 got one of the first radiocarbon dates for Bölling of Switzerland : 12 690 ± 240 B.P. (B-398). It is in good agreement with Murifeld (WELTEN, 1982) and Marais de Rosey (GAILLARD, 1981) as shown in Fig. 5.

The *Betula* depression of **L 6 = *Betula-Salix-Artemisia* paz** seems to be a minor event, but it is interesting for two reasons :

- such features were sometimes interpreted as a climatic cooling and correlated with the Older Dryas (Ic)
- a major faunal change is registred there (ELIAS and WILKINSON, 1983).

As LANG (1963) pointed out, rather different and even contradictionary criteria have been used to correlate minor fluctuations before the Alleröd with the Older Dryas of IVERSEN (1942, 1954, 1973) : either a *Betula* peak during the expansion of *Pinus* (LANG, 1952, discussed by MÜLLER, 1962) or a *Betula* depression. In the northern alpine foreland such *Betula* depressions corresponding with NAP-increases mainly caused by Gramineae and *Artemisia* were often interpreted as a regression of the forest, thought to be a result of lower temperaturre (BERTSCH, 1961b; WEGMÜLLER, 1966; AMMANN-MOSER, 1975; EICHER and SIEGENTHALER, 1976; GAILLARD, 1981; KÜTTEL, 1982; WELTEN, 1982). But the most consistent feature in these interpretations is the questionmark following "Ic" (see also de BEAULIEU, 1977 pp. 227). Do those changes in the pollen curves necessarily indicate a regression in temperature ? The development of the local vegetation (macrofossils in other profiles of Lobsigensee, TOBOLSKI, in prep.; GAILLARD, 1978; WEBER, 1978; GAILLARD, 1981) does not show any regression but is rather progressive. Pollen concentrations for AP in L 6 (Fig. 3) are not significantly lower than in L 5. Unfortunately *Betula* concentrations fluctuate widely. Concentrations for *Juniperus* and NAP (especially for *Artemisia* and Gramineae) are somewhat higher. GAILLARD (1981) showed that, in terms of pollen concentrations, the increase of *Salix* and Gramineae is not connected with a decrease of *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 refroidissement climatique, mais évoque plutôt une stabilisation des températures". For the period comparable to L 6, WELTEN (1982) writes : "Den relativ günstigen Charakter des Klimas der Aelteren Dryas unterstreicht die Tatsache der Einwanderung der Föhre vor dem endgültigen Rückgang der *Artemisia*- und Mineralpartikel-Werte". Could the *Betula* depression be the record of drier conditions ? Neither *Artemisia* nor the Gramineae nor *Salix* are identifiable to species, but the first two pollen types could as well be indicators for steppic conditions (MENENDEZ AMOR and FLORSCHÜTZ, 1963; LANDOLT, 1977, p. 166). *Ephedra distachya*-type was found several times in L 6. *Filipendula 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 Older Dryas in northwest Europe was given by KOLSTRUP, 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 USINGER, 1978, but on the other hand the same phase is strongly felt in diagrams from the central German dry area (MÜLLER, 1953 : Galterslebenersee, todays precipitation < 500 mm/year). For western Belgium VERBRUGGEN (1979) discussed aeolian activity during Ic. RUDDIMAN and McINTYRE (1981a, b) emphazize the importance of moisture conditions during deglaciation. For Logsigensee ELIAS and WILKINSON (1983) demonstrate a faunal shift during L 6 which contradicts the interpretation 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*-paz** in most features resembles the first one (= L 5). Towards its end the percentages of *Pinus* start to rise. Provided our correlation 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, because this latter should immediatly precede the Alleröd. The classical "birch zone" (Birkenzeit, FIRBAS, 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 SCHMEIDL (1971) and BEUG (1976). At Lansersee/Innsbruck, on the contrary, the *Betula* peak in the percentage diagram after 13 250 B.P. does not take place in the concentration diagram - reforestation after the *Juniperus-Hippophaë-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 HAMMEN and VOGEL (1966) as a Bölling sensu lato comprehending the Susacà interstadial, the Earliest Dryas and the Bölling s.str. (about 13 700 to 12 000 B.P.). As a chronozone for Norden the Bölling was established by MANGERUD *et al.* (1974) comprising the period 13 000 to 12 000 B.P.. Based on many pollen diagrams (WELTEN, 1982; de BEAULIEU, 1977; I. BORTENSCHLAGER, 1976; S. BORTENSCHLAGER, 1980; GAILLARD, 1981 and others) and on studies of oxygen isotopes (EICHER and SIEGENTHALER, 1976; EICHER *et al.*, 1981) WELTEN (1982, p. 96) proposed to include in a pollen zone Bölling sensu latissimo or a Bölling-complex the pollen zone of the Older Dryas as well. The main reason for doing so was that the Older Dryas pollen zone seems, at least for the northern alpine foreland, to have been only a minor event : "So sehr wir uns der skandinavischen Chronozonengliederung anschliessen, möchten wir vorschlagen, die sog. Aeltere Dryas als letzte der negativen Schwankungen des Böllings aufzufassen und mit ihm zu vereinigen. Man würde dann in der chronozonalen Grossgliederung des Spätglazials vorläufig die vier Abschnitte unterscheiden

Aelteste Dryas	Bölling	Alleröd	Jüngere Dryas	
13 000	12 000	11 000	10 000 B.P.	

WELTEN (1982) also stressed that all lateglacial zones may show minor fluctuations (which depend on local conditions and on our methods) and that radiocarbon dates from lateglacial material may be affected by several complications (OESCHGER *et al.*, 1980; see also LOWE and WALKER, 1980; SUTHERLAND, 1980; MIELKE and MÜLLER, 1981; HEITZ, PUNCHAKUNNEL and ZOLLER, 1982). Comparing the chronozones proposed by WELTEN (1982) with MANGERUD *et al.* (1974), we see that WELTEN incorporates the period of 12 000 to 11 800 B.P. into the Alleröd chronozone. The abandonment of the Older Dryas for the northern alpine foreland as a major biostratigraphic and climatostratigraphic zone between Bölling and Alleröd is in accordance with results from other parts of Europe ("Late Weichselian Interstadial", e.g. VRIES, FLORSCHÜTZ and MENEDEZ AMOR, 1960; PENNINGTON, 1970, 1975; COOPE, 1970, 1977; BIRKS, 1973; BERGLUND, 1979b, LOWE and GRAY, 1980). WATTS (1980) summarizes : "The two 'warm' phases are therefore distinct in some areas but united in others". BEUG (1976) emphazizes : "Während der Abschnitte Ib und Ic liefen mehr pollenanalytisch nachweisbare Prozesse der Vegetationsentwicklung ab als im gesamten weiteren Verlauf der Späteiszeit."

4. THE ALLERÖD (L 8 AND L 9)

The beginning of the pollen zone II has been discussed for several sites in the northern alpine foreland (e.g. Tourbière de Coinsin by WEGMÜLLER, 1966, 1977; GAILLARD, 1981). Different trends in *Betula* and *Pinus* curves at neighbouring sites (LANG, 1963 : Buchensee versus Radolfzeller Bucht, 4 km apart; WELTEN, 1982 : Murifeld versus Lörmoos, 8 km apart) are explained by local environmental differences favoring one or the other genus. Beside such local differences we found also a differenciation according to facies : within the basin of Lobsigensee the littoral profiles resemble the ones from Radolfzeller Bucht and Murifeld (with early dominance of *Pinus* i.e. in Alleröd and Younger Dryas), whereas the profundal profiles resemble the ones from Buchensee and Lörmos (with late dominance of *Pinus* in Younger Dryas only and with an Alleröd showing *Betula* and *Pinus* mixed at medium values, AMMANN, in prep.). We assume that those facial differences are produced by differential pollen flotation of birch and pine (HOPKINS, 1950; DAVIS and BRUBAKER, 1973; HEATHCOTE, 1977) and accumulation of *Pinus* pollen along the shore. We therefore think that the crossing level of the percentage curves of the two genera under consideration is not a reliable criterion to fix the opening of pollen zone II. But the beginning of the rise of the pine curve is visible inspite of various interplays of *Betula* and *Pinus* curves. This beginning rise could reflect the arrival of pine in the area. We are aware of the fact that such a criterion, depending as it does on migration, is valuable only for a restricted area (in the eastern and southern Alps *Pinus* had already expanded during the Bölling, I. BORTENSCHLAGER, 1976; de BEAULIEU, 1977). But as shown by Fig. 5 the beginning rise of *Pinus* is dated on the Swiss Plateau at about 12 000 B.P. (GAILLARD, 1981; WELTEN, 1972, 1982; RÖSCH, 1982) and can be used as the beginning of the Alleröd chronozone (omitting the Older Dryas, according to WELTEN, 1982).

Our Alleröd at Lobsigensee 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 still a rather important role, they all show tapering curves at the transition from L 8 to L 9. Or should we take "on our search for an Older Dryas" this L 8 as an alternative to L 6 ? But 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 11 500 to 11 000 or 10 800 B.P.. If we ever get enough reliable radiocarbon dates to calculate pollen influx, considerations on changes in forest density will be better substantiated. Within the upper half on L 9 in 150e as well as 150a + b van den BOGAARD (1983) identified the remnants of the volcanic eruption in Laach/Eifel (Middle Laacher See Tephra, glass, titanaugit and kaersutitic 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 diagrams in the area we may assign the slight but consistent decrease in AP and increase in NAP to the beginning of the Younger Dryas. The beginning of the chronozone 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 *Ephedra* increase but also the shrubs *Juniperus* and *Hippophaë*. In contrast to the more sensitive regions near the alpine timberline the densly 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 *Alnus*, *Quercus*, then *Corylus*, *Ulmus* and *Tilia* and a new increase of *Betula*. This development was dated at about 10 000 B.P. (Fig. 5 : GAILLARD, 1981; WELTEN, 1982). It marks the boundary between the chronozones of Younger Dryas and Preboreal and between the Late-Würm and the Holocene. The explosive increase in pollen concentrations may be partly due to the change in sediment (very low sedimentation rate in the peat : 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 chronozone). 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 *Pinus*. As a chronozone the Bölling sensu WELTEN (1982) lasted from 13 000 to 12 000 B.P.. It was initiated by a *Juniperus- Hippophaë -Salix*-scrub (L 4 = *Juniperusi-Hippophaë*-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 a cooling climate and very little for a drier one.
- The Alleröd pollen zone comprises the *Pinus* expansion (L 8 = *Betula-Pinus*-paz) and the *Pinus* dominance until shortly after the eruption of the Laacher See (L 9 = *Pinus-Betula*-paz); as a chronozone the Alleröd sensu WELTEN (1982) lasted from 12 000 to 11 000 B.P. The crossing level of the percentage curve of *Betula* and *Pinus* is rejected as a criterion for the opening of the Alleröd pollen zone.
- During the Younger Dryas (recorded in L 10 = *Pinus*-Gramineae-*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., chronozone 11 000 to 10 000 B.P.).
- The early Holocene is reflected by the immigration of deciduous trees during the Preboreal (L 11 = *Pinus-Betula* -thermophilous-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 was not found. 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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