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Vegetation and climate history of a high alpine mesolithic camp site in the Eastern Alps

ABSTRACT:

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During the archeological excavation of a mesolithic camp site - located on the Hirschbichl near-by the Staller Sattel (Osttirol/Austria) - palaeoecological investigations for the reconstruction of the palaeoenvironment of the site were done. The pollen diagrams exhibit that the vegetational succession started with a *Pinus-Artemisa*-zone at the transition of the Younger Dryas/Preboreal. The *Pinus-Artemisia*-zone is superseded by a *Pinus-Juniperus*-zone indicating the spread of *Pinus-Larix*-woodland at the beginning of the Preboreal. At the end of the Preboreal a *Pinus-Picea-Corylus*-zone starts which lasts until the middle of the Atlanticum. Then *Picea* is becoming more and more important and forms a *Picea-Pinus*-zone until the Subatlanticum. This vegetational succession has been confirmed by botanical macrofossil analyses.

To anticipate the most important results: already in the Preboreal the timber line had extended upwards to the altitude of the camp site. During the Preboreal and Boreal distinct penetrations of the *Pinus* pollen-curve and the synchronous NAP-curve maxima indicate a disturbance in the subalpine forests. The macrorest analyses confirm these data by a depression in the records of *Pinus cembra* and *Larix* plant remains. The evidence of charcoal fragments indicate fire as disturbance-factor in the subalpine forests during these periods.

Parole chiave: Italia settentrionale, Alpi orientali, Mesolitico, polline, macrofossili vegetali, paleoecologia, linea del legno, incendi boschivi.

Key words: Northern Italy, Eastern Alps, Mesolithic, pollen, plant macrofossils, palaeoecology, timberline, forest fire.

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1. Introduction

One of the northern-most high alpine Mesolithic sites in the Adige basin is the seasonal camp located on the Hirschbichl near-by the Staller Sattel (Fig. 1). The mesolithic dwelling place is situated beside a small tarn at an altitude of 2,140 m a.s.l. From the palaeoecological point of view the uniqueness of the site is that this lake is placed isolated on a hill-top similar to a maar. Because of this topography disturbances of the tarn sediments by avalanches and by falling stones can be excluded. Soundings in the lake have proven this fact and showed undisturbed organic sediments of 3,4 m ideal for palaeoecological investigations of the early holocene vegetation development. The tarn covers an area of roughly 50 m in diameter and is now almost entirely overgrown, with an open-water area of ca 10 m in diameter.

The present tree-limit of the investigation area is formed by a *Larici-Pinetum cembrae* community and lies at the same altitude as the lake. The wider vicinity of the



Fig. 1 - The geographical location of the mesolithic camp site on the Hirschbichl/Osttirol (marked with an asterisk) and other places mentioned in the text.

tarn, however, is bare of trees except for some stunted dwarf specimens of *Pinus cembra* and *Larix decidua*. The flat surroundings of the tarn and the adjacent mountain slopes support a *Rhododendretum extrasyticum* community, which is replaced by a *Loiseleurietum* on wind-exposed edges.

The archaeological excavations showed that the finds are concentrated in the vicinity of the tarn. The artefacts found confirm that the Hirschbichl was visited by bands of hunters throughout the Mesolithic period (STADLER, 1992). The excavations carried out so far indicate a particular accumulation of artefacts from the Older Mesolithic period (9,000 - 8,000 BP).

Two sediment cores - taken 1 m apart - were obtained from the centre of the lake-basin using a GEONOR borer. Both bore cones extended from the surface to the underlying solid rock. The palynological and plant macrofossil investigations of the lake-sediments were intended to facilitate a reconstruction of the vegetational conditions during the Mesolithic period. Special attention was paid to determining the time at which the tree-limit rose above the altitude of the site.

Table 1 - Radiocarbon datings mentioned in text (radiocarbon laboratories: HV = Hannover, VRI = Vienna). *) published by SEIWALD, 1980.

Sample Code	Locality	Altitude (m a.s.l.)	Sediment	Depth (cm)	14C-age (a BP)	Horizon
VRI-1136 VRI-1137	Hirschbichl I Hirschbichl II	2140 2140	gyttia gyttia	290 - 295 320 - 322	9110 ± 90 9370 ± 170	<i>Picea</i> -expansion beginning of organic sedimentation
HV 8466 HV 8465	Malschötscher Hotter *) Malschötscher Hotter *)	2050 2050	peat peat	155 - 160 115 - 120	6810 ± 85 5050 ± 75	rational pollen limit of <i>Abies</i> , <i>Fagus</i> beginning of the <i>Picea</i> -decline
VRI-548 VRI-549	Duramoor *) Duramoor *)	2080 2080	gyttia gyttia	385 - 405 330 - 340	8920 ± 130 7870 ± 140	<i>Picea</i> -expansion beginning of <i>Picea</i> -dominance
VRI-553	Schwarzsee *)	2030	gyttia	375 - 393	9370 ± 150	beginning of organic sedimentation

2. Local and regional biostratigraphy

The sediments laid down in the tarn include the whole vegetation development of the Holocene. The succession starts with a *Pinus-Artemisia* zone (Ipaz 1, Fig. 3, 4, 5, 6), the older part of which corresponds with the Younger Dryas Chronozone (sensu MANGERUD *et al.* 1974). The values of AP (= Arboreal Pollen) reach 80 %. Pollen grains of *Pinus diploylon*-type dominate, although pollen of *Pinus cembra*-type and *Juniperus* are also present. Among the NAP (= Non Arboreal Pollen) plants of open habitats are frequent, such as *Artemisia*, *Chenopodiaceae*, *Poaceae* and *Thalictrum*. Typical representatives of the late-glacial apocaratic flora that should be mentioned are the two *Ephedra*-species, *E. distachya*- and *E. altissima*-type. The presence of these apocaratic floral elements prompts the conclusion that the area in the immediate vicinity of the tarn was still treeless. This *Pinus-Artemisia* zone is superseded by a *Pinus-Juniperus* zone (Ipaz 2, Fig. 3, 4) at 9400 yr BP. *Pinus* pollen continues to be dominant, though gradually declining (60 - 50 %). Pollen of *Alnus*, *Larix* and *Picea* first appears in percentage values at the beginning of this paz (= pollen assemblage zone). *Pinus cembra*-type increases a little and attains together with *Larix* their highest relative values within this

paz. The increase in the pollen influx values for *Larix* and *Pinus cembra* provide evidence of the local presence of these tree-species on the Hirschbichl itself from the mid-Preboreal period onwards (Fig. 4, 6). Among the NAP Cyperaceae and Poaceae dominate. In particular during the older section of this paz apocaromatic species (*Artemisia*, *Chenopodiaceae*, *Thalictrum*) are still frequent. Beneath these species of open habitats Apiaceae, Cichoriaceae and Rosaceae attain percentage values. A radiocarbon-dating of $9.110 + 90$ yr BP (VRI-1136) at the upper limit shows that these spectra belong to the Preboreal. A marked increase in the percentage values of *Picea* constitutes the lower limit of the *Pinus-Picea-Corylus* zone (Ipaz 3, Fig. 3, 4, 5, 6). Although *Pinus* continues

Fig. 2 - Signatures to Figs. 3 - 6.

Chronozones:

SB = Subboreal

AT = Atlanticum

BO = Boreal

PB = Preboreal

DR = Younger Dryas

Ipaz = local pollen assemblage zone

Signatures for the main diagram:

- Betula sp.
- Pinus sp.
- △— Picea sp.
- tree pollen sum
- Gramineae

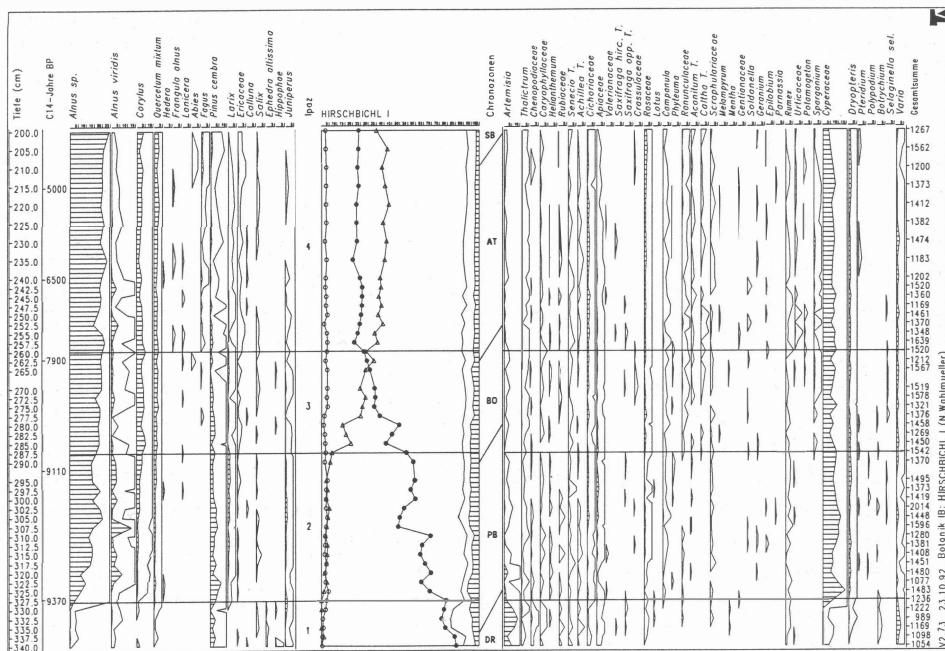


Fig. 3 - Pollen percentage diagram Hirschbichl I showing the relative frequencies of pollen types for the lake sediments on the Hirschbichl covering the early Holocene sequences up to the Subboreal (for pollen curve symbols see Fig. 2). The basis of the calculations is the percentage of $\Sigma P = AP + (NAP - \text{Cyperaceae})$, for Cyperaceae, Pteridophytes, mosses and aquatics $\Sigma P + n$. The radiocarbon data are indicated as uncorrected ^{14}C -datings. The correlation of data for the Atlanticum sequences is based on the palynostratigraphy of the investigation area (see Table 1).

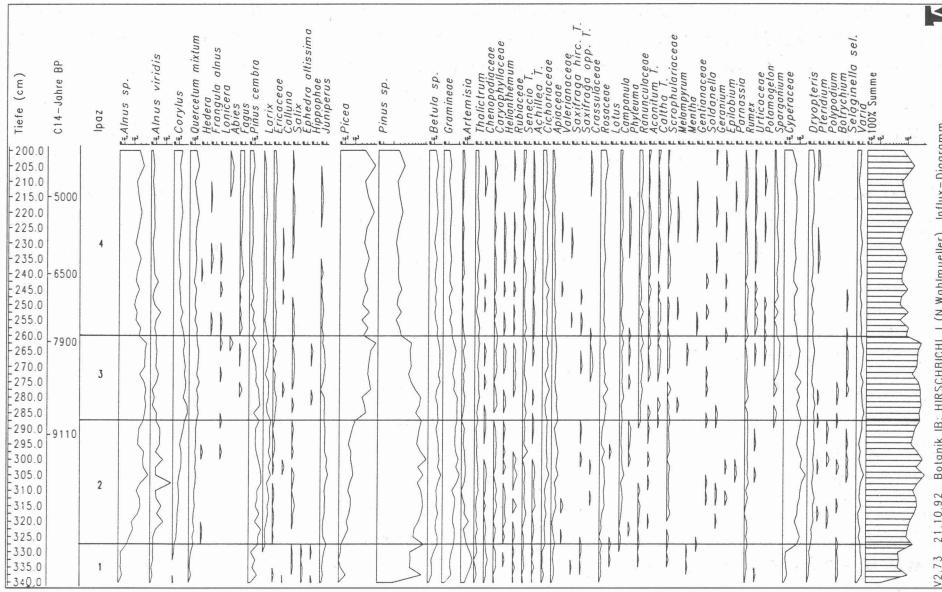


Fig. 4 - Pollen influx (pollen accumulation rate) diagram Hirschbichl I showing the absolute frequencies of pollen types per unit area of sediment surface per unit time (pollen grains.cm⁻².yr⁻¹) for the same sequences as reproduced in Fig 3.

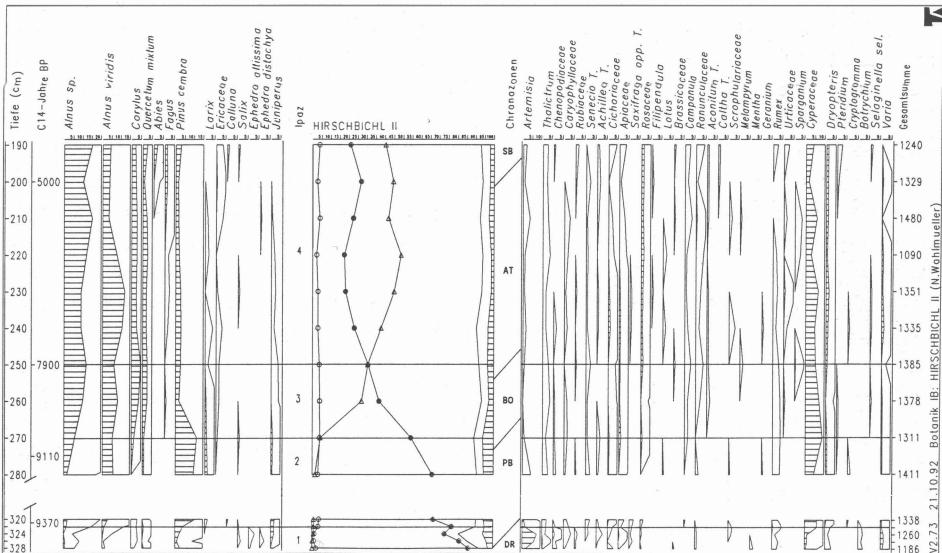


Fig. 5 - Pollen percentage diagram Hirschbichl II showing the relative frequencies of pollen types for the lake sediments on the Hirschbichl covering the early Holocene sequences up to the Subboreal (for pollen curve symbols see Fig. 2). The sediment sample was taken 1 m apart from the Hirschbichl I coring. This profile is showing a hiatus from 280 - 320 cm. Further explanations in the text.

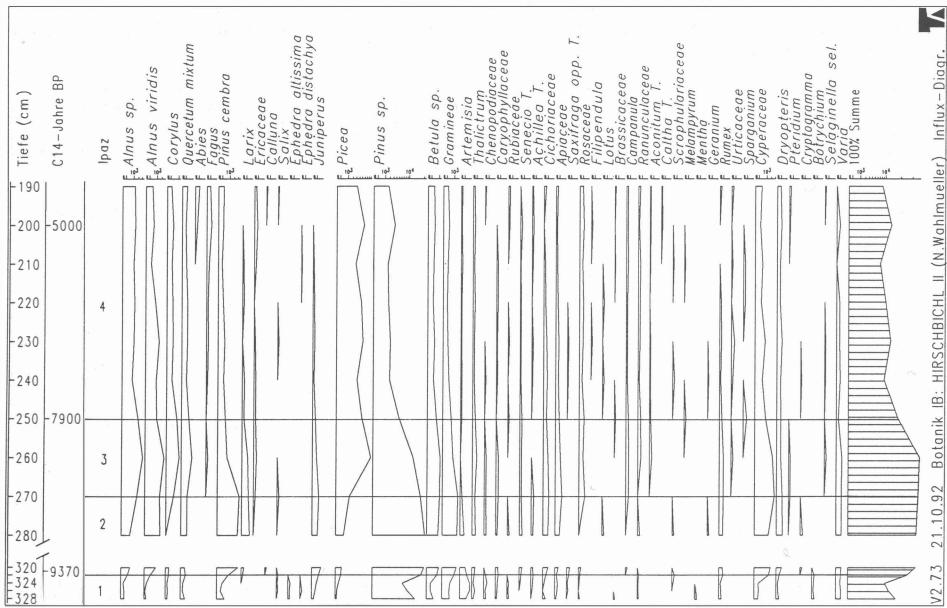


Fig. 6 - Pollen influx diagram Hirschbichl II showing the absolute frequencies of pollen types for the same sequences as reproduced in Fig. 4.

to decline from 45 % to 25%, it remains the dominant tree pollen. *Picea* values - both percentage as well as pollen influx values - increase from the start of the paz, which shows the immigration of *Picea* in the *Pinus-Larix* forests. *Larix* and *Juniperus* still attain percentage values. The NAP sum fluctuates only slightly around a mean value of 15%. As well as Poaceae and Cyperaceae pollen of the Apiaceae, Cichoriaceae, Rosaceae, *Sparganium* and *Thalictrum* attain percentage values. The *Pinus-Picea-Corylus* zone ends at the crossing of the percentage curves of *Picea* and *Pinus*. This event is radiocarbon-dated to 7900 yr BP (SEIWALD, 1980) and gives a good biostratigraphical marker for the Boreal/Atlanticum transition in the investigation area. From now on *Picea* pollen (31 - 38%) predominates, which is characteristic for the *Picea-Pinus* zone (Ipaz 4, Fig. 3, 4, 5, 6). The percentage values of *Pinus* pollen maintain around 25 %. *Alnus viridis* and *Pinus cembra*-type sink to their lowest values in the course of this paz. Even *Larix* only reaches percentage values at the start. *Fagus* now shows a continuous curve. Towards the end of this zone the first pollen grains of *Abies* occur. The NAP values decline from 16 - 10%.

The local biostratigraphy of the high alpine regions is confirmed by pollenanalytical investigation of the Villanderer Alm, ca 60 km westwards (SEIWALD, 1980). Representative for this area the well radiocarbon-dated pollendiagramm of the Duramoor is mentioned.

To sum up the biostratigraphical development of the subalpine regions in the sense of vegetation types (Table 2): *Pinus-Larix* woodlands dominate from the mid-Preboreal until the end of the Boreal. In the second half of the Boreal *Picea* immigrates into the *Pinus-Larix* woodlands. At the beginning of the Atlantic period *Picea* becomes dominant in altitudes of ca 2100 m a.s.l.

Table 2 - Composition of the subalpine woodlands in the mountains surrounding the Adige valley during the early Holocene.

Age (yrs BP)	Rinderplatz 1780 m (SEIWALD 1980)	Seiser Alm 1880 m (KRAL 1983)	Schwarzsee 2038 m (SEIWALD 1980)	Malschötscher Hotter 2055 m (SEIWALD 1980)	Dura Moor 2080 m (SEIWALD 1980)	Hirschbichl 2150 m
5000						
6000	Picea-Pinus	Picea-Pinus	Picea-Pinus	Picea-Pinus	Picea-Pinus	Picea-Pinus
7000						
8000		Pinus-Picea-Larix	Picea-rich Pinus-Larix	Picea-rich Pinus-Larix	Picea-rich Pinus-Larix	Picea-rich Pinus-Larix
9000	Pinus-Larix					
10000						

3. Local vegetation development during the early holocene

One main question was to reconstruct the local vegetation of the tarn and to determine the time at which the timber-line rose above the altitude of the site. In addition to pollen concentration diagrams analyses of plant macrofossils are ideal to trace local vegetational changes like timber-line fluctuations. Supplementary plant macrofossils permit a more detailed view in the local vegetational development. Sediment samples paralleling those taken for pollen analyses were investigated for plant macroremains. The above conclusions drawn from pollenanalyses are confirmed by these plant macrofossil analyses (Fig 7, 8). The basal sediments of the tarn - the *Salix herbacea-Dryas octopetala* zone (Imaz 1) - contain mainly remains of widely distributed arctic-alpine dwarf shrubs. *Arabis alpina*, *Dianthus cf. glacialis*, *Dryas octopetala*, *Gypsophila repens*, *Saxifraga moschata*, *Saxifraga oppositifolia* and *Silene cf. acaulis* indicate the presence of pioneer communities of alpine lawns and screes. Snowbed communities are represented by *Salix herbacea*, *Cephalozia ambigua* and *Polytrichum norvegicum*.

The *Larix-Pinus* zone (Imaz 2, Fig. 7) encompasses the change from open conditions to forest establishment on the Hirschbichl, with the first finds of needles of *Larix*, *Pinus cembra* and *Pinus mugosylvestris*. Remains of the pioneer plants of open habitats in the alpine zone and those of snowbed communities (*Polytrichum norvegicum*, *Cephalozia ambigua*) dissapear from the record at the same time. *Larix-Pinus* woodlands expanded at the altitude of the Hirschbichl in ca 2150 m. This ecological change has been radio-carbon dated to 9370 ± 170 yr BP (VRI-1137).

The establishment of the *Larix-Pinus* woodlands is continued in the *Alnus-Betula-Larix-Pinus* zone (Imaz 3, Fig. 7, 8)). Remains of *Alnus viridis*, *Betula pendula*, *Larix*, *Pinus cembra* and *Pinus mugosylvestris* confirm the local occurrence of these trees and shrubs on the Hirschbichl. The macrofossils of *Rhododendron* sp. and *Vaccinium* sp. give evidence of the presence of characteristic species of the *Larici-Pinetum cembrae* community on the Hirschbichl already from the mid-Preboreal onwards. In contrast to the picture presented by the pollen diagram where *Larix* pollen is underrepresented, the macrofossil diagram shows that remains of *Larix* predominate over those of *Pinus* sp. and *Pinus cembra*. The explanation for this *Larix*-overrepresentation in the macroremains is because

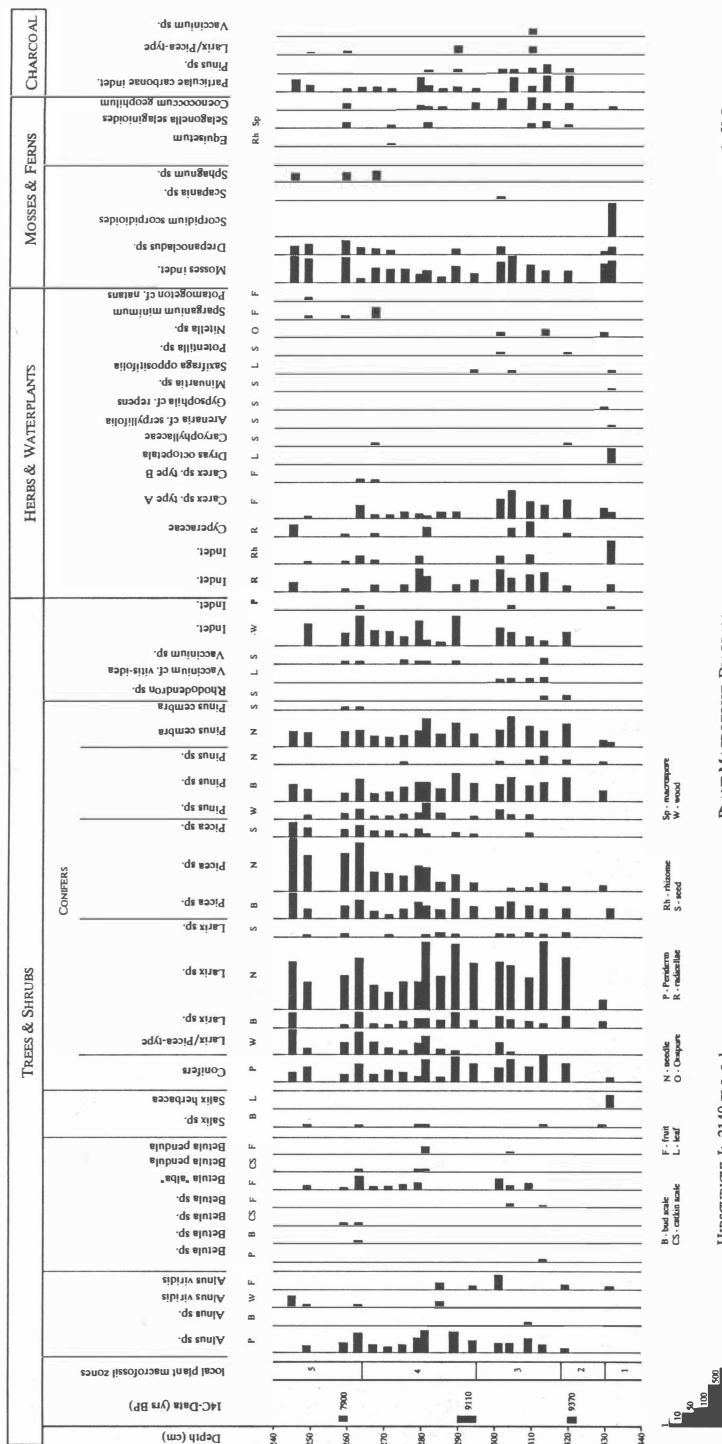


Fig. 7 - Plant macrofossil diagram Hirschbichl I for the same sequences as reproduced in Fig. 3 showing the absolute frequencies of plant remains per 100 cm³.

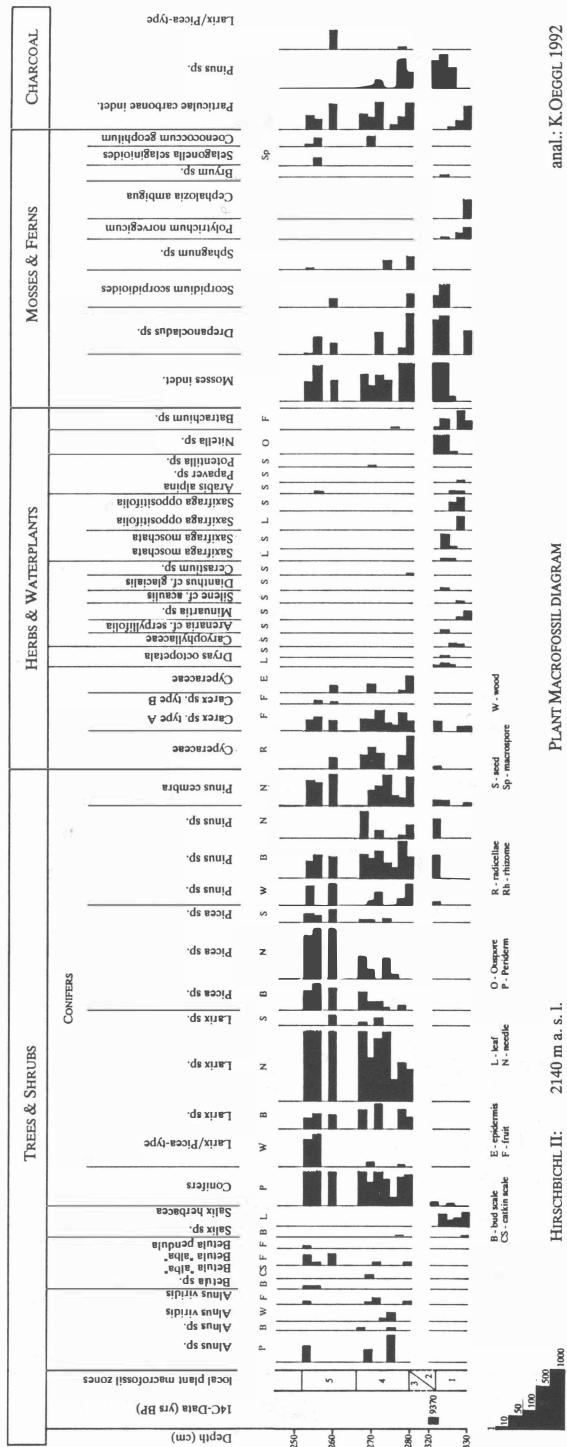


Fig. 8 - Plant macrofossil diagram Hirschgibl II for the same sequences as reproduced in Fig. 5 showing the absolute frequencies of plant remains per 100 cm³.

Larix sheds its needles annually. Nevertheless, the results emphasize the important role this species played in the subalpine forest during the early Holocene.

Picea becomes a component of the forests at the altitude of the investigation site at the beginning of the Boreal. This is documented in the *Alnus-Betula-Larix-Picea-Pinus* zone (Imaz 4, Fig. 7, 8). The spread of *Picea* is reflected in the marked increase in the frequency of the needles among the macrofossils. A radio-carbon dating of 9110 ± 90 yr BP places this event at the end of the Preboreal. From now on *Picea* continues to expand. At the beginning of the *Alnus-Betula-Larix-Picea* zone (Imaz 5, Fig. 7, 8) remains of *Picea* predominate, those of *Larix* and *Pinus* are still frequent.

4. Vegetation changes in the alpine ecosystem during the early Holocene

The pollenanalytical investigations of the Hirschbichl tarn sediments show that the timber-line lay already close to the altitude of the site in the Younger Dryas, as confirmed by the high percentage values and pollen accumulation rate for *Pinus* (Fig 4, 6). At 9400 yr BP the change from open conditions to forest establishment comes to pass. *Larix-Pinus* woodlands expand on the top of the Hirschbichl. This vegetational shift is a regional phenomenon and is confirmed by radio-carbon datings of two sites on the Villanderer Alm (SEIWALD, 1980), namely 9370 ± 150 (VRI-553) and $8920 + 130$ yr BP (VRI-548). By the close of the Preboreal, the *Larix-Pinus* woodlands had reached the 2300 m level on the «Alpenhauptkamm» of the Eastern Alps (BORTENSCHLAGER, 1984).

One may assume, that in the Hirschbichl area the forest had colonized the slopes up to an altitude of at least 2200 m. This forest was composed of *Pinus* (probably *Pinus mugo* mainly), *Pinus cembra* and *Larix decidua*. *Alnus viridis* had already colonised the wetter habitats at and above the timberline. The forest floor community in the *Larix-Pinus* woods already included members of the ericaceous dwarf-shrub community (*Rhododendron*, *Vaccinium*; Fig 3, 7). The *Larix-Pinus* woodlands itself had a fairly open structure since light demanding species such as *Caryophyllaceae*, *Chenopodiaceae*, *Juniperus* and *Helianthemum* were widespread. Pioneer species of the alpine zone were still present sporadically, e.g. *Saxifraga oppositifolia*.

At the beginning of the Boreal (9000 yr BP) *Picea* immigrated into the *Larix-Pinus* woodlands (Ipaz 3, Fig 3, 4). Isolated occurrences of *Picea* needles in the Preboreal sediment samples indicate that this tree species was gradually approaching the site level. *Picea* pollen exceeds the 5 % limit at 285 cm depth and the macrofossil finds from this horizon (bud scales, needles, seeds) confirm its local occurrence (Imaz 4, Fig. 7, 8) as well as the significant rise in the pollen influx values (Fig. 4). *Picea* was thereafter able to spread widely, attaining its maximum distribution in the older Atlanticum, both regionally and altitudinally. At the same time, the forest cover on the Hirschbichl became denser, as shown by the progressive decline in NAP values (*Poaceae*, *Artemisia*, *Helianthemum*). This *Picea* dominance in the forest at this altitude was maintained up to the Subboreal.

Apart from a minor regressive phase at the beginning of the Preboreal, the development of the vegetation cover on the Hirschbichl progressed uninterruptedly right up to and during the Subboreal. The glaciers, also, had at the latest by the mid-Preboreal, regressed to their present-day extents and at no time since did they exceed, to any real degree their maximum extents at that time. The implication is thus that the climate, too,

had more or less approximated to its present-day limits by the mid-Preboreal (PATZELT & BORTENSLAGER, 1973). Since by that time, at latest, the tree-limit had risen above the altitude of the Hirschbichl, no further climatic fluctuations are evidenced by changes in the pollen diagram, despite the close sampling intervals and the fact that the site today lies close to the local altitudinal tree-limit. That the climate in the early Holocene was relatively favourable can be deduced from the permanency of the distribution of *Larix*, *Pinus* sp., *P. cembra* and *Picea* after the mid-Preboreal (Fig. 4). They achieve their maximum distributions, however, only during the older Atlanticum.

The relative falls in *Pinus* pollen values, in the middle of the *Pinus-Juniperus* zone (Ipaz 2, Fig. 3) and again at the start of the *Pinus-Picea-Corylus* zone (Ipaz 3) are only accompanied by relatively minor increases in the NAP curve (Fig. 3). Higher values attain *Artemisia*, *Caryophyllaceae*, *Chenopodiaceae*, *Gramineae* and *Thalictrum*. These declines in the *Pinus* values at 310 and 287,5 cm occur abruptly. Synchronous a gradually rise in the pollen influx values (Fig. 4) of the species mentioned above can be detected signalling either an opening of the forest cover or a minor timber-line depression.

At both these levels in the macrofossil diagram (Fig. 7, 8) there are increases in the frequency of charcoal fragments. The specific identification show that *Pinus* sp. (including carbonised needles and wood of *Pinus cembra*), carbonised wood fragments of *Larix/Picea* type and also of *Ericaceae* (*Vaccinium* sp.) are involved. The size of the charcoal fragments concerned (mostly the > 2 mm range) and the species spectra indicate the local occurrences of forest-fires. In the pollen diagram the involvement of forest fires lead to the occurrence of Pteridophyte spores, such as those of *Botrychium*, *Pteridium* and *Selaginella selaginoides*. Coincident with the *Pinus* decline at 310 cm there is a fall in the *Ericaceae* curve and that for *Calluna* rises (Fig. 3, 4). Subsequently, a succession, involving *Betula pendula* followed by a renewed increase in *Pinus* pollen, can be seen in the pollen and plant macrofossil diagram (Fig. 7).

Localised forest fires represent a disturbance factor in the *Larix-Pinus* forests that plays a significant role throughout the early Holocene. This is shown by the presence of charcoal fragments throughout that epoch, although with obvious maxima during the Preboreal and Boreal (Fig. 7, 8). During the Atlanticum the charcoal values decline. Reconstructions of the environment of mesolithic sites in the uplands of northern England (Pennines) have shown that there was a similar increase in the frequency of forest fires during the Mesolithic period. Evidence of repeated burning of forests at regular intervals by Mesolithic hunters, over a period of 4000 years, leading to a fall in the tree-limit of ca. 350 m thereabout has been found (JACOBI *et al.*, 1976). Such evidence for a deliberate burning of the subalpine forest by man has not been uncovered by the Hirschbichl investigations. Nevertheless, in the past, fire has probably contributed materially to the maintenance of the open structure of the subalpine forests, such that patches of alpine lawn communities could find a footing between the knee-timber and trees. Only after the marked expansion of *Picea* in the forests at these altitudes during the Atlantic, did the canopy become closed enough to exclude these ground-cover communities.

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ZUSAMMENFASSUNG

Parallel zu den archäologischen Ausgrabungen eines mesolithischen Lagerplatzes auf dem Hirschbichl nahe dem Staller Sattel (Osttirol/Austria) wurden Untersuchungen zur Paläoumwelt durchgeführt. Die Sedimente aus dem See auf dem Hirschbichl erfassen die Entwicklung vom Übergang Jüngere Dryas/Präboreal bis in das Subatlantikum (Chronozonen sensu MANGERUD *et al.*, 1974) ohne erkennbare Störung. Die Vegetationsentwicklung beginnt im Pollendiagramm mit einer *Pinus-Artemisia*-Zone (Jüngere Dryas pp.), der sich eine *Pinus-Juniperus*-Zone anschließt, die bis ans Ende des Präboreals reicht. Danach folgt eine *Pinus-Picea-Corylus*-Zone (Boreal), die im Atlantikum in eine *Picea-Pinus*-Zone übergeht. Diese dauert bis in das Subboreal an. Dann übertrifft *Pinus* wieder *Picea* und bildet eine *Pinus-Picea*-Zone (Subboreal, Subatlantikum). Diese Zonen der Vegetationsentwicklung aus dem Pollendiagramm werden durch die pflanzlichen Großrestdiagramme bestätigt. Demnach dominierten in der ausgehenden Jüngeren Dryas auf dem Hirschbichl alpine Pionierrasengesellschaften, die im Präboreal durch einen Zirben-Lärchen-Wald (*Larici-Pinetum cembrae*) abgelöst werden. Schon früh wandert in den subalpinen Zirben-Lärchenwald (*Larici-Pinetum cembrae*) die Fichte (*Picea*) ein. Diese drei Baumarten beherrschen von nun an die Vegetationsverhältnisse während des gesamten Holozäns.

Wie aus dem Pollenkonzentrationsdiagramm und den pflanzlichen Makrofossilanalysen ersichtlich wird, übersteigt die Waldgrenze den Bereich des Lagerplatzes (2150 m) bereits im Präboreal. Während des Präboreals und Boreals sind deutliche Einbrüche in der *Pinus*-Pollenkurve zu erkennen, denen NAP-Gipfel gegenüberstehen. Diese palynologischen Daten werden durch die Großrestanalysen bestätigt, wonach *Larix*- und *Pinus cembra* Rückschläge verzeichnen. Synchronie Holzkohlen-Funde decken mehrfache Brände in den subalpinen Wäldern auf, die die Störungen im *Larici-Pinetum cembrae* verursachen. Diese tragen auch zur offenen Struktur des Zirben-Lärchen-Waldes (*Larici-Pinetum cembrae*) bei, sodaß alpine Rasen zwischen den Gehölzen bestehen können. Erst mit der drastischen Ausbreitung von *Picea* im Zirben-Lärchen Wald (*Larici-Pinetum cembrae*) um 8000 BP verschwinden diese Rasengesellschaften.

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