XXIV. MOOREXKURSION

16.-24. September 2000

SOUTHERN ALPS

Excursion guide

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Excursion Program

Sept. 16 Departure from Bern in the morning, meeting point Splügen (CH) in the afternoon
Accommodation: Locanda Cardinello, Via Baldiscio 2, 23024 Isola/Madesimo.
Tel. +39-0343-53058

Sept. 17 **Pian dei Cavalli and Lago Basso (2250 m asl)**: Mesolithic human activity, climatic and human impact at timberline – F.G. Fedele, L. Wick
Accommodation: Locanda Cardinello, Via Baldiscio 2, 23024 Isola/Madesimo.
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Sept. 18 **Chiavenna**: visit of the „Prehistory Hall" at the local museum – F. Fedele
Late-Glacial and Holocene vegetation development in Brianza**: Lago del Segrino**, **Lago di Alserio** – L. Wick
Monte Barro: Phytogeographical significance of the Lombardian Pre-Alps and the Insubrian region – C. Ravazzi. Mid-Holocene *Abies* decline and fire history at **Lago di Annone** – L. Wick
Accommodation: Bar Ristorante EREMO, Eremo di M. Barro, Galbiate (LC).
Tel. +39-0341-240525

Sept. 19 **Conca di Crezzo**: Holocene vegetation development, *Abies* decline – L. Wick
Leffe and **Pianico**: Interglacial pollen sequences – C. Ravazzi, S. Rossi
Accommodation: Hotel Parco, Via Nazionale 44 and Albergo Edelweiss, Via Nazionale 2, 25040 Corteno Golgi. Tel. +39-0364-74346 (Parco), 0364-74126 (Edelweiss)

Sept. 20 **Pian di Gembro** revisited: Late-glacial and Holocene vegetation history and bog development – C. Andreis, R. Pini
Col di Val Bighera (2087 m) and **Passo del Tonale (1883 m)**: Late-glacial and Holocene vegetation development in the upper Val Camonica – R. Gehrig
Accommodation: Grand Hotel Trento, Via Alfieri 1/3, 38100 Trento.
Tel. +39-0461-271000

Sept. 21 **Piano del Cansiglio** and **Lago di Revine:** Late-glacial and early-Holocene forest development / Glacial refugia; Late-Paleolithic and Mesolithic sites – C. Ravazzi, M. Peresani, L. Wick
Accommodation: Hotel Schönblick, Reiperting 1a, Riscone, 39031 Brunico

Sept. 22 **Staller Sattel: Obersee** and **Hirschbichl:** Holocene timberline development, Mesolithic sites, human impact – W. Kofler, K. Oeggl, B. Wahlmüller
Accommodation: Hotel Tourist, Via Dante 28, Brixen. Tel.+39-0472-831545

Sept. 23 **Bolzano/Archaeological Museum** (09.00-11.00 a.m.)
Vegetation development at **Lake Montiggl** – K. Kompatscher, K. Oeggl
The Bronze Age settlement Ganglegg: archaeobotanical investigations – H. Steiner, A. Schmiedl
Accommodation: Hotel Engel, Kirchplatz 7, 39020 Schluderns. Tel. +39-0473-615278

Sept. 24 Schluderns – Bern

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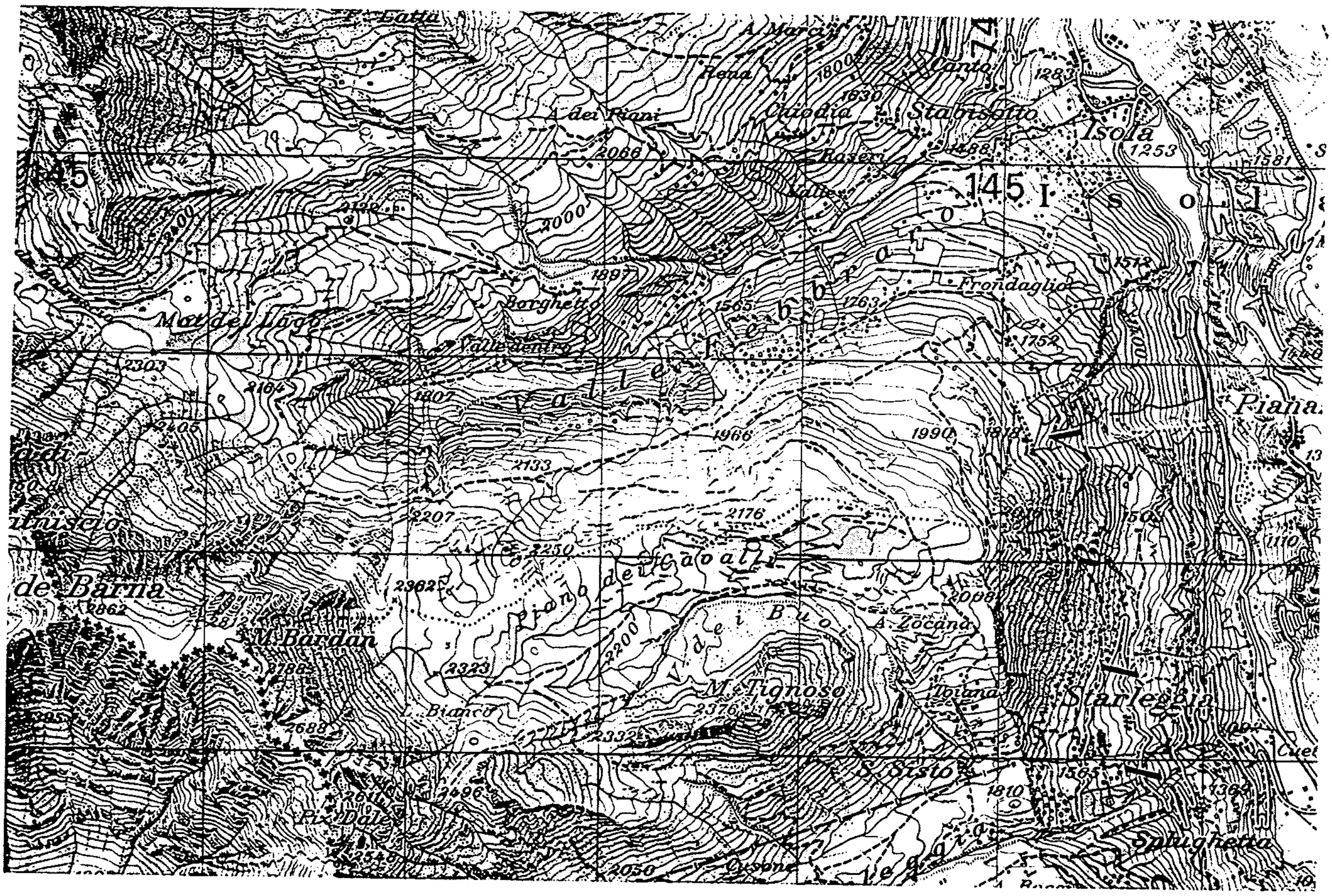
Pian dei Cavalli and Lago Basso (2247 m asl)



A comprehensive investigation on early human presence at the former timberline, on the southern side of the Splügen Pass watershed, was undertaken in 1986 in combination with environmental and paleoecological studies (Fedele 1985; 1986; 1992). Programmed exploration has resulted, so far, in the discovery of **43 prehistoric sites** above the present-day timberline, between elevations of 2000-2420 m asl. These include 27 sites on the Pian dei Cavalli alone, an elevated plateau which was selected as the test-area for the initial attempts of the project (Fedele 1998; 1999; Fedele *et al.*, annual reports in *Clavenna 26-38*, 1987-1999). The intensive-study area was chosen on purpose along the Swiss-Italian border, with an explicit focus on the Alpine watershed zone, the timberline phenomena, and the hypothetical early-human interactions with both.

The **Pian dei Cavalli** or Horses' Plateau (2000-2300 m asl) is an escarped and isolated block of carbonate rocks, mainly limestone and related breccias and marbles. It hangs beautifully above the Spluga Valley furrow and is closely surrounded by high-altitude peaks of crystalline units. The plateau dips east, while on its northern side it displays an imposing escarpment onto the next lateral valley, Val Febbraro. Access from valley floors is difficult from the west, in spite of some passes, including Baldiscio/*Balnisc'*, and rather demanding from all other directions. Portions of the plateau are punctuated by karst forms (dolines and sinkholes). Tardiglacial moraines and rock-falls line its SW zone. Its upper «bench» to the west coincides with gneiss-micaschist rocks and was carved by glacial abrasion into hillocks and hollows, these formerly occupied by lakes and ponds. **Lago Basso** or *lagh di fiòc* (*fiòc* = *Eriophorum*) is the lowermost, and one of two surviving glacial lakes cored within the project by a Bern University team (Lucia Wick; see below). Concurrently, a number of peatbogs in the nearby areas have been studied by a Bergen University group led by Dagfinn Moe.

At least a half of the Pian dei Cavalli archaeological sites are **Mesolithic** in age and culture, representing an outstanding example of high-altitude circulation within the Alpine core, at the very beginning of post-glacial human colonization. Two have been excavated, including the largest and most informative, Cavalli-1 (CA1), located at 2200 m asl on the northern escarpment. Two more, CA15 and CA24, were tested in 1997-99, turning out to be very rich in artifacts and charcoal, and quite possibly Mesolithic, but unfortunately still undatable. A major configuration of Mesolithic sites is the closely spaced series along the upper part of the plateau's northern cliffs, deglaciated since Bølling-Allerød times. This is the «northern rim cluster», which includes CA1 as a focal site at its lower end (a complete lack of findspots is apparent down from CA1). Site CA15 and Lago Basso itself belong within this particular archaeological zone.

Age control is assured by eighteen ^{14}C measurements from excavated contexts. In agreement with the artifactual record, dates cluster at 8200-7900 cal BC and 6800-6400 cal BC, corresponding to local Mesolithic phase 1 and phase 2 respectively. Phase 1 can be equated with the Early Mesolithic of the usually accepted Alpine and circum-Alpine sequence (Crotti 1993; Broglio 1994), while Phase 2, which includes trapezoid microliths, belongs to the Late Mesolithic. Significantly, man-made fires in the 8300-7850 and (7300?)7000-6300 cal BC intervals are indicated by charcoal particle influx at Lago Basso. According to geomorphology (C. Rosskopf, University of Naples), the surroundings of Lago Basso may have seen snowfields during the Younger Dryas readvance, well into the 10th millennium cal BC.

All recorded sites presently lie in the alpine grassland horizon. Most sites tend to be very poor in cultural residue (less than 5 artifacts per square metre), as befits a marginal area in the cultural geography of the Early Holocene: they clearly consist of extremely short occupations. On the other hand, chert and quartz raw materials reveal circulation across elevated terrain, probably including the Alpine watershed itself. In addition to lithic findspots there are also «charcoal» sites, i.e. burnt features without recognizable artifacts. Some were radiocarbon-dated to the later prehistory and attributed to human activities. These are part of the limited Pian dei Cavalli data on subsequent phases of colonization, from the Late Neolithic to the Final Bronze Age (c.3500-1000 cal BC).

Ten seasons of excavation at CA1 (1986-97) have resulted in a studied area of about 200 m^2. The site displays an impressive series of combustion features or «hearths», mainly at ground level. The only cultural layer is Mesolithic, 10-20 cm thick and located within loess-derived silts (M. Joos, Basel University), later commonly occupied by an alpine podsol's albic (E) horizon (F. Previtali and R. Comolli, University of Milan; cf. Fedele & Wick 1996). The base of the cultural layer appears to record an episode or episodes of early Mesolithic burning, directed at the sparse, small conifer trees of the Preboreal timberline, including *Pinus cembra*. Lobed hollows interpreted as rooted bases of trees were recognized in the excavation. The timberline must have followed the site's rim, a little below the 2200 m contour line. Human circulation on a regular basis may have continued for portions of the 8th millennium cal BC, unless the most acute phases of the Venediger deterioration shifted people away from the inner and higher areas. The existence of later, 7th millennium sites, such as CA13 and a karst-fissure hearth at the western end of site CA1 (c.6700 cal BC), suggests an interval of renewed interest for the uplands, Mesolithic phase 2, which possibly spans the whole 7th millennium cal BC or the Lower Atlantic chronozone. Knowledge of this phase is still very scanty, however.

(Francesco Fedele)

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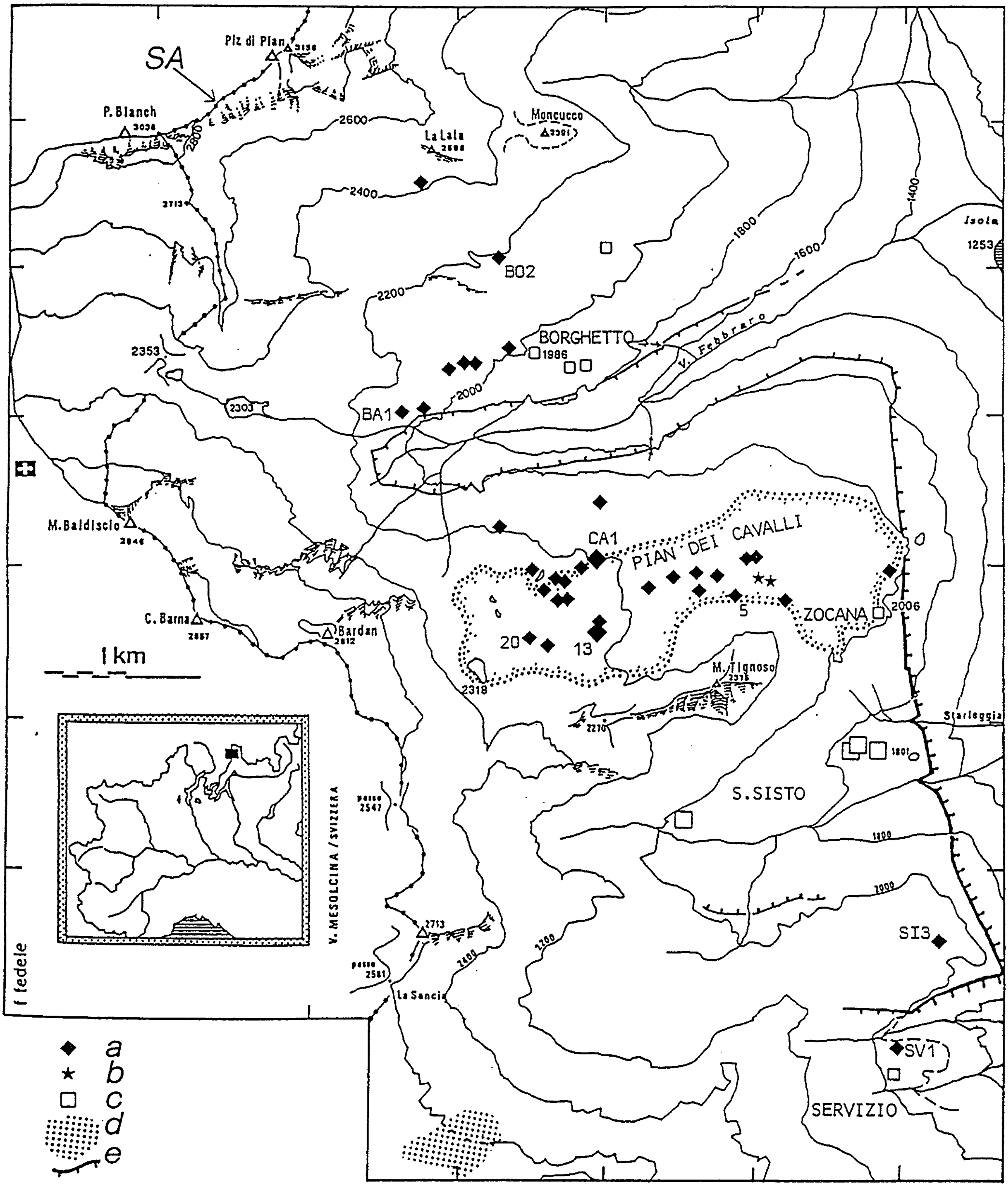

Fig. 1 - Upper Spluga Valley: distribution of prehistoric sites in the Pian dei Cavalli-Borghetto-S.Sisto study area. (a = Lithic artifact sites; b = charcoal-only sites; c = summer huts or "alps"; d = Pizzo Quadro glacier; e = main escarpments; SA = Alpine watershed.)

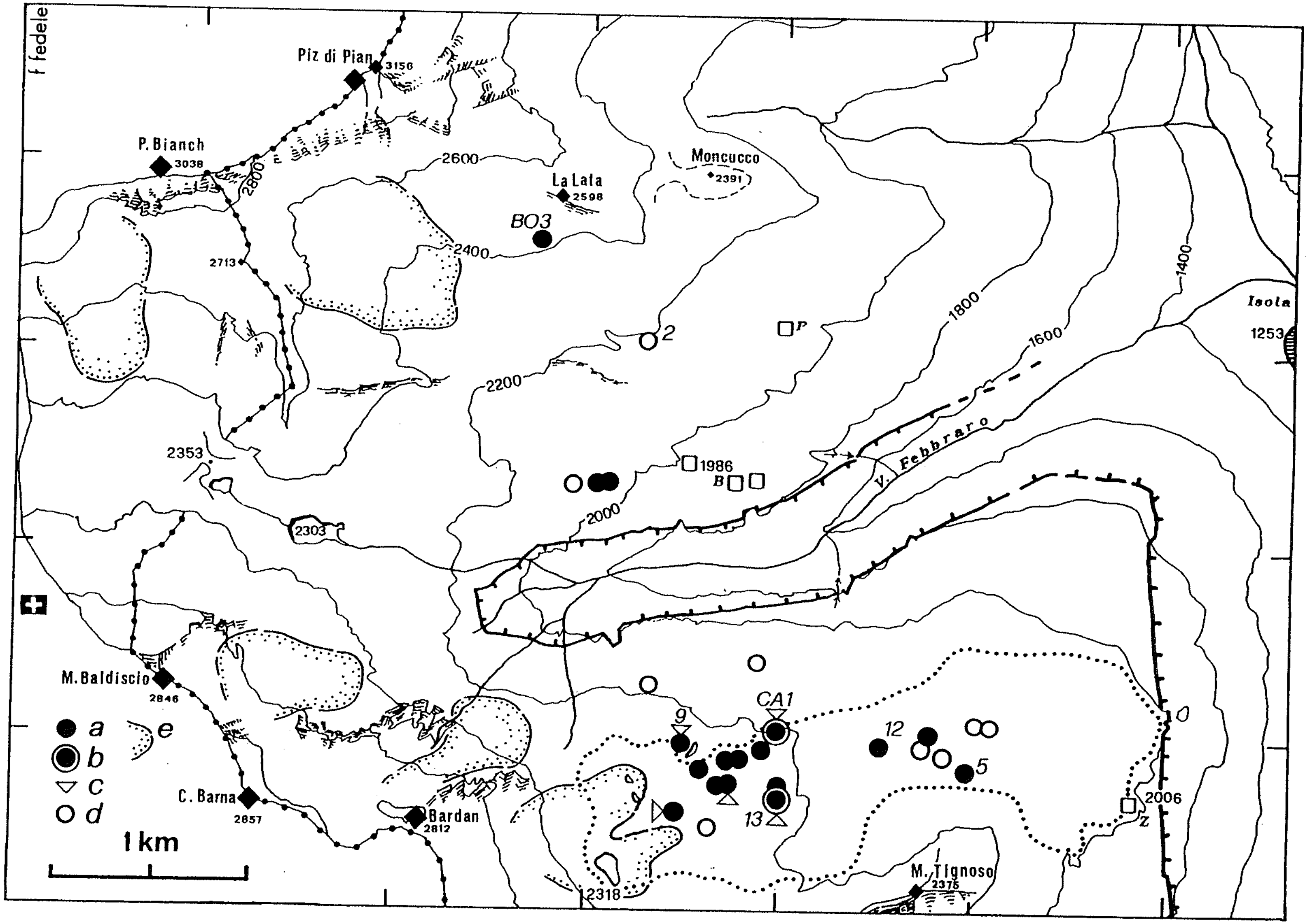

Fig. 2 - Distribution of Mesolithic sites (a) in the Pian dei Cavalli and Borghetto areas (b = excavated, c = with charcoal, d = probably Mesolithic). Hypothetical Little Ice Age snowfields are shown (e).
Distribuzione dei siti mesolitici (a) nelle aree del Pian dei Cavalli e di Borghetto (b = in scavo, c = con carboni, d = mesolitici probabili). Sono indicati i presunti limiti dei nevati della Piccola Età Glaciale (e).

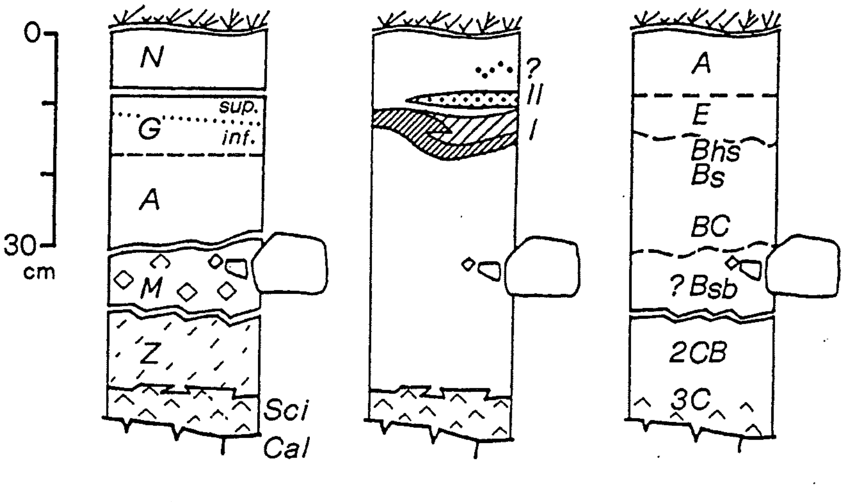

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Fig. 3 – Pian dei Cavalli, site CA1: lithostratigraphy (L), ethnostratigraphy or cultural stratigraphy (E), pedostratigraphy (P). A, G, N = sandy-silty sediments; M = morainic debris; I, II = Mesolithic „hearths“; bedrock may comprise schist (Sci) and/or limestone (Cal) units. Scale at left shows the average thickness of the uneroded A-N sequence

Fig. 4 – Pian dei Cavalli: a section of artifact types representing local Mesolithic phase 1, above (from sites CA1, CA3, FE2) and phase 2, below (from site CA1, feature F159). **a**, knives; **b**, borers and burins; **c**, end-scrapers; **d**, utilized blades; **e**, geometric microliths and black-bladelet fragments; **f**, prismatic core; **g**, blades and knife; **h**, trapezes (M = mark of glue) and crescent.

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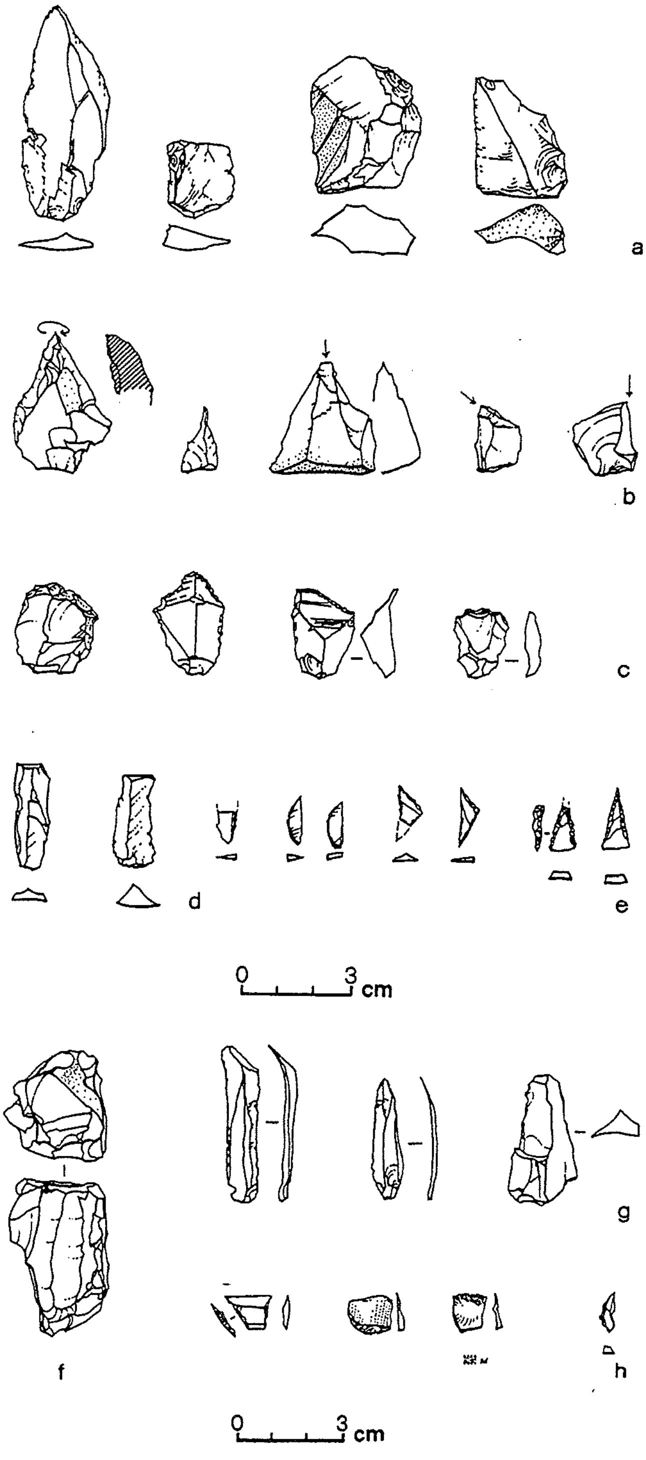
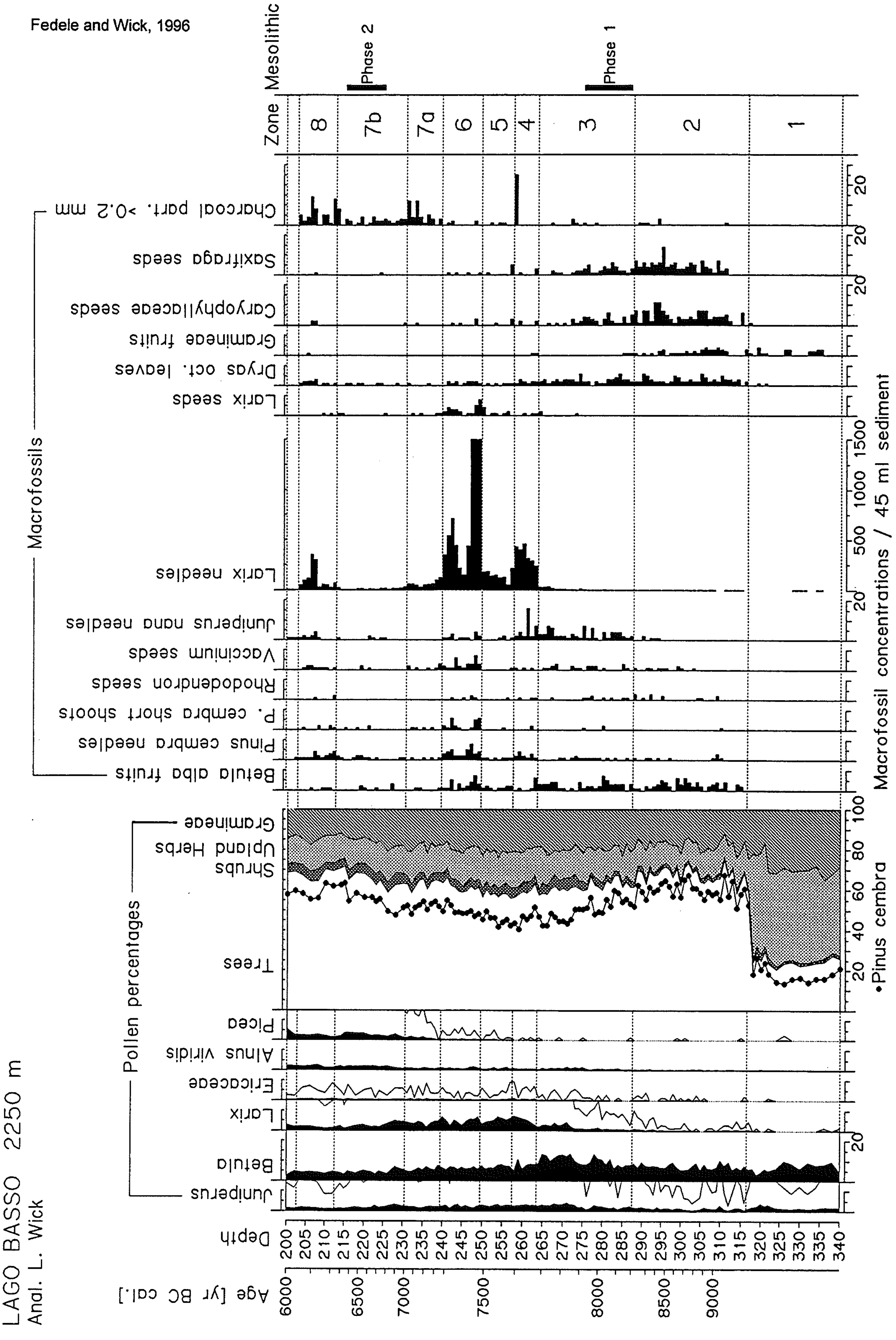


Fedele and Wick, 1996

Fedele and Wick, 1996



Palaeoecological studies at timberline: Lago Grande (2303 m) and Lago Basso (2250 m)

The bedrock geology in the study area consists of gneiss and schist of the Penninic nappes. Pian dei Cavalli represents a small remnant of Mesozoic carbonates covering the silicious bedrock. It is characterised by karstic features. Late-Glacial sediments at the base of both of the profiles and the absence of glacier moraines indicate that no local glaciers covered the sites during the Younger Dryas.
Due to the situation of the area at the southern border of the eastern Central Alps in a north-south valley, the climate shows characteristics of both a dry central-alpine and a humid southern-alpine climate: annual precipitation of up to 2000 mm at lower altitudes (Campodolcino, 1100 m asl) indicates the influence of the Insubrian climate, whereas only 1250 to 1600 mm at 2000 m asl refer to a more central-alpine climate. The maximum monthly precipitation is recorded in summer, when thunderstorms coming from the west cause heavy rainfalls. The mean annual temperature at 2000 m (Splügen Pass) is 2.2°C. The upper limit of the subalpine forest, which is dominated by *Picea abies* in the lower part and *Larix decidua* near the timberline is located at 1950 to 2000 m asl. In less intensively grazed areas the forest limit is located between 2050 and 2100 m, and individual trees are growing up to 2250 m. Swiss stone pine (*Pinus cembra*) is absent from the Splügen Pass area today.
Lago Grande is located in the upper Febbraro valley near the Baldiscio Pass. Its maximum water depth is 5 m and its sediments are minerogenic. No tree macrofossils were found at Lago Grande, but a few pine stomata point to scattered individuals of *Pinus cembra* between about 8500 and 6000 BP. Human impact since the Bronze Age resulted in increasing sediment accumulation rates (erosion).
Lago Basso is a small pond at the northwestern border of Pian dei Cavalli. Its Holocene sediments (fine detritus gyttja) are very rich in plant macrofossils. Due to its low water depth of only about 80 cm the sediments of the last 2000 to 3000 years are partly disturbed.
Strong fluctuations in tree macrofossils at Lago Basso indicate Holocene timberline fluctuations caused by climatic changes. The major timberline fluctuations at Lago Basso can be correlated with cold phases previously described in the Southern Alps (Zoller, 1960, 1977a, 1977b), and in the Austrian Alps (Patzelt, 1977) and with timberline fluctuations in the Central Alps of Valais (Wick and Tinner, 1997).
The timberline data fit with cooling events during the early and mid-Holocene recorded in the Swiss lowlands (seed production of Najas flexilis and lake level changes) and with other proxy records of regional climate change, such as stable isotopes in the Greenland ice cores (Haas et al., 1998).

References

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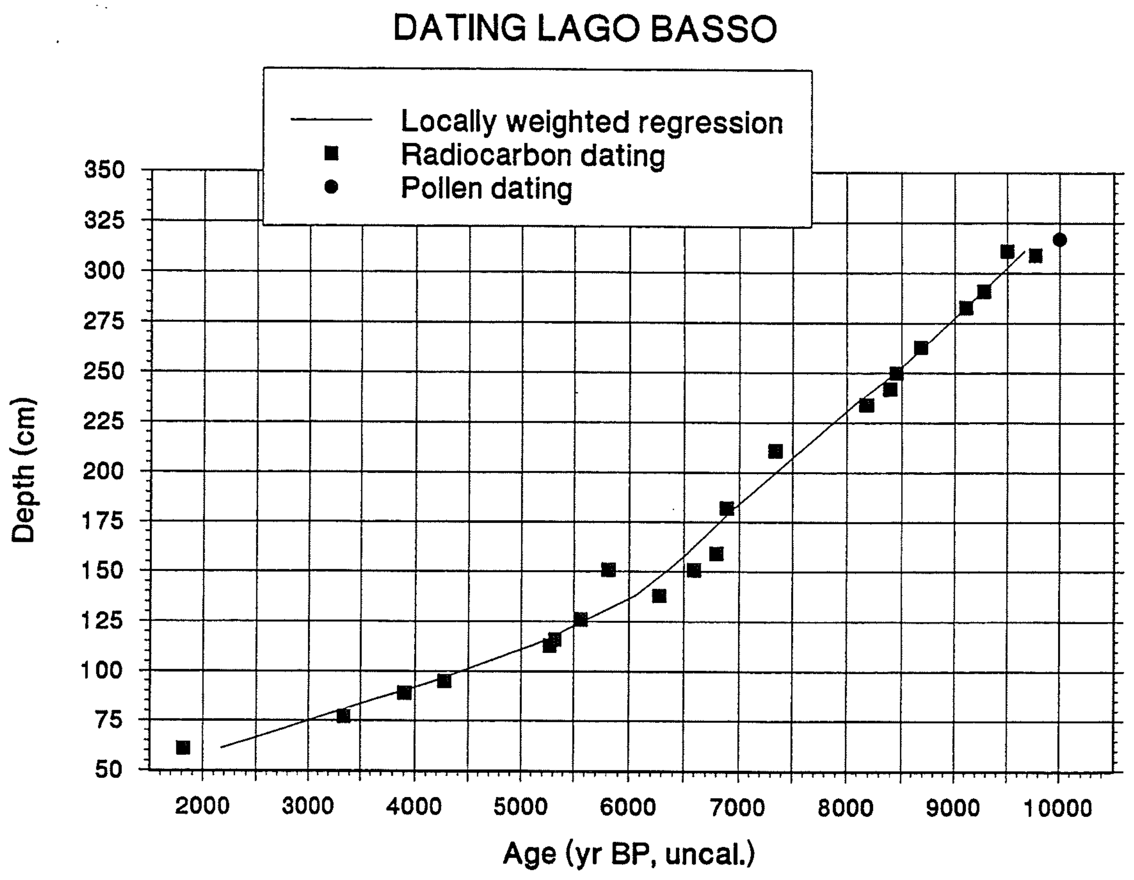
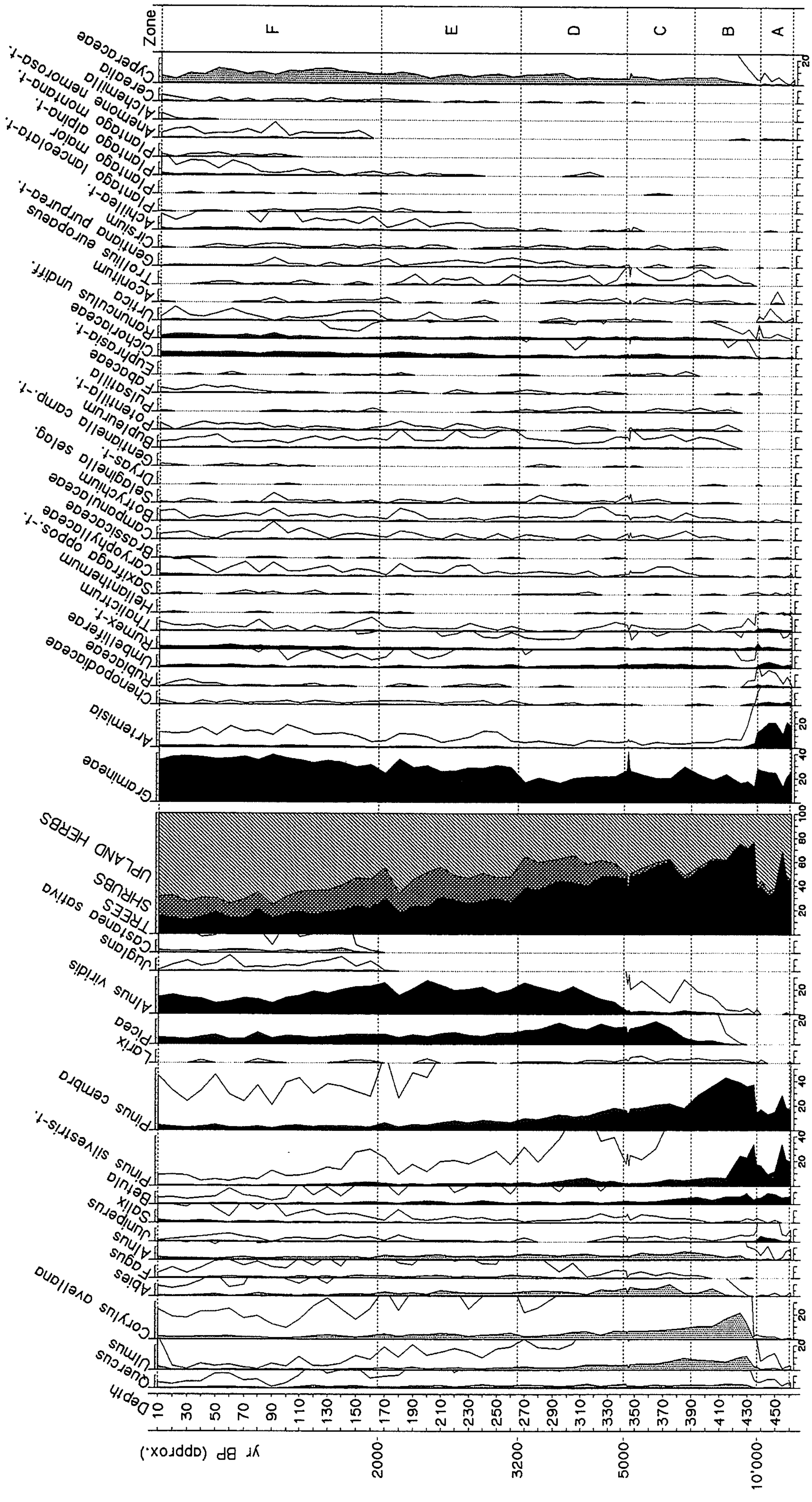
Wick and Tinner, 1997: **Abstract**

Pollen and plant-macrofossil data are presented for two lakes near the timberline in the Italian (Lago Basso, 2250 m) and Swiss Central Alps (Gouillé Rion, 2343 m). The reforestation at both sites started in the Preboreal by *Pinus cembra*, *Larix decidua*, and *Betula*. The timberline reached its highest elevation between 8000 and 5000 BP and retreated after 5000 BP, due to a mid-Holocene climatic change and increasing human impact since about 3500 BP (Bronze Age). The expansion of *Picea abies* at Lago Basso between ca. 7500 and 6200 BP was probably favoured by climatic oscillations and by increasing oceanicity, whereas in the area of Gouillé Rion, where spruce expanded rather late (between 4500 and 3500 BP), human influence equally might have been important. The mass expansion of *Alnus viridis* between ca. 5000 and 3500 BP probably can be related to both climatic change and human activity at timberline.

During the early and middle Holocene a series of timberline fluctuation is recorded as declines in pollen and macrofossil concentrations of the major tree species, and as increases in non-arboreal pollen in the pollen percentage diagram of Gouillé Rion. Most of the periods of low timberline can be correlated by radiocarbon dating with climatic changes in the Alps as indicated by glacier advances in combination with palynological records, solifluction, and dendroclimatical data. Lago Basso and Gouillé Rion are the only sites in the Alps showing complete palaeobotanical records of the climatic oscillations between 10,000 and 2000 BP with a very good time control. The altitudinal range of the Holocene treeline fluctuations caused by climate most likely was not more than 100-150 m.

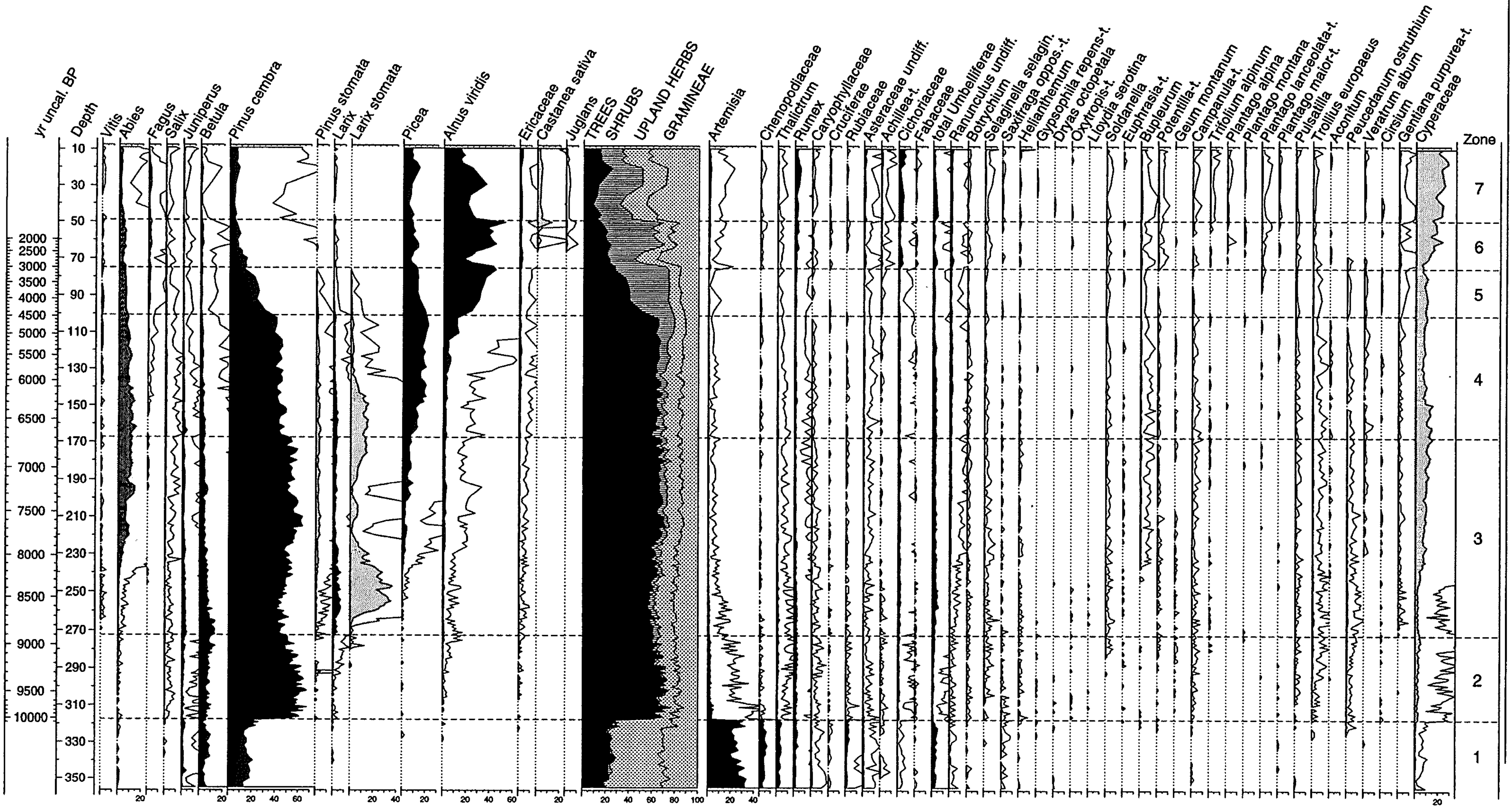
A possible correlation of a cold period at ca. 7500-6500 BP (Misox Oscillation) in the Alps is made with palaeoecological data from North America and a climatic signal in the GRIP ice core from central Greenland 8200 yr ago (ca. 7400 yr uncal. BP).



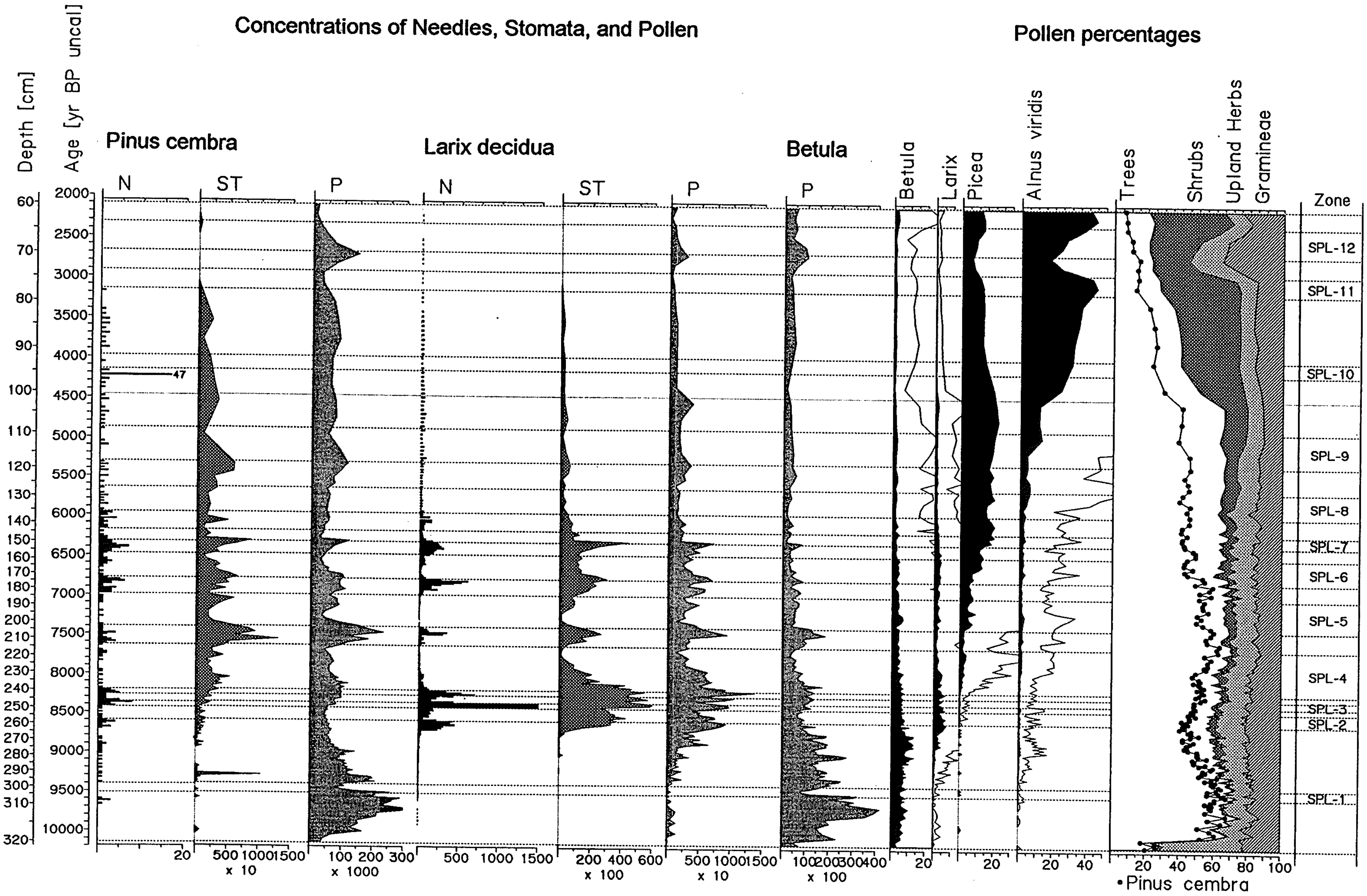


LAGO GRANDE 2303 m a.s.l.
Analysis L.Wick

LAGO BASSO 2250 m asl.
Analysis L.Wick



LAGO BASSO


Concentrations of Needles, Stomata, and Pollen
Pollen percentages
Depth [cm]
Age [yr BP uncal]
Pinus cembra
Larix decidua
Betula
N
ST
P
N
ST
P
P
Betula
Larix
Picea
Alnus viridis
Trees
Shrubs
Upland Herbs
Gramineae
Zone
SPL-12
SPL-11
SPL-10
SPL-9
SPL-8
SPL-7
SPL-6
SPL-5
SPL-4
SPL-3
SPL-2
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•Pinus cembra
60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320
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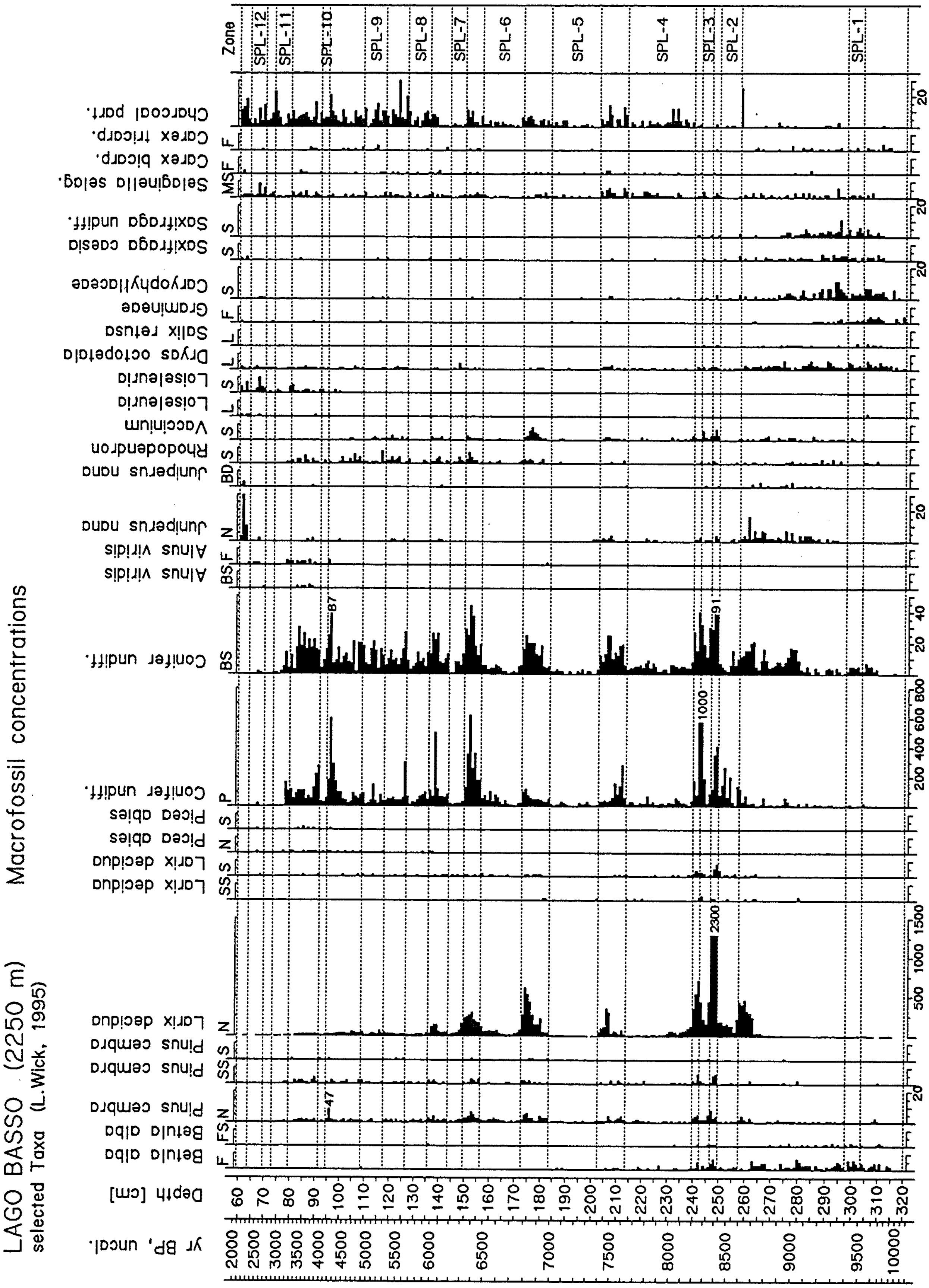
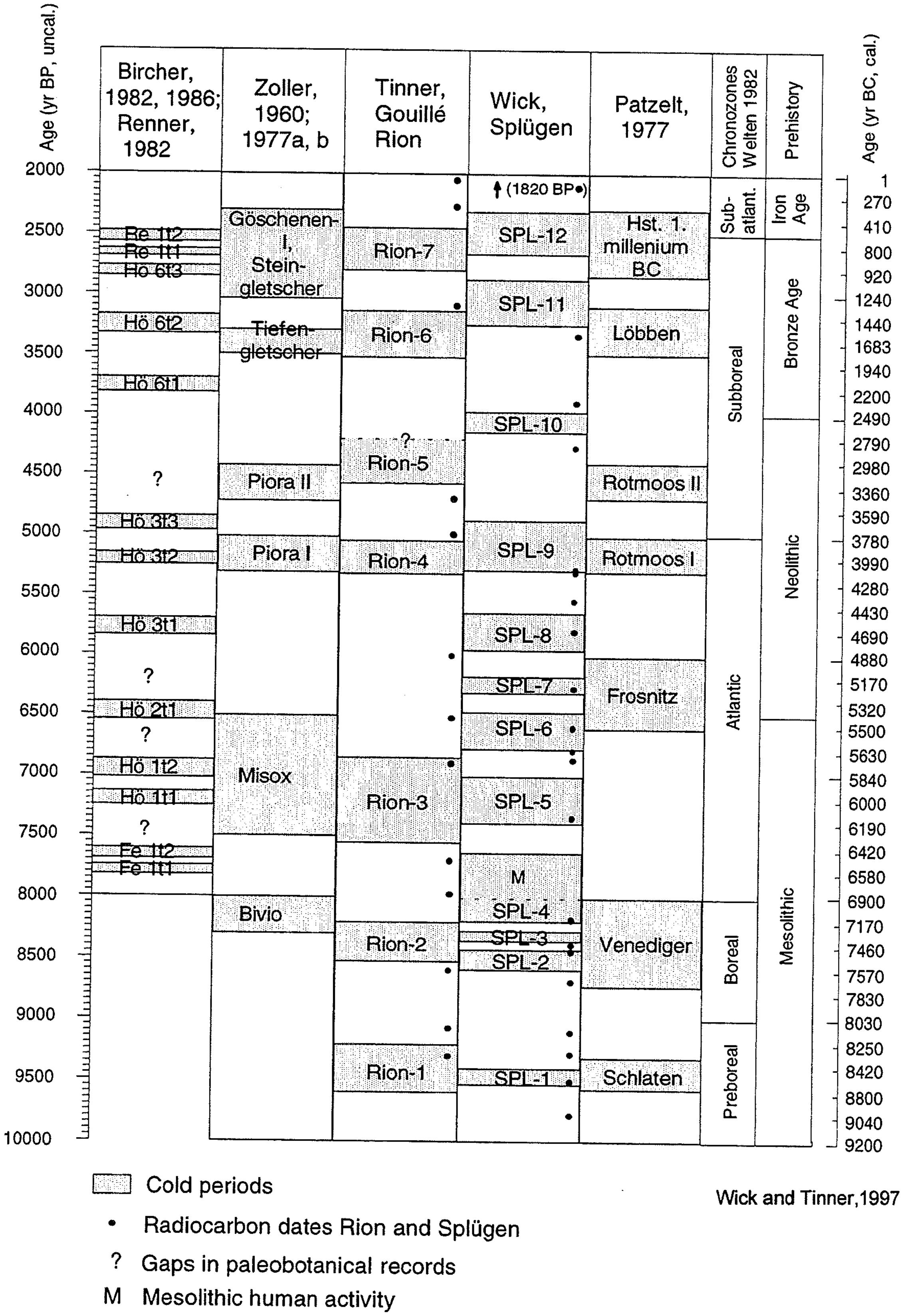


LAGO BASSO (2250 m)
selected Taxa (L.Wick, 1995)

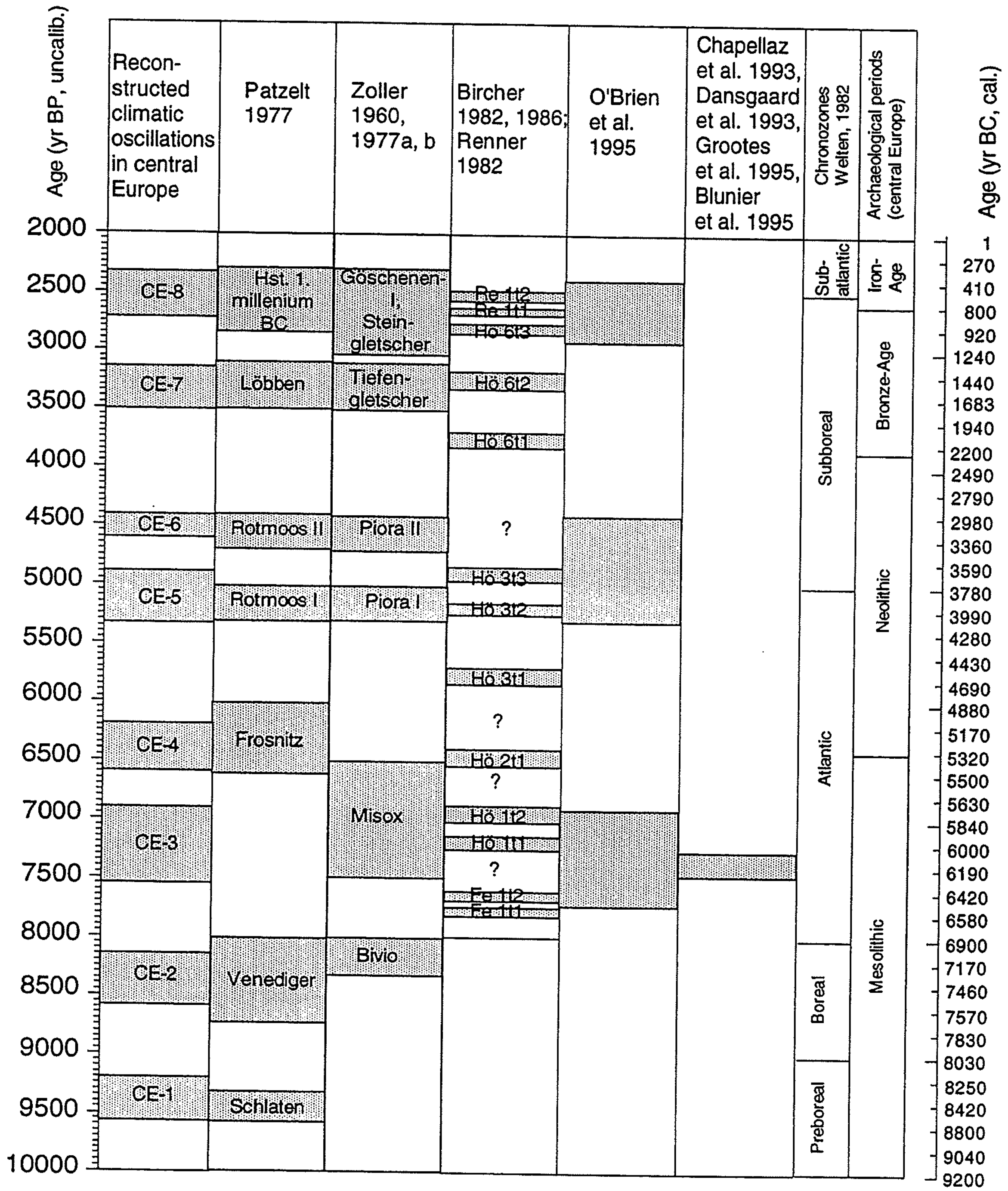
Macrofossil concentrations

Holocene climatic oscillations in the Central and Eastern Alps



Wick and Tinner,1997

Holocene climate oscillations in central Europe and Greenland



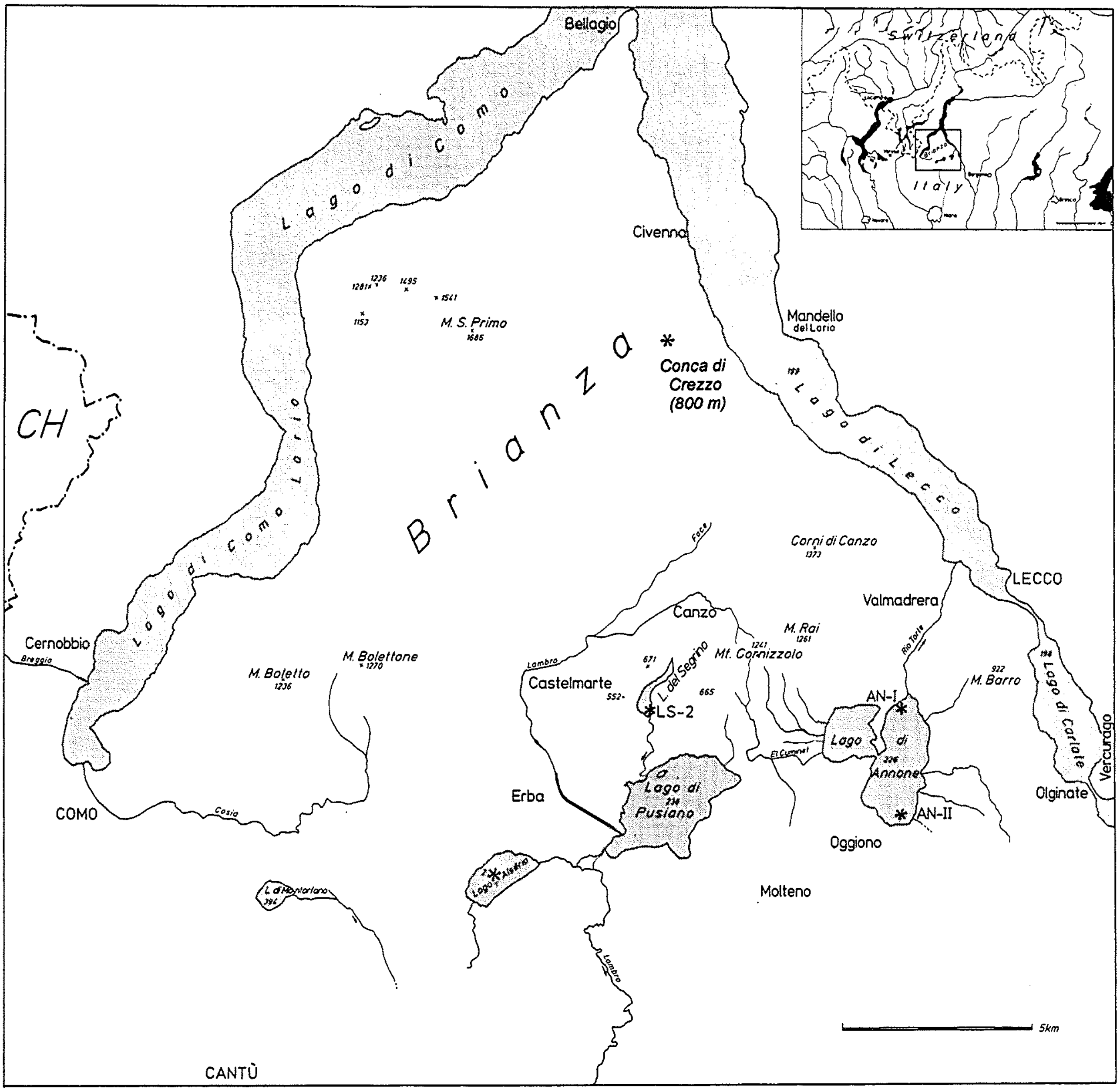
Site	Alps and Swiss lowland plateau	Austrian Alps	Swiss Alps	Swiss Alps	Greenland	Greenland
Methods	present study	Sedimentology	Pollen Sedimentology	Dendrodensitometry	Glaciochemistry	Oxygen isotops, methan and ice accumulation

▨ Cold (humid) periods

? Data not available

Haas et al., 1998

BRIANZA



Brianza is the name of the triangle between the two southern ends of Lake Como, Lago di Como and Lago di Lecco. The bedrock in the area consists of Mesozoic carbonates, which partly are covered by Quaternary gravels and moraines. Monte Barro (922 m asl) and other hills in the surroundings of Lago di Annone are built by Cretageous flysch. Karst phenomena and a large number of small springs (many of them subaquatic) are characteristic for the area.

The climate in the study region is of the Insubrian type with mild and rather dry winters and humid summers. The forest vegetation is attributed to the submediterranean vegetation complex covering the lowlands at the foothills of the southern and southeastern Alps up to 800 to 1000 m asl (Oberdorfer, 1964). It is dominated by deciduous oaks with *Castanea sativa*, *Alnus glutinosa*, *Fraxinus excelsior*, *Tilia cordata* and *Ulmus minor* on fresher and richer soils. Open stands of *Fraxinus ornus* and *Ostrya* *carpinifolia* (Orno-Ostryon) on dry slopes and hilltops are characteristic for this vegetation complex. However, the pollen records of the Brianza suggest that they represent successional stades rather than klimax communities as claimed by Oberdorfer (1964).

The lakes of the Brianza are located just inside the end-moraine system of the Adda glacier, but they are not considered as real intermoraine lakes (Bini, 1995). They have been formed mainly as a consequence of the characteristics of the bedrock and – to a lesser extent – glacial deposition.

Lago di Annone (226 m)

max. water depth: 11.3 m (in the eastern basin)
water surface: 5.5 km^2
catchment area: 22.5 km^2, reaching altitudes of 1261 m asl in the north (M. Rai) and 922 m at M. Barro
sediments: two cores, both at about 6 m water depth:

- *AN-1*: northern part of the lake, 750 cm, sand at the basis. Transition from silt to calcareous gyttja at 704 cm. Includes Late Glacial and parts of the Holocene; hiatus between 4000 and ca. 1000 BP
- *AN-2*: southern part of the lake, 1400 cm, the moraine was not reached. Includes 700 cm Late-Glacial silt (extremely low pollen content) and 685 cm Holocene sediments (calcareous gyttja, ca. 60% minerogenic). The Late-Glacial interstadial is represented in only 15 cm.

Lago del Segrino (375 m)

max. water depth: 8.6 m
water surface: 0.38 km^2
catchment area: 3 km^2, no superface inlet, but subaquatic springs
sediments: *LS-2*: littoral core (70 cm water depth), 1600 cm of sediments, the moraine was not reached. Includes only Late-Glacial and early Holocene. Silt in the lowest part; transition to lake marl at 1100 cm, contemporaneously with the expansion of *Betula*.
LS-3: central part of the lake (ca. 650 cm water depth), 1040 cm of sediments, sand and gravels at the basis. Calcareous gyttja. Includes the Holocene and parts of the Late Glacial.

Lago di Alserio (260 m)

max. water depth: 8.1 m
water surface: 1.23 km^2
catchment area: 17.03 km^2
sediments: central core (8 m water depth), 2100 cm of sediments, the moraine was not reached. Sand and silt in the lower part of the core, transition to calcareous gyttja at 1425 cm; increasing sediment accumulation rates and turbidites due to human impact after about 4000 yr cal. BP (Bronze Age)

Conca di Crezzo (800 m)

Conca di Crezzo is a small pond located on the mountain ridge separating the catchment of the river Lambro from the basin of Lago di Lecco. It is about 1 m deep and almost completely covered by *Phragmites*.

The sediments:

720-600 cm: calcareous gyttja with several sand layers; Younger Dryas?
600-253 cm: fine detritus gyttja
253-243 cm: transition
243-119 cm: Cyperaceae peat, decomposed, mainly between ca. 140 and 119 cm
119-40 cm: silt, very hard
40-0 cm: recent and subrecent *Phragmites*

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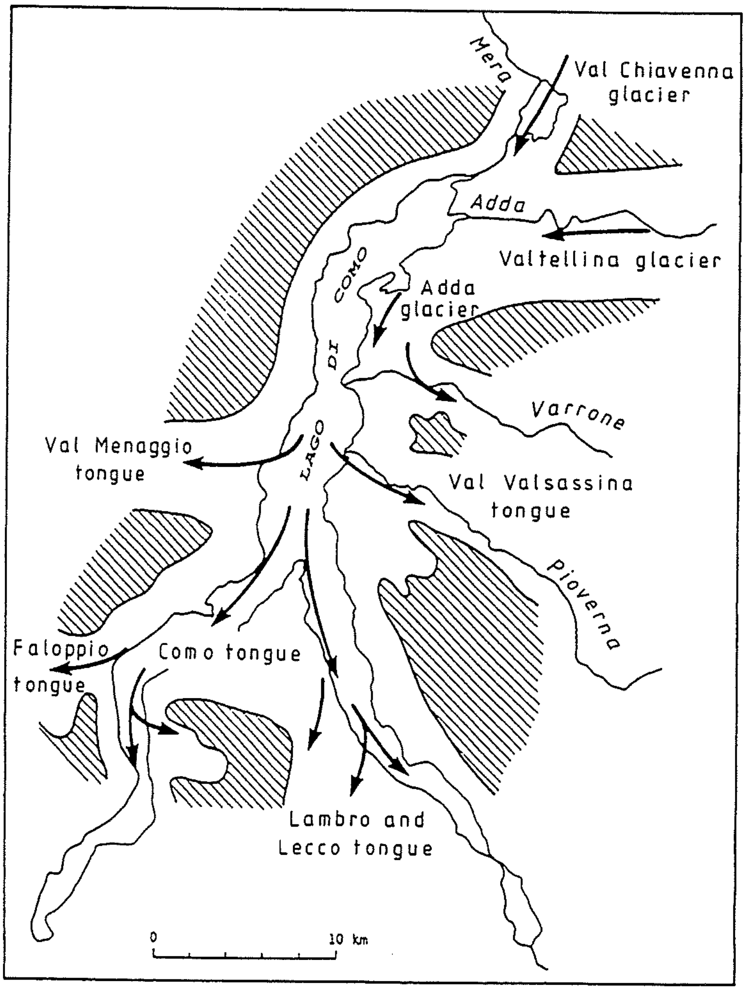


Fig. 14 Schematic map showing the Adda glacier in the central sector of Lago di Como (from GAETANI & BINI, in CITA et al. 1991: 210, modified)

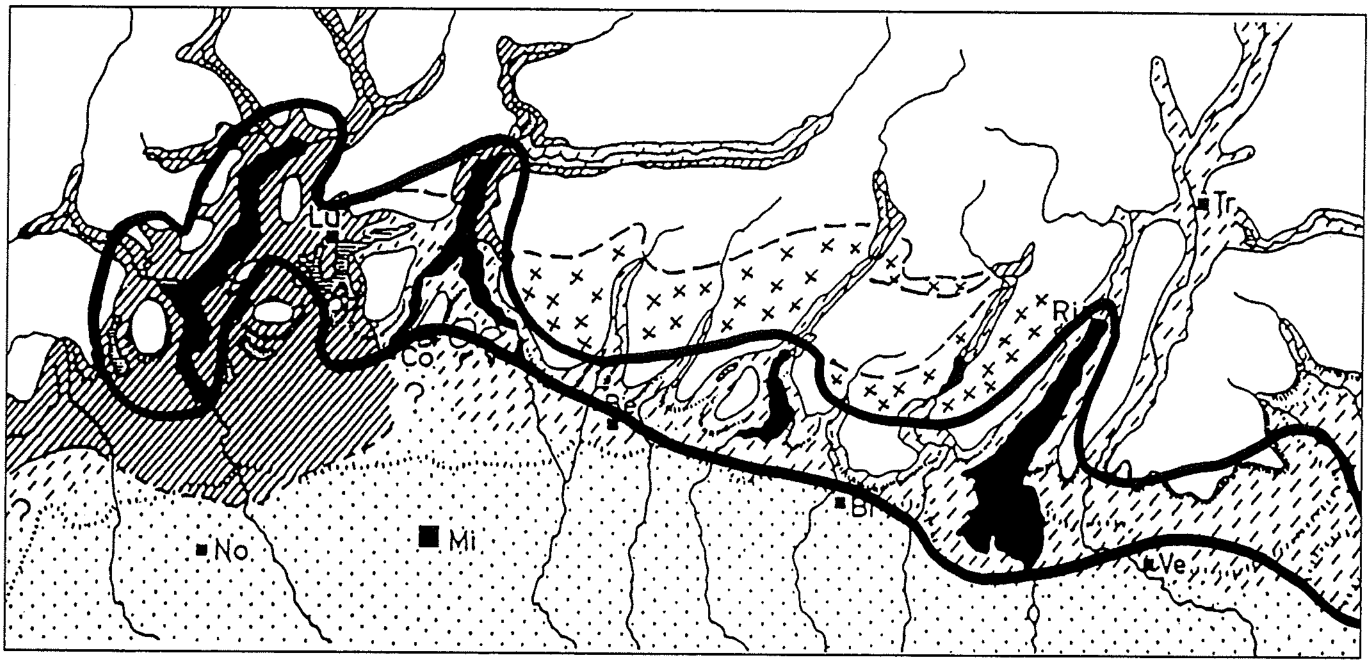
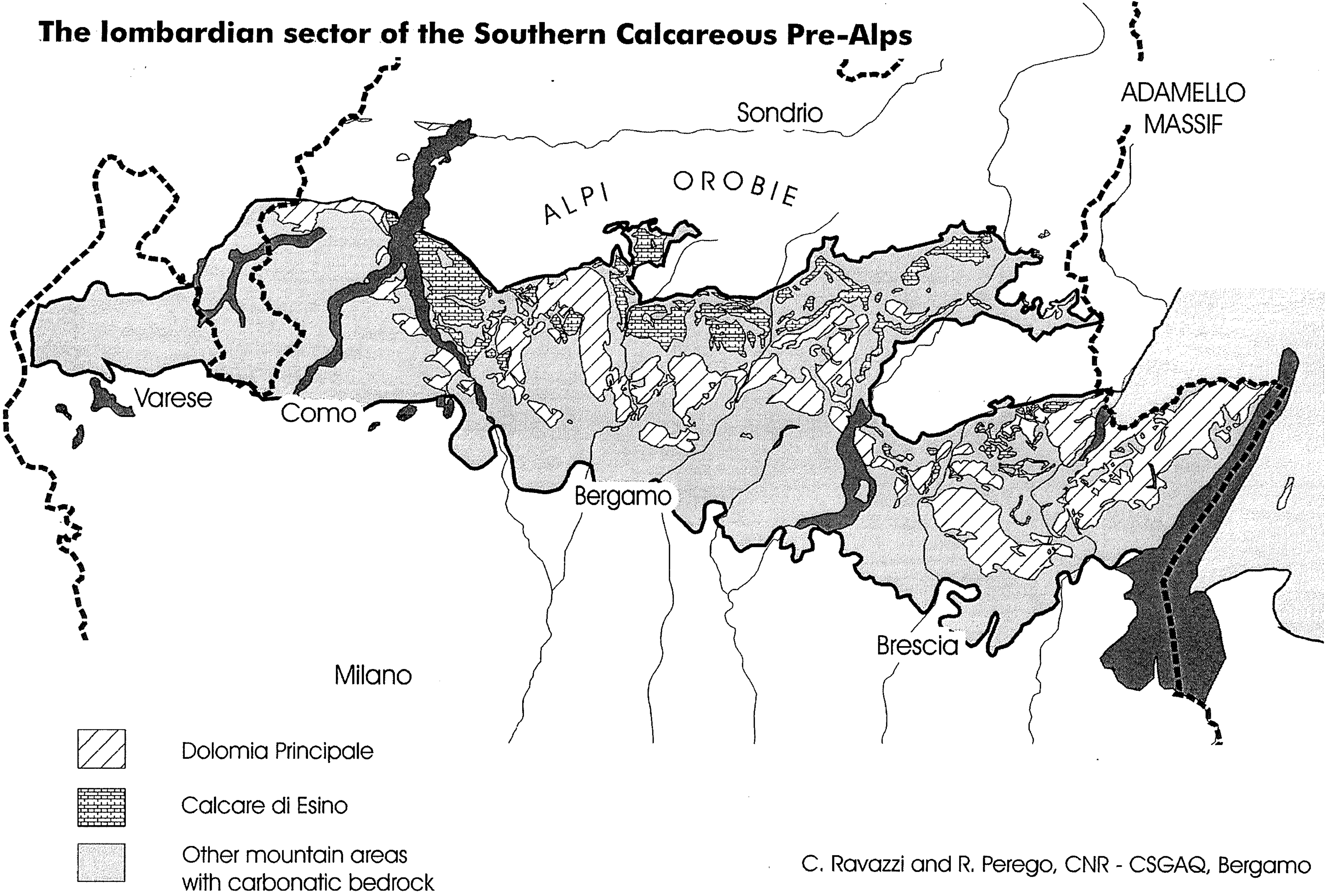


Fig. 1 - Distribuzione della fascia a vegetazione ‘insubrica’ (barrato obliquo) e ‘submediterranea’ (trattini obliqui) secondo Oberdorfer (1964) nelle Prealpi. Con la linea marcata è evidenziato il limite del ‘distretto insubrico’ di Giacomini e Fenaroli (1958). Le crocette evidenziano la porzione delle Prealpi Lombarde che risulta esclusa dall’Insubria sia secondo Oberdorfer che secondo Giacomini e Fenaroli (da Oberdorfer, 1964, modificato).

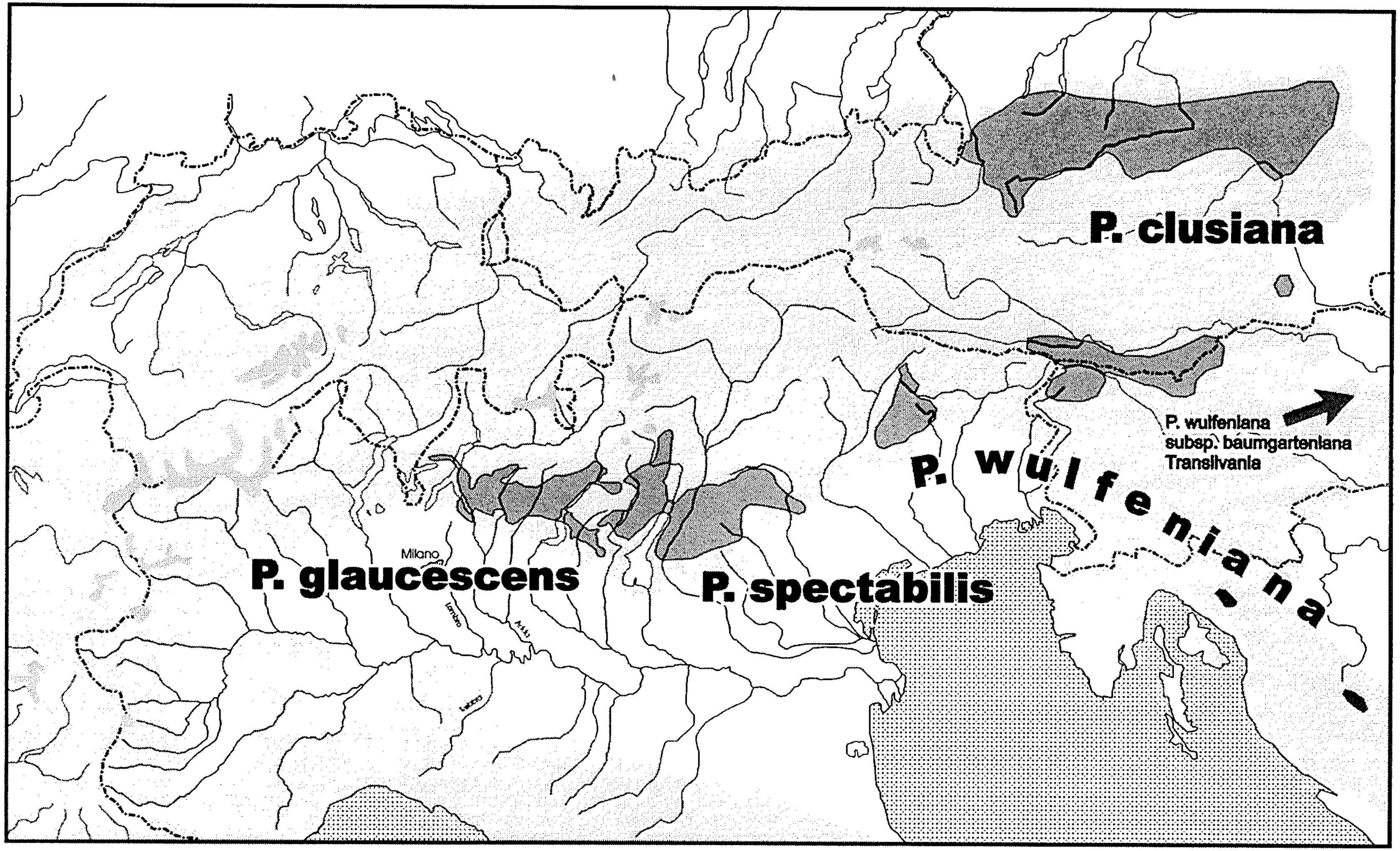
The lombardian sector of the Southern Calcareous Pre-Alps



C. Ravazzi and R. Perego, CNR - CSGAQ, Bergamo

Distribution of species belonging to *sect. Arthritica* of genus *Primula*

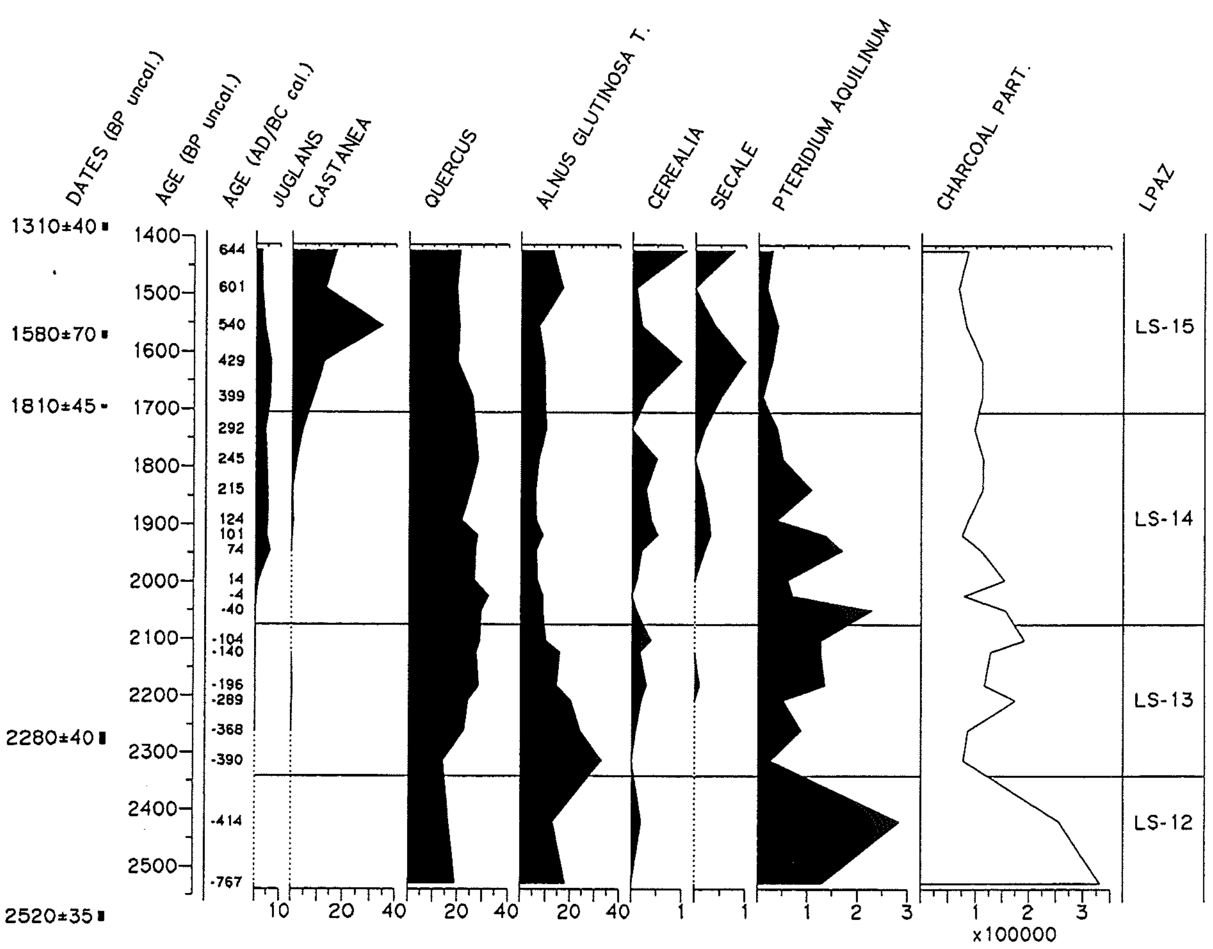
(Dergang, 1904; Aichinger, 1933; Horvat, 1974; Arietti & Crescini, 1976; Martini, 1987; Ravazzi, 1997)

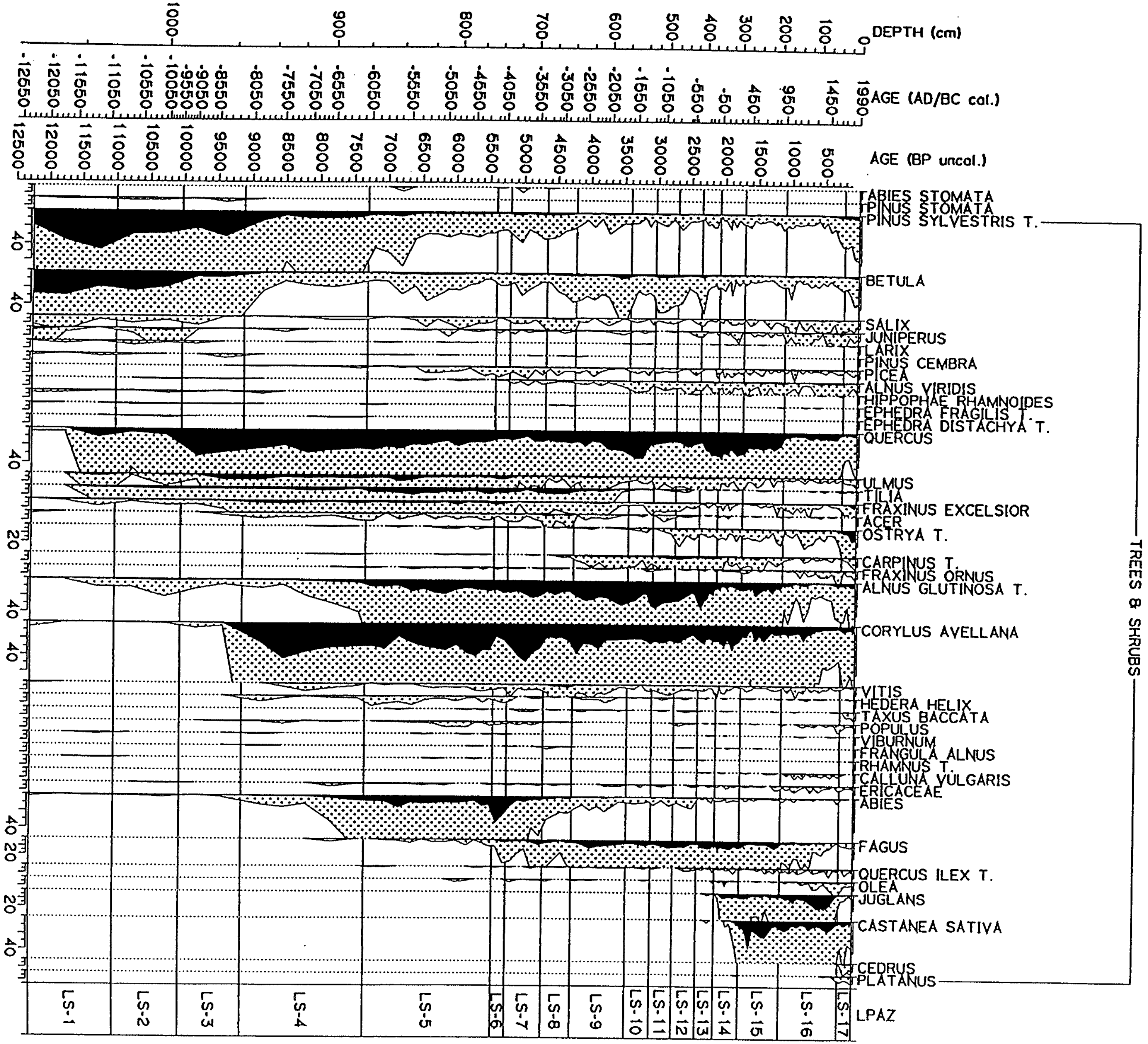


Cesare Ravazzi (unpublished), 2000

Gobet et al., in press:

Abstract. Vegetation history for the study region is reconstructed on the basis of pollen, charcoal and AMS ^{14}C investigations of lake sediments from Lago del Segrino (calcareous bedrock) and Lago di Muzzano (siliceous bedrock). Late-glacial forests were characterised by *Betula* and *Pinus sylvestris*. At the beginning of the Holocene they were replaced by temperate continental forest and shrub communities. A special type of continentallowland forest, with *Abies alba* as the most important tree, was present in the period 8300 to 4500 B.P. Subsequently, Fagus, Quercus and Alnus glutinosa were the main forest components and *A. alba* ceased to be of importance. *Castanea sativa* and *Juglans regia* were probably introduced after forest clearance by fire during the first century A.D. On soils derived from siliceous bedrock, *C. sativa* was already dominant at ca. A.D. 200 (calendar years). In limestone areas, however, *C. sativa* failed to achieve a dominant role. After the introduction of C. sativa, the main trees were initially oak (*Quercus* spp.) and later the walnut (*Juglans regia*). *Ostrya carpinifolia* became the dominant tree around Lago del Segrino only in the last 100-200 years though it had spread into the area at ca. 5000 cal. B.C. This recent expansion of *Ostrya* is confirmed at other sites and appears to be controlled by human disturbances involving especially clearance. In any case, these forests cannot be regarded as climax communities. It is suggested that under undisturbed succession they would develop into mixed deciduous forests consisting of *Fraxinus excelsior, Tilia, Ulmus, Quercus* and *Acer.*




DEPTH (cm)
1000 900 800 700 600 500 400 300 200 100 0
AGE (AD/BC cal.)
-12550 -12050 -11550 -11050 -10550 -10050 -9550 -9050 -8550 -8050 -7550 -7050 -6550 -6050 -5550 -5050 -4550 -4050 -3550 -3050 -2550 -2050 -1650 -1050 -550 -50 450 950 1450 1990
AGE (BP uncal.)
12500 12000 11500 11000 10500 10000 9500 9000 8500 8000 7500 7000 6500 6000 5500 5000 4500 4000 3500 3000 2500 2000 1500 1000 500
ABIES STOMATA
PINUS STOMATA
PINUS SYLVESTRIS T.
BETULA
SALIX
JUNIPERUS
LARIX
PINUS CEMBRA
PICEA
ALNUS VIRIDIS
HIPPOPHAE RHAMNOIDES
EPHEDRA FRAGILIS T.
EPHEDRA DISTACHYA T.
QUERCUS
ULMUS
TILIA
FRAXINUS EXCELSIOR
ACER
OSTRYA T.
CARPINUS T.
FRAXINUS ORNUS
ALNUS GLUTINOSA T.
CORYLUS AVELLANA
VITIS
HEDERA HELIX
TAXUS BACCATA
POPULUS
VIBURNUM
FRANGULA ALNUS
RHAMNUS T.
CALLUNA VULGARIS
ERICACEAE
ABIES
FAGUS
QUERCUS ILEX T.
OLEA
JUGLANS
CASTANEA SATIVA
CEDRUS
PLATANUS
TREES & SHRUBS
40
40
40
20
40
40
40
20
20
40
LPAZ
LS-1
LS-2
LS-3
LS-4
LS-5
LS-6
LS-7
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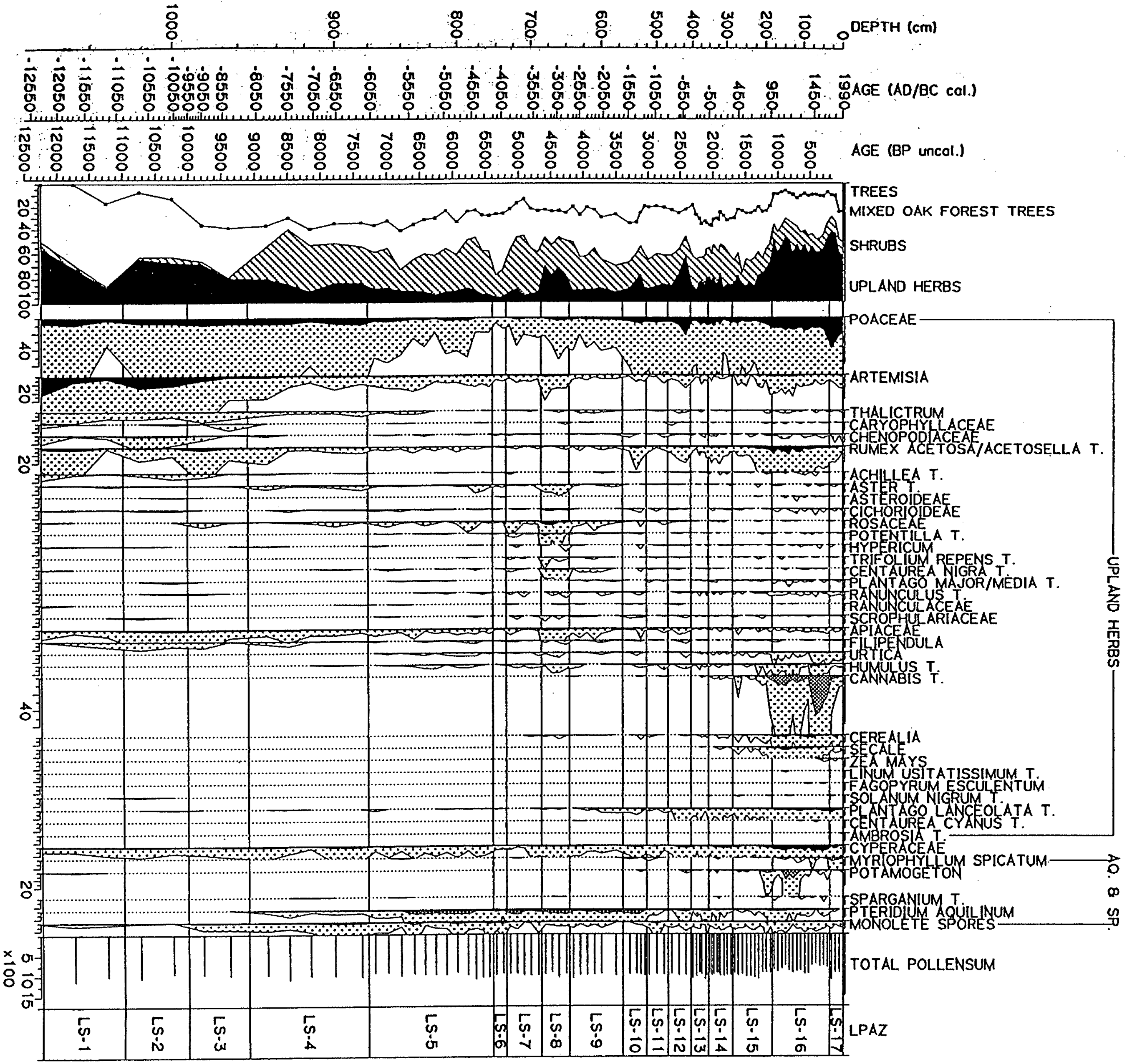
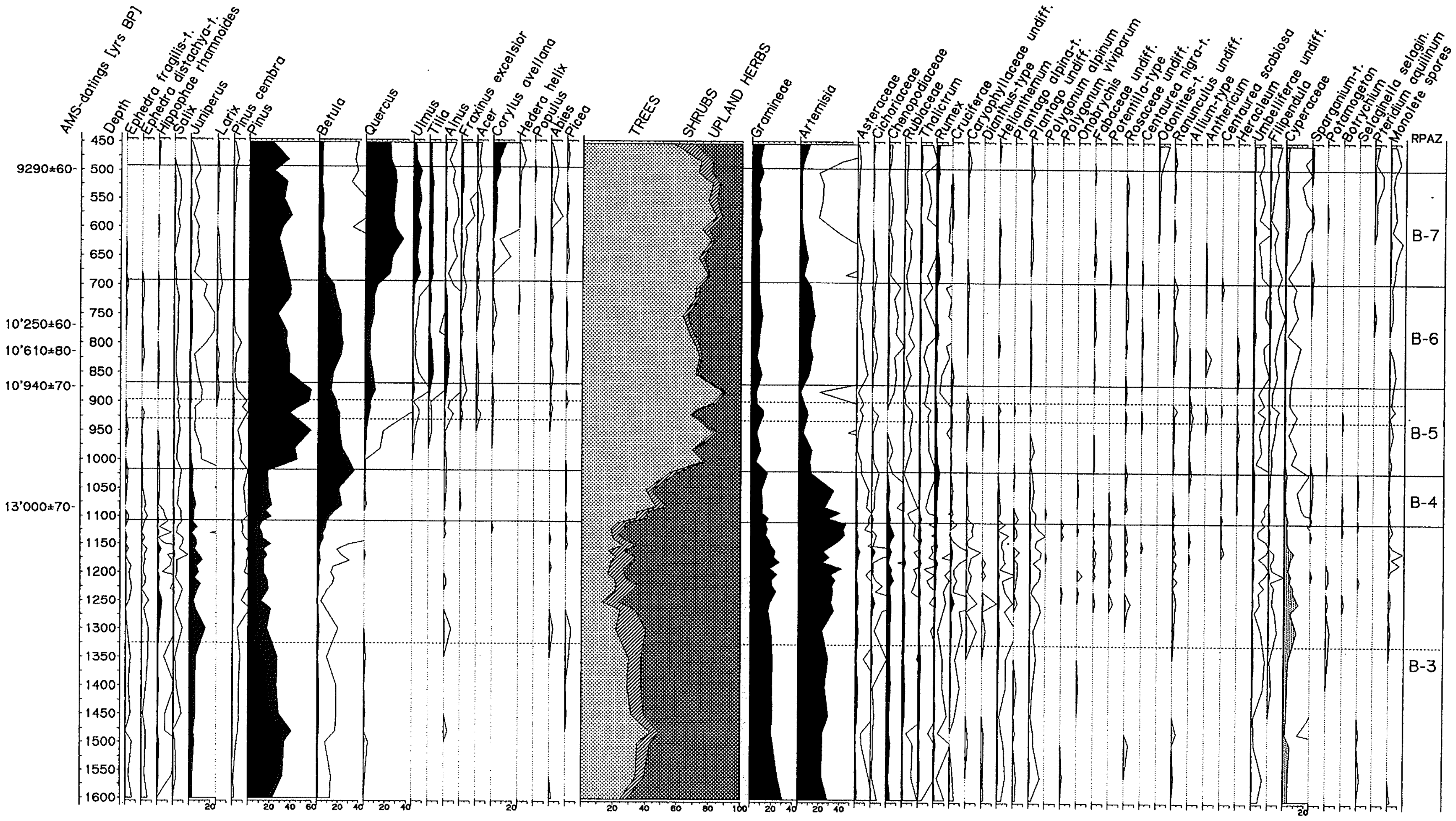
LS-14
LS-15
LS-16
LS-17


DEPTH (cm)
1000 900 800 700 600 500 400 300 200 100 0
AGE (AD/BC cal.)
-12550 -12050 -11550 -11050 -10550 -10050 -9550 -9050 -8550 -8050 -7550 -7050 -6550 -6050 -5550 -5050 -4550 -4050 -3550 -3050 -2550 -2050 -1550 -1050 -550 -50 450 950 1450 1990
AGE (BP uncal.)
12500 12000 11500 11000 10500 10000 9500 9000 8500 8000 7500 7000 6500 6000 5500 5000 4500 4000 3500 3000 2500 2000 1500 1000 500
20 40 60 80 100
TREES
MIXED OAK FOREST TREES
SHRUBS
UPLAND HERBS
POACEAE
ARTEMISIA
THALICTRUM
CARYOPHYLLACEAE
CHENOPODIACEAE
RUMEX ACETOSA/ACETOSELLA T.
ACHILLEA T.
ASTER T.
ASTEROIDEAE
CICHORIOIDEAE
ROSACEAE
POTENTILLA T.
HYPERICUM
TRIFOLIUM REPENS T.
CENTAUREA NIGRA T.
PLANTAGO MAJOR/MEDIA T.
RANUNCULUS T.
RANUNCULACEAE
SCROPHULARIACEAE
APIACEAE
FILIPENDULA
URTICA
HUMULUS T.
CANNABIS T.
CEREALIA
SECALE
ZEA MAYS
LINUM USITATISSIMUM T.
FAGOPYRUM ESCULENTUM
SOLANUM NIGRUM T.
PLANTAGO LANCEOLATA T.
CENTAUREA CYANUS T.
AMBROSIA T.
CYPERACEAE
MYRIOPHYLLUM SPICATUM
POTAMOGETON
SPARGANIUM T.
PTERIDIUM AQUILINUM
MONOLETE SPORES
UPLAND HERBS
AQ. & SP.
20 40 20 20 40 20
TOTAL POLLENSUM
5 10 15 x100
LPAZ
LS-1 LS-2 LS-3 LS-4 LS-5 LS-6 LS-7 LS-8 LS-9 LS-10 LS-11 LS-12 LS-13 LS-14 LS-15 LS-16 LS-17

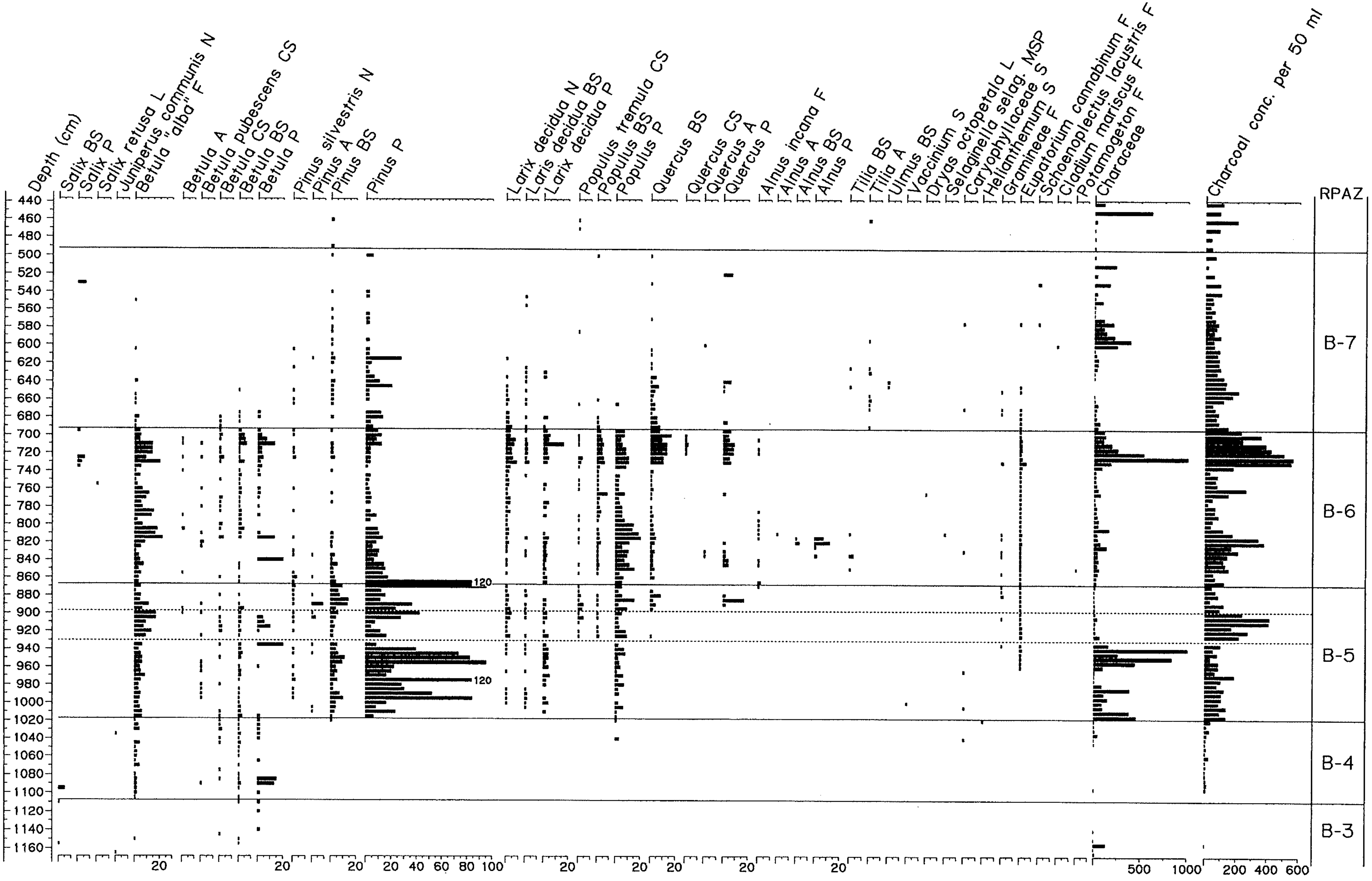
LAGO DEL SEGRINO LS-2 Late Glacial

Analysis L.Wick



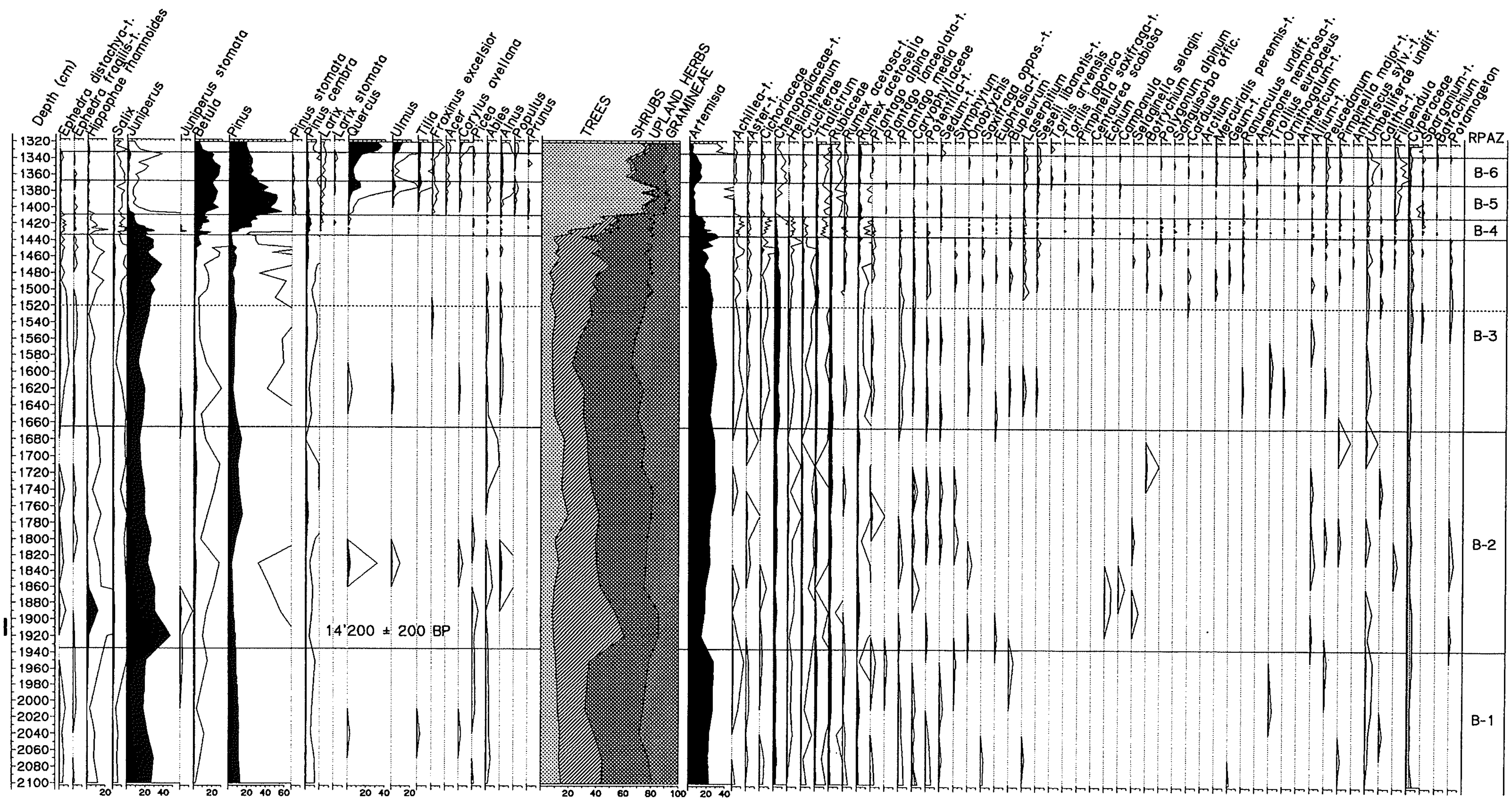
LAGO DEL SEGRINO (374 m asl) Late Glacial: Macrofossil concentrations

Analysis L.Wick, 2000



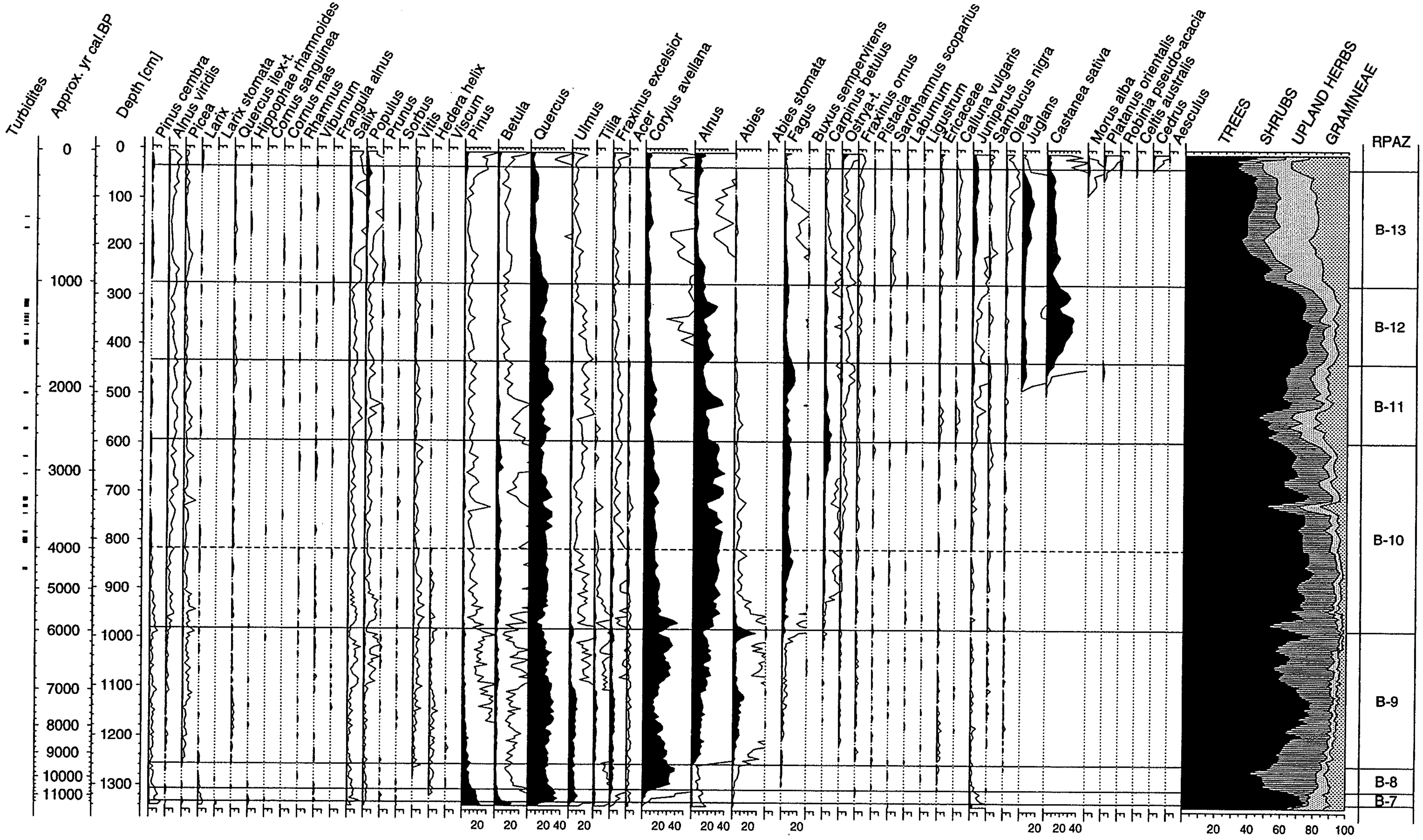
A: anthers, BS: bud scales, CS: catkin scales, F: fruits, L: leaves, N: needles P: periderm (mm^2), S: seeds

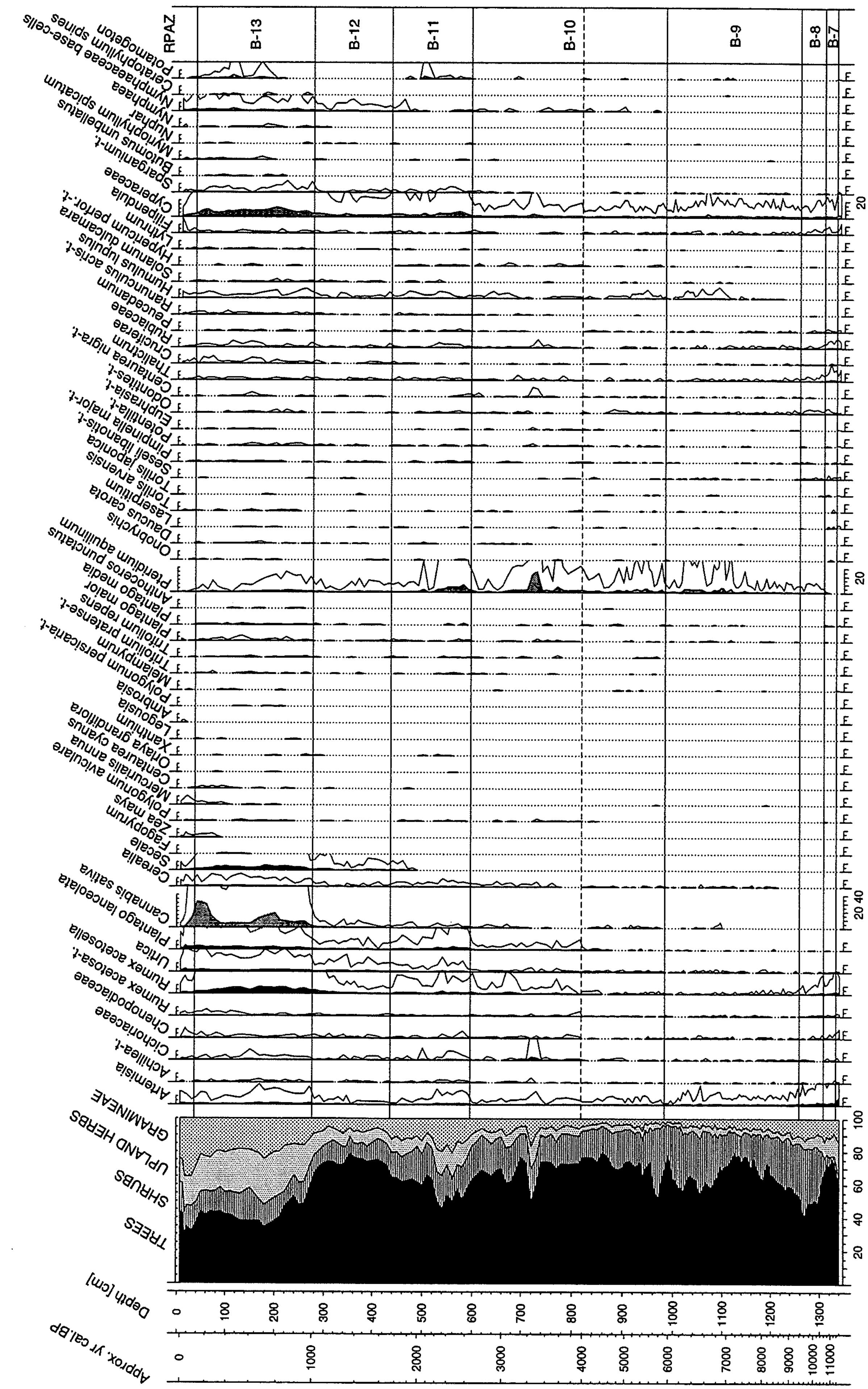
LAGO DI ALSERIO 260 m asl
Late Glacial
Analysis L.Wick



LAGO DI ALSERIO 260 m asl Arboreal pollen

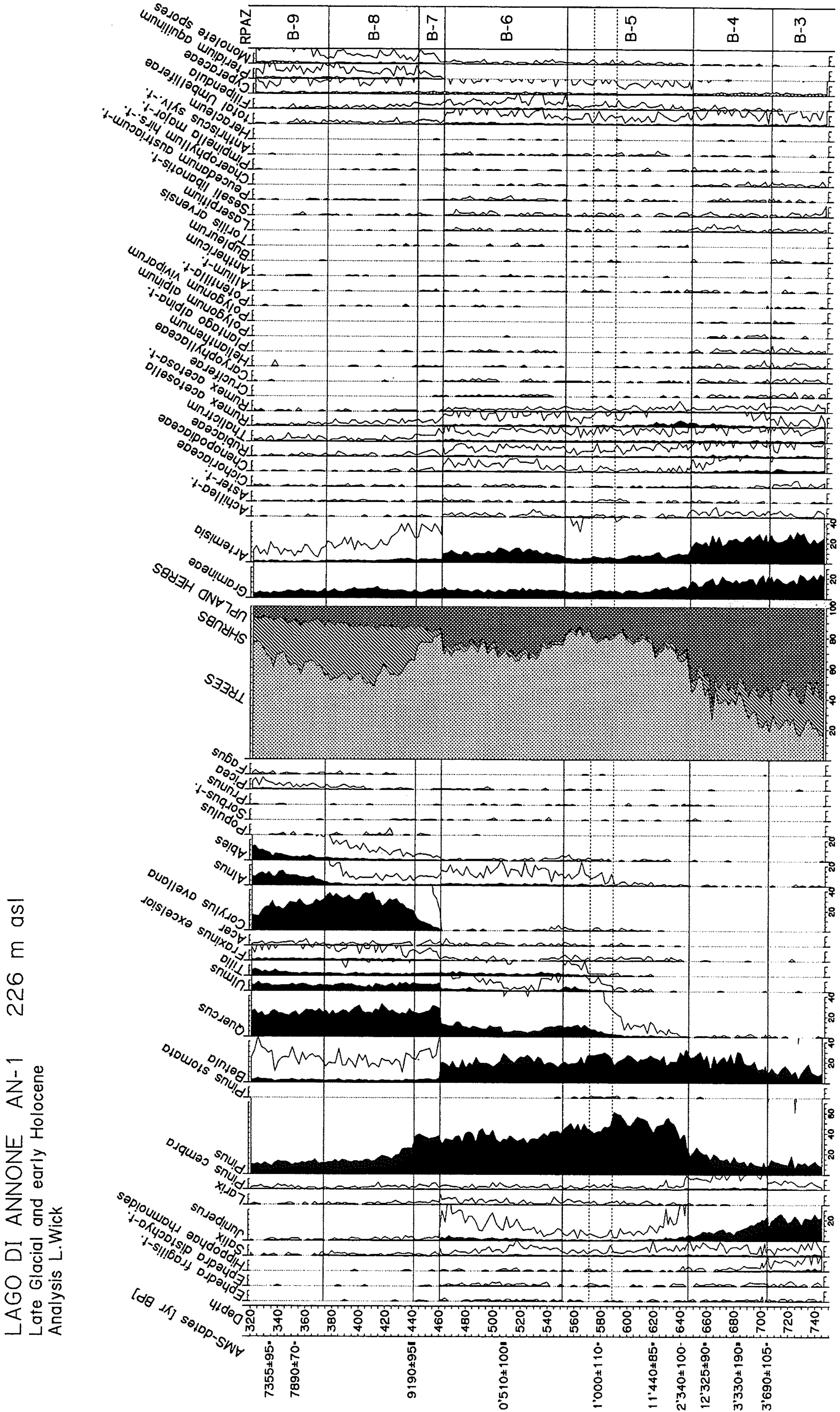
Analysis L.Wick



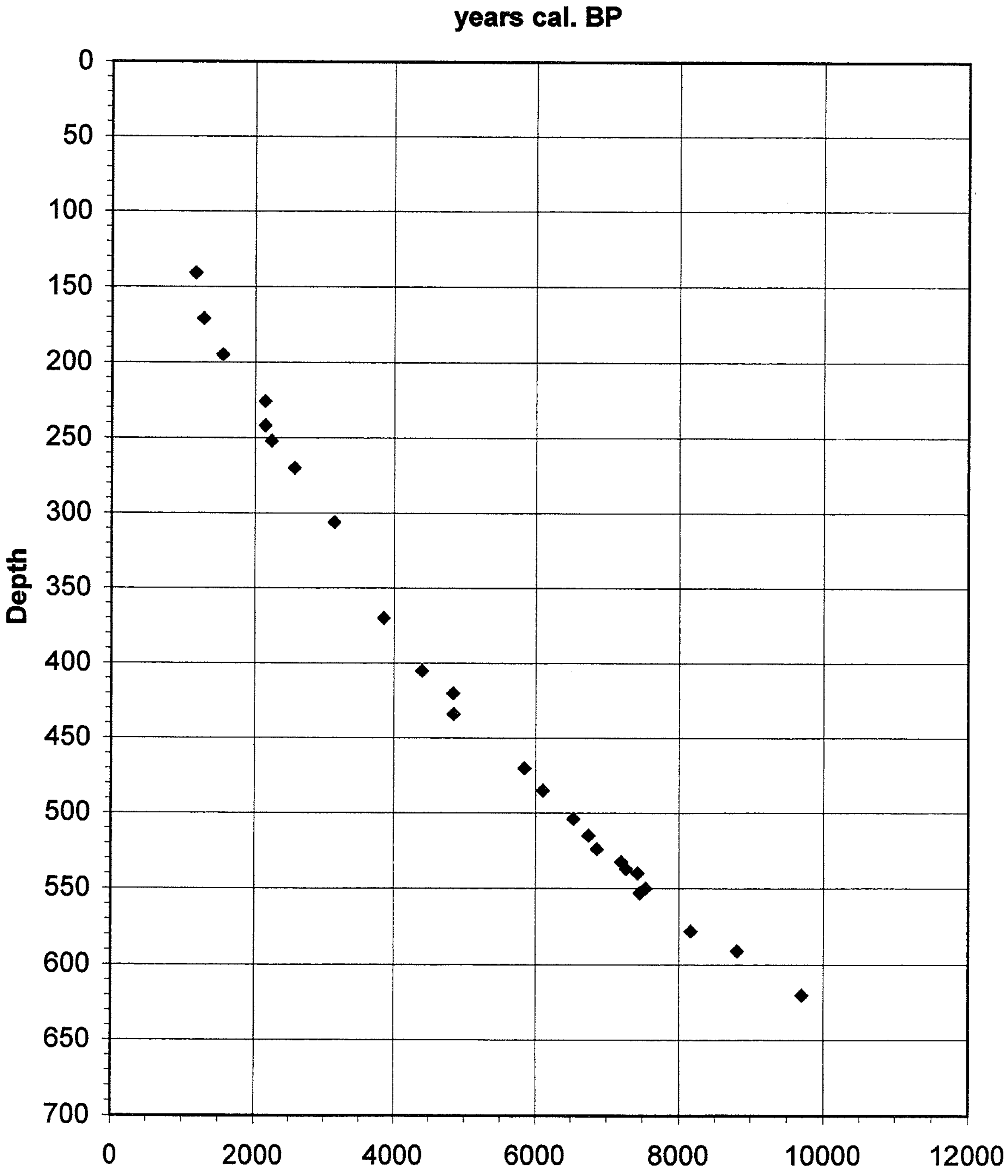


LAGO DI ALSERIO 260 m asl NAP

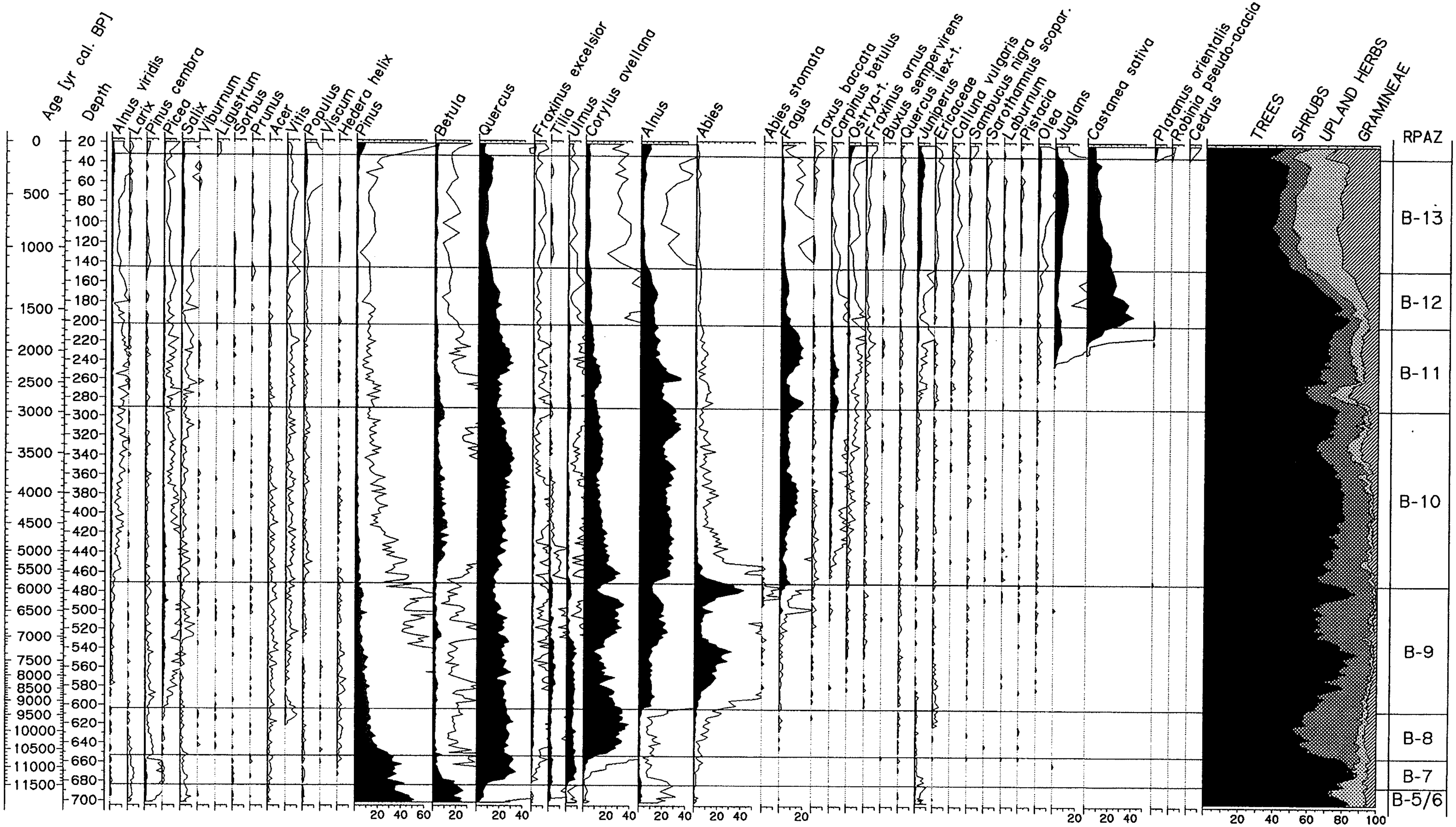
Analysis L.Wick

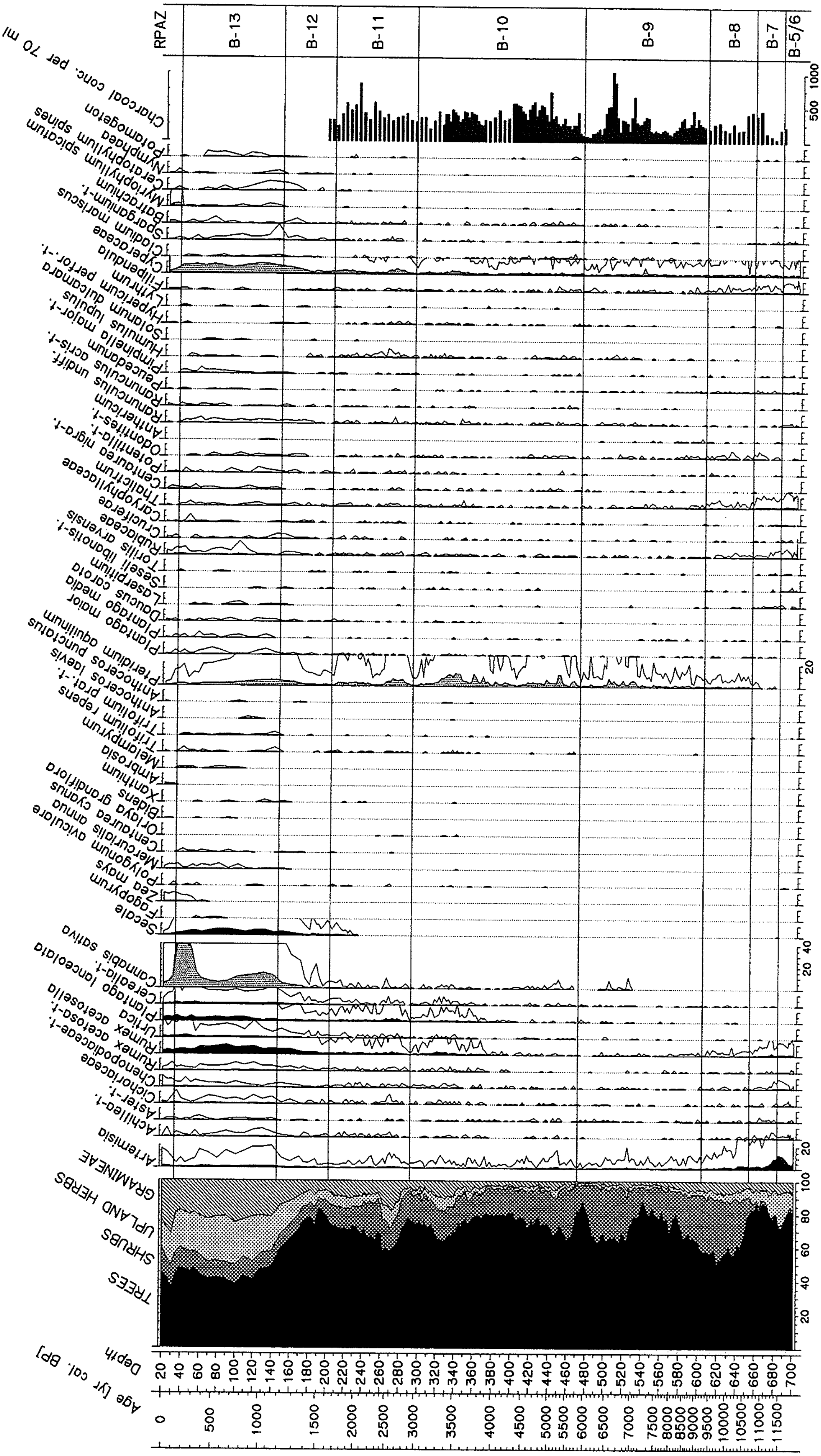

LAGO DI ANNONE AN-1 226 m asl
Late Glacial and early Holocene
Analysis L.Wick
RPAZ
B-9
B-8
B-7
B-6
B-5
B-4
B-3
Monolete spores
Pteridium aquilinum
Cyperaceae
Filipendula
Umbelliferae
Torilis-t.
Heracleum sylv.-t.
Anthriscus sylv.-t.
Pimpinella major-t.
Chaerophyllum hirs.-t.
Peucedanum austriacum-t.
Seseli libanotis-t.
Laserpitium
Torilis arvensis
Bupleurum
Anthericum
Allium-t.
Potentilla-t.
Polygonum viviparum
Polygonum alpinum
Plantago alpina-t.
Helianthemum
Caryophyllaceae
Cruciferae
Rumex acetosa-t.
Rumex acetosella
Thalictrum
Rubiaceae
Chenopodiaceae
Cichoriaceae
Aster-t.
Achillea-t.
Artemisia
Gramineae
UPLAND HERBS
SHRUBS
TREES
Fagus
Picea
Prunus-t.
Sorbus-t.
Populus
Abies
Alnus
Corylus avellana
Acer
Fraxinus excelsior
Tilia
Ulmus
Quercus
Betula
Pinus stomata
Pinus cembra
Larix
Juniperus
Salix
Hippophaë rhamnoides
Ephedra distachya-t.
Ephedra fragilis-t.
Depth
AMS-dates [yr BP]
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
7355±95
7890±70
9190±95
10'510±100
11'000±110
11'440±85
12'340±100
12'325±90
13'330±190
13'690±105
20
40
60
80
100

Depth-Age Annone AN-2



LAGO DI ANNONE AN-2 arboreal pollen
Holocene
Analysis L.Wick





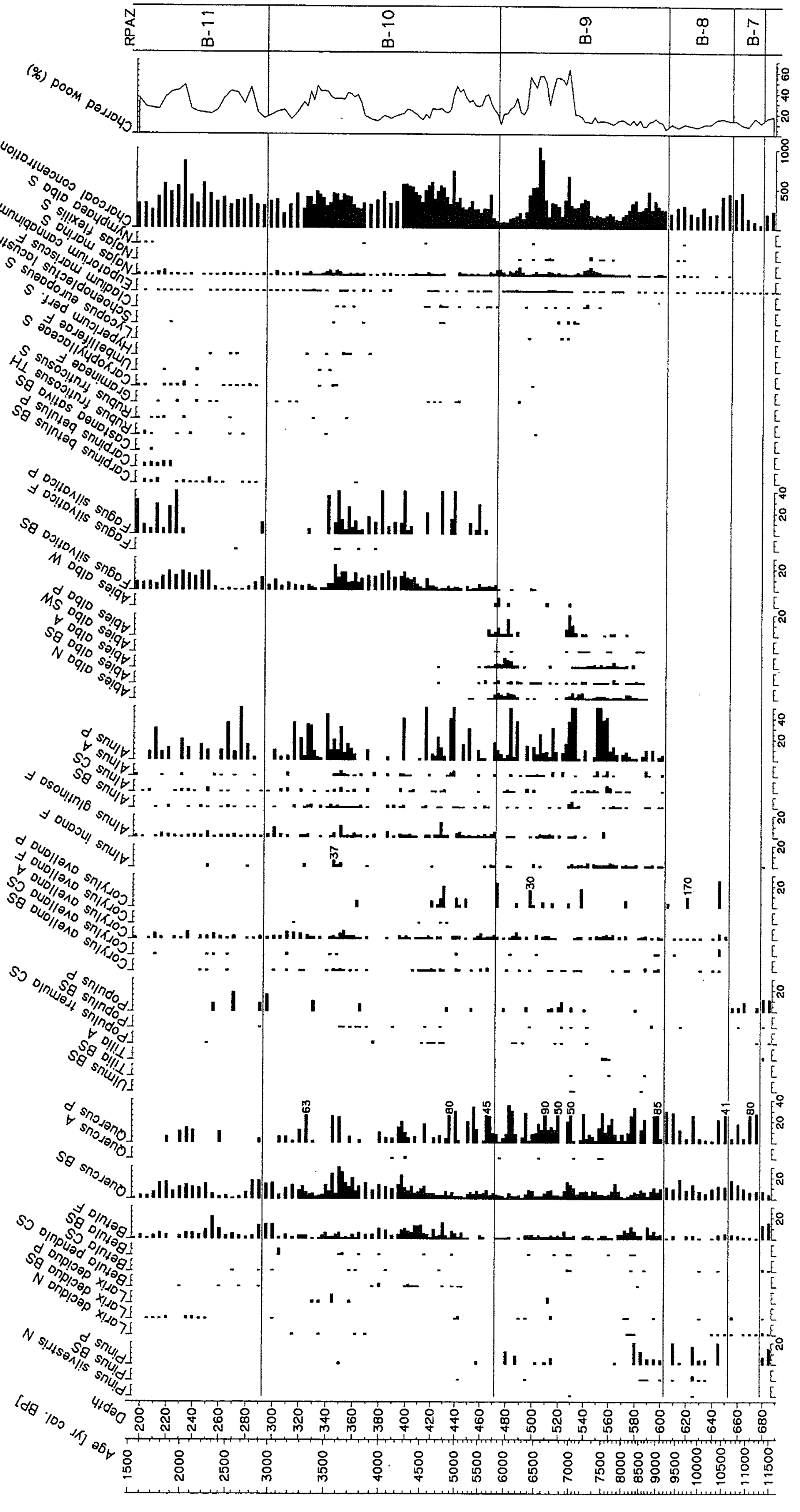
LAGO DI ANNONE AN-2 NAP

Holocene

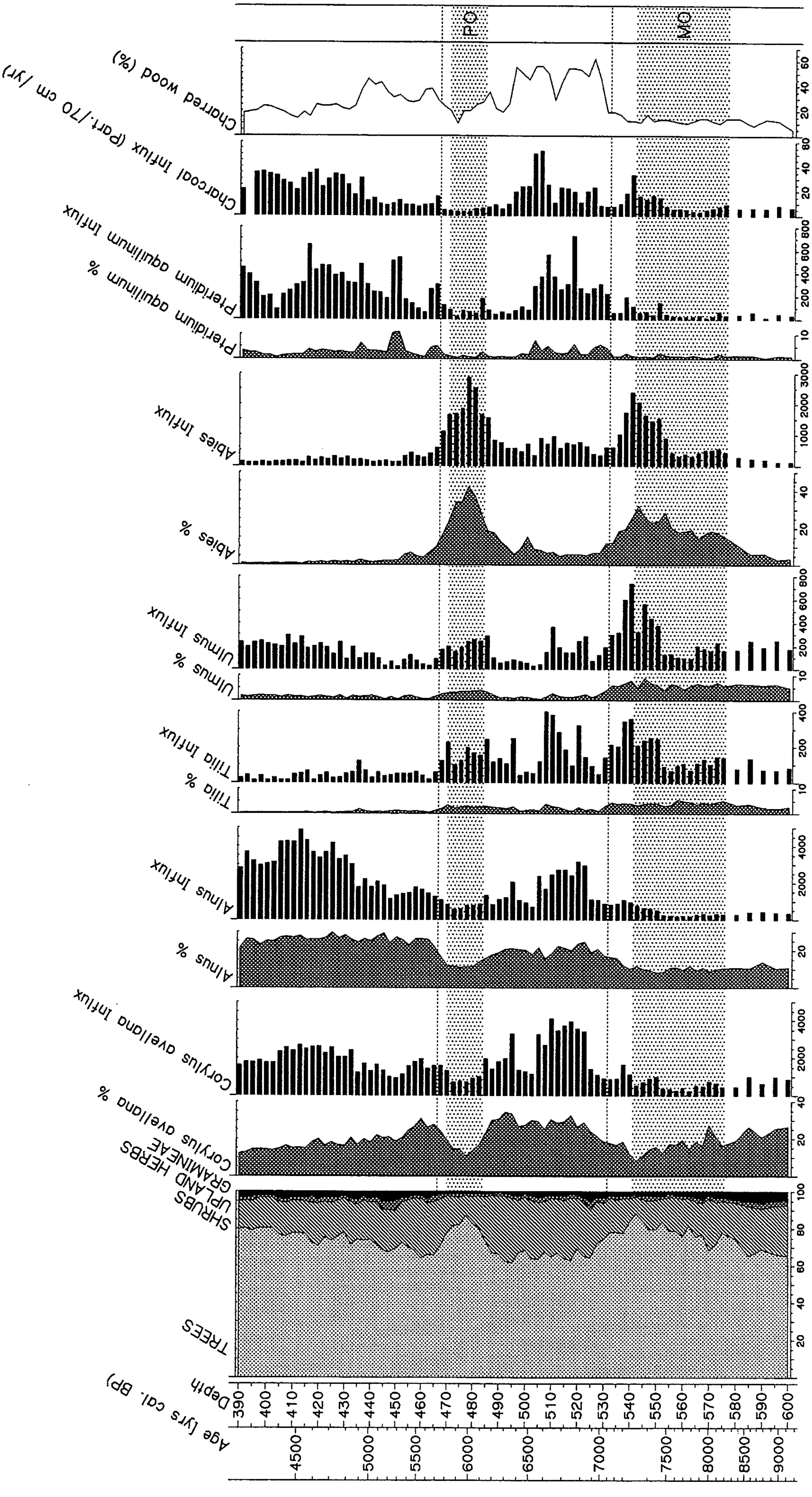
Analysis L.Wick

LAGO DI ANNONE Macrofossil Concentrations

Analysis L.Wick

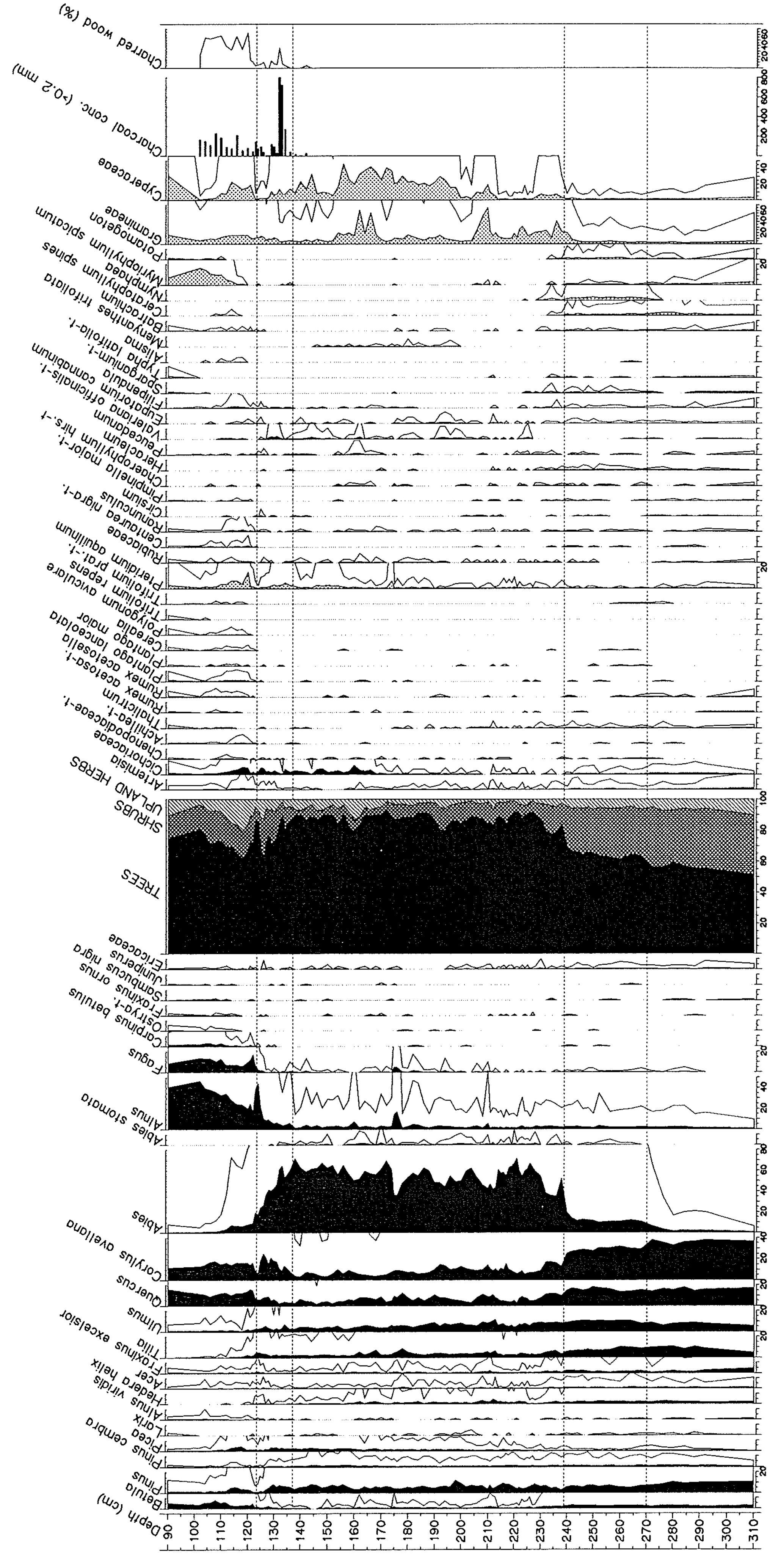


A: anthers, BS: bud scales, CS: catkin scales, F: fruits, N: needles, P: periderm, S: seeds, SW: seed wings, TH: thorns



LAGO DI ANNONE AN-2
Pollen Percentages and Influx

MO = Misox oscillation, PO = Piora-I oscillation



CONCA DI CREZZO 800 m asl
Analysis L.Wick

Excursion guide for the paleoenvironmental evolution of the Leffe Basin (Lombardy, Italy)

Cesare Ravazzi

C.N.R. - Centro Geodinamica Alpina Quaternaria, Milano, Italy

Introduction and subject of the excursion

The Leffe lacustrine sequence in the Lombard Pre-Alps provided the first long pollen record of continental Early Pleistocene deposits in Europe (Lona, 1950). Lona studied pollen samples extracted from "lignite" (brown coal) mine shafts. He documented several vegetation cycles interpreted as a sequence of three complex glacial and interglacial phases. They were correlated with the Donau, Günz and Mindel glaciations, in terms of the glacial morphostratigraphy of the Alps (Penck and Brückner, 1909).

The upper part of the very thick Leffe succession (more than 220 m of lacustrine and palustrine deposits) was exposed during the activity of lignite mine and clay quarries up to the 1960'. This allowed recovering many faunal and plant remains (Vialli, 1956; Ravazzi, 1995). Recently, the area has been heavily urbanized, and most outcrops have disappeared.

In 1991, a core of 186 m was drilled and studied for magnetostratigraphy, lithostratigraphy (Ravazzi & Moscariello, 1998), pollen analysis (Ravazzi, 1993; Ravazzi & Rossignol Strick, 1995; Pini, 1996) and wood identification (Ravazzi & Van der Burgh, 1994). This core covers the middle and the lower part of the basin infill (Fornace Martinelli - FM drilling - see Fig. 2). The multidisciplinary investigation is still in progress.

The objectives of the excursion are: 1) Understanding the particular geological conditions that allowed the Leffe Basin to record a sequence spanning more than 400,000 years in the Early Pleistocene; 2) Discuss the pollen record so far available from the Fornace Martinelli core.

2. The Leffe Basin: location and geological evolution

Location. The Leffe Basin (Bergamo, Lombardian Pre-Alps) is located at 290-600 m altitude in a small valley, cut in Triassic carbonates and surrounded by 1000-1600 m high mountains, 15 km from the southern margin of the Pre-Alps.

The Leffe Succession **(Fig. 1).** It includes two stratigraphic complexes (Cremaschi and Ravazzi, 1995): the lower one (Leffe Formation) represents a fan-delta, lacustrine and palustrine sedimentary assemblage. The Leffe Formation is overlain by the Gandino Formation, which is composed of conglomerates and turbiditic lacustrine deposits, also of Early Pleistocene age.

Geological evolution **(Fig. 2).** The basin originated in the Late Pliocene (i.e. the Gelasian Stage), in a deep valley cut during Neogene entrenchments (Bini et al., 1978; Ravazzi, 1993, see **Fig. 2a**). At this time, the Po plain area was partially occupied by the sea. Before the end of Pliocene, the onset of fluvial deposition by the main river (Serio River) dammed the tributary valley leading to the existence of a lake. The lake was initially filled up with detrital sediments (lower unit of the Leffe Formation), then became isolated from the Serio River. During this second phase, prevalent biogenic deposition occurred (Biogenic unit of the Leffe Formation - **Fig. 2b**). Subsidence prevented the lake from being infilled throughout this phase, allowing the deposition of a thick sedimentary sequence rich in biogenic remains (Cremaschi and Ravazzi, 1995). Subsequently, a phase of increased detrital sedimentation rate and aggradation by the Serio river produced environmental transformations: the contact with the Leffe lake was re-established, the basin was filled up, covered with fluvial sediments, and again dammed by the river. This new lake was filled with a succession (25 m thick) of rythimic clay-silt couplets (turbidites) which do not contains biogenic remains, nor pollen (Argille di Cà Manot unit, **Fig. 1**). This succession probably documents the effects of the first major Pleistocene glacial expansion in the Southern Alps.

The Biogenic Unit of the Leffe Formation. This succession, 60 m thick (24-84 m depth in the FM core), consists of lacustrine, mainly biogenic, carbonate deposits, alternating with three organic beds (brown coal and gyttja) from the top downwards: the first brown coal seam (25.69-27.65 m depth in the FM core); the second one, 12 m thick (49.30-62 m) and the third (71.20-73 m). The sedimentary environments for these facies are shown in **Fig. 3**. The second brown coal seam includes a rich plant macroflora (Sordelli, 1896; Ravazzi, 1995) and mammal fauna, the latter assigned to the Upper Villafranchian Mammal Age (Azzaroli et al., 1986). It most probably is also equivalent to the Tasso or the Farneta Faunal Unit. Another faunal assemblage, which includes *Archidiskodon meridionalis vestinus*, was discovered in the 1950s during clay exploitation in the overlying upper unit of the Leffe Formation (**Fig.**

1). The latter assemblage, previously attributed to the Cromerian (Vialli, 1956, Lona and Follieri, 1957), has been re-assigned to the end of the Upper Villafranchian (Azzaroli et al., 1986).
On the basis of palaeomagnetic investigations (Billard et al., 1983, Ravazzi 1993), the biogenic unit is of Matuyama Chron age, starting shortly after the upper reversal of the Olduvai Subchron (97 m in the FM core) and ending before the base of the Jaramillo Subchron.

3. The biogenic unit: pollen record (Fig. 4), vegetation dynamics and climate cycles

The pollen record of the biogenic unit (Ravazzi, 1993) shows a repetition of successional percentage peaks, which involves the entire woody vegetation. The basic pattern of this cycle has been discussed in the interval 33-49 m of the core (Ravazzi and Rossignol Strick, 1995). This vegetation succession can be identified by the following main stages (the letter "a" indicates the warmer part of the cycle with deciduous forests prevalent and letter "b" its colder part, with coniferous forest and partially open vegetation):

a1 - Mixed oak forests of dry-temperate climate, showing successional peaks in the following order: *Quercus/Eucommia, then Corylus/Ulmus/Carpinus/Fraxinus*;
a2 - Juglandaceae-dominated vegetation, rich in trees indicating a wet climate and high edaphic humidity (*Carya sspp., Pterocarya, Fagus, Aesculus* aff. *hippocastanum*);
b1 - Coniferous forests of cooler climate (*Picea, Tsuga, Cedrus, Abies*);
b2 - Partially open vegetation (*Artemisia-Betula-Larix* pollen zone), interrupting the forest succession. This indicates a drier and continental climate.

Fig. 4 presents the pollen record of selected trees for the core interval 24 to 56 m. The basic vegetation succession is repeated five times, but stage b2 is missed in some cycles (there is no interruption in forest succession). Using the nomenclature system proposed by Ravazzi and Rossignol Strick (1995), these cycles are defined as follows: Cycle L (53-49.4 m); Cycle M (49.4-36.9 m); Cycle N (36.9-29.85 m); Cycle O (29.85-26.7 m); Cycle P, 26.7-21.7 m

The determination of the complete series of percentage peaks in detail required a closer sampling of the organic seams, where a single cycle is represented by a thinner interval of deposits, where single taxon peaks are very close. This fact points to important differences in the sedimentation and compaction of the organic in the comparison to the minerogenic material.

Correlation of the FM core pollen record with Lona's record **(Fig. 5).** Lona (1950) and Lona and Follieri (1957) studied 208 pollen samples from the Biogenic Unit. Samples were taken in the S. Lucio mine shaft, 600 m N of the FM core, in the deeper part of the Leffe lake, whereas the FM core originates from its southern part. The correlation of these pollen records permits an evaluation of the thickness variations of correlated pollen zones, in terms of sedimentation rate, sedimentary facies and distance from the lakeshore. Unfortunately, Lona and collaborators did not publish a detailed pollen diagram. The original pollen data by Lona have been plotted in **Fig. 5**, with the stratigraphic column described by Venzo (1950) and with the glacial / interglacial stratigraphy and the climatic curve proposed by Lona (1950). Lona did not included herbaceous pollen in the pollen sum; therefore herbs were also excluded from the FM core pollen sum in Fig. 5, for comparison. A rough stratigraphic control is provided by the positions of the first and the second brown coal seams. The correlation of the two diagrams has been worked out by Pini (1996), thanks to a detailed analysis of the FM core interval 30.5 to 29 m depth. This interval, in fact, is made by very compressed brown coal where the vegetation succession is recorded in a few cm of deposit (see for example the *Quercus* peak at 30.2 m depth).

Estimated duration of vegetation cycles. The sedimentation rate, determined from pollen concentrations and calibrated by counts of about 3000 varves preserved in some part of the endogenic carbonates (Ravazzi & Moscariello, 1998), allows an estimate of the duration of some of the vegetation cycles represented in the biogenic unit (e.g. cycle M would have lasted 40 - 50 ka). Cycles M, N, O, P are estimated to have a comparable duration. This excludes the hypothesis by Venzo (1953), that, ignoring the variation in sedimentation rate and compaction of organic deposits, recognized a complex climatic regime, characterized by cold phases marked by short climatic events, and stable conditions during interglacials.

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Caption of Fig. 5, page 46:

Figure 5. Correlation between the Fornace Martinelli core pollen record (on the left) and Lona's (Lona, 1950, Lona and Follieri, 1957) diagram (in the middle and on the right) in the Leffe Formation biogenic unit. All curves have been calculated using a pollen sum excluding herbs, since Lona ignored herbaceous plant pollen. The sum of thermophilous plants defined by Lona includes: *Carya, Pterocarya, Juglans, Quercus, Ulmus, Zelkova, Carpinus, Corylus, Tilia, Ostrya* and *Castanea*. The middle part of the figure (from Lona, 1950) illustrates the lithological column described from the San Lucio mine shaft (5 = second brown coal seam; 6 = chalk and calcareous gyttja; 7-8-9 = first brown coal seam), the glacial / interglacial stratigraphy and the climatic curve proposed by Lona (1950) (from Ravazzi & Moscariello, 1998).

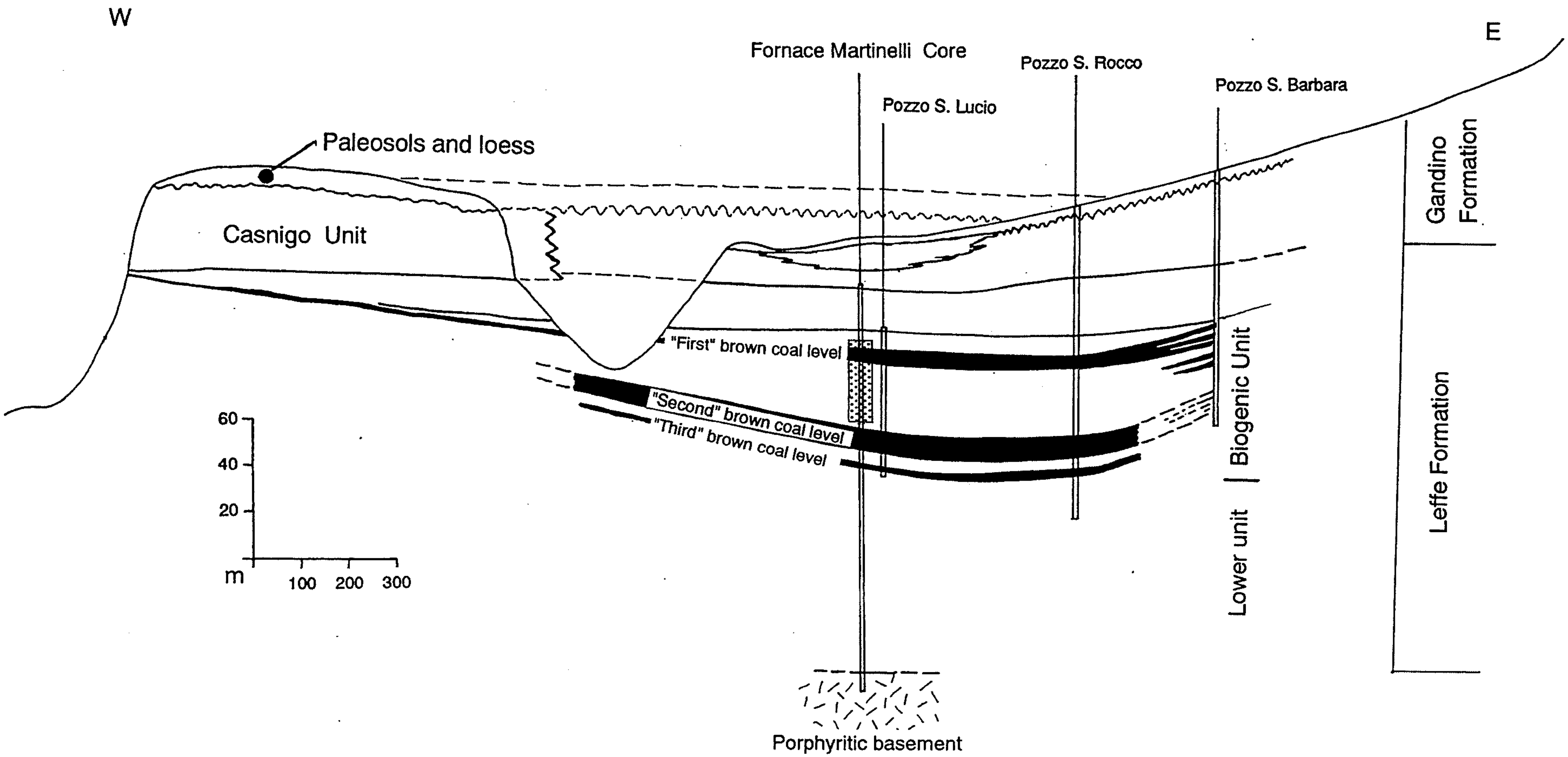
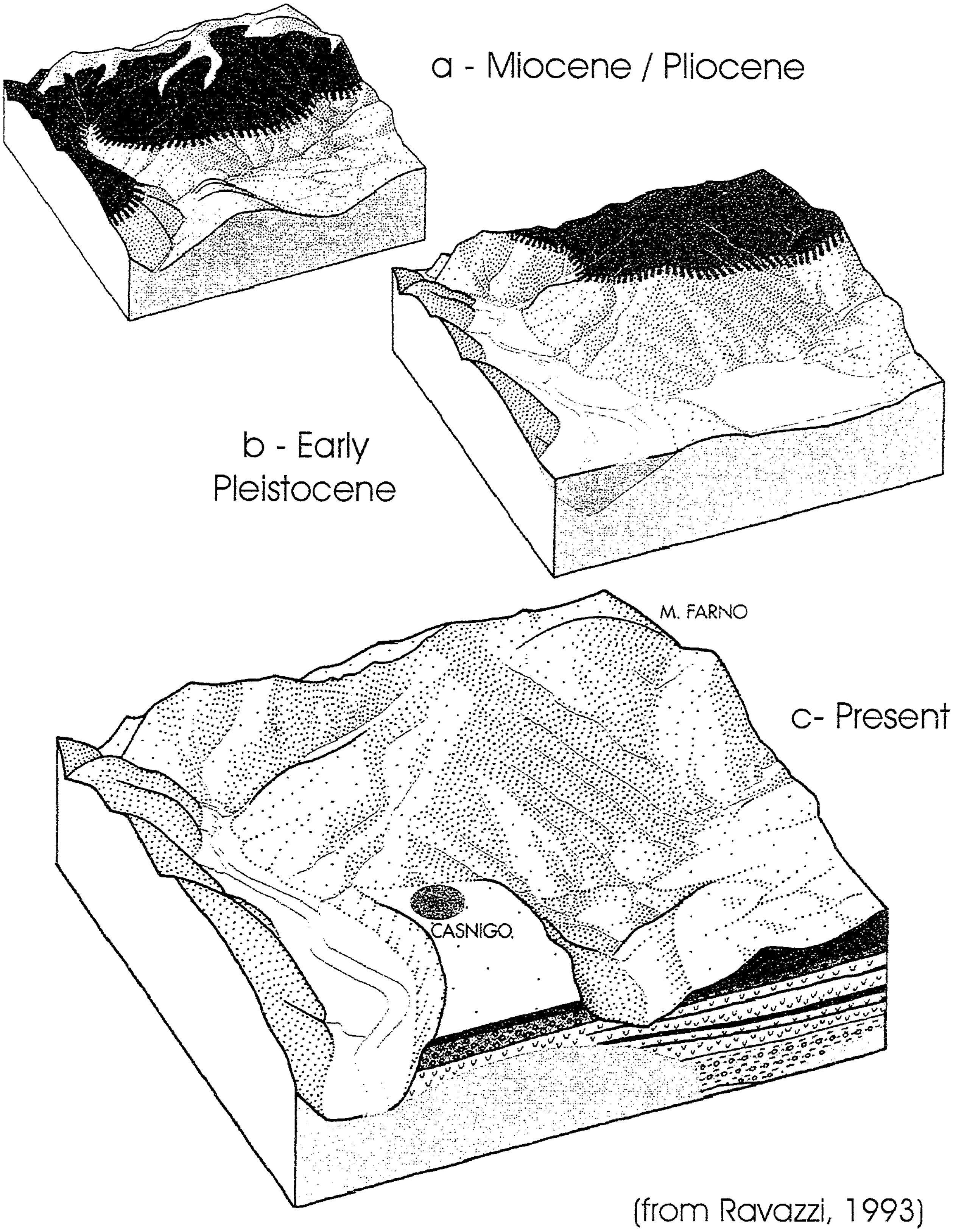


Figure 1. Cross section W-E through the Leffe Basin. Lithostratigraphic units and the position of the Fornace Martinelli core are indicated. The pointed area shows the interval studied for pollen analsysis (24-56 m depth in the FM core) (from Cremaschi & Ravazzi, 1995).

Scheme of the evolution of the Leffe Basin



(from Ravazzi, 1993)

Figure 2. Scheme of the geological evolution of the Leffe Basin from Neogene to present time.

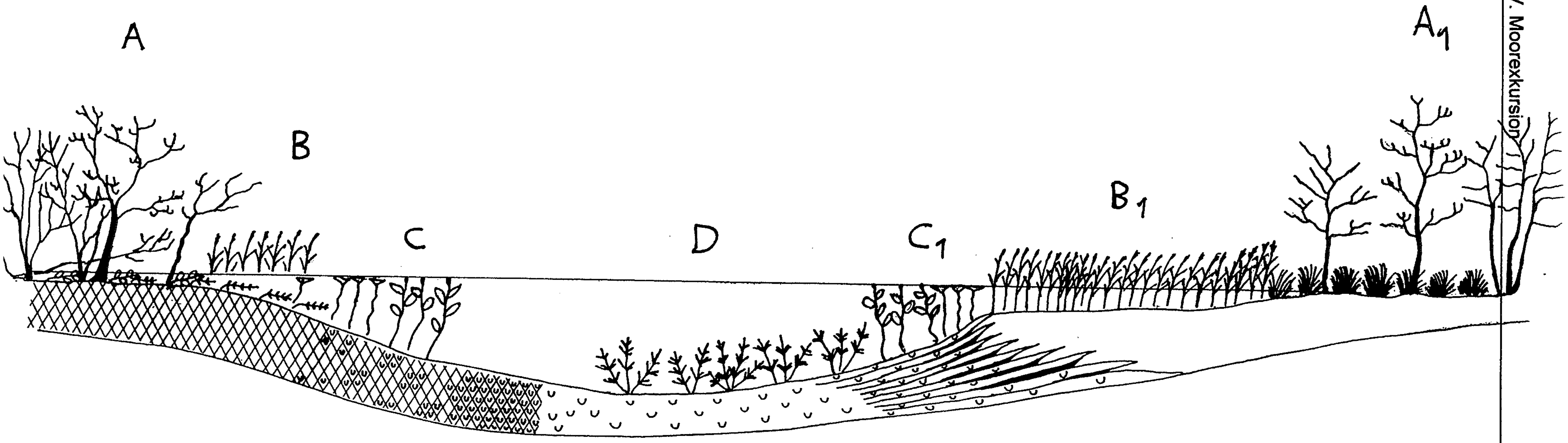
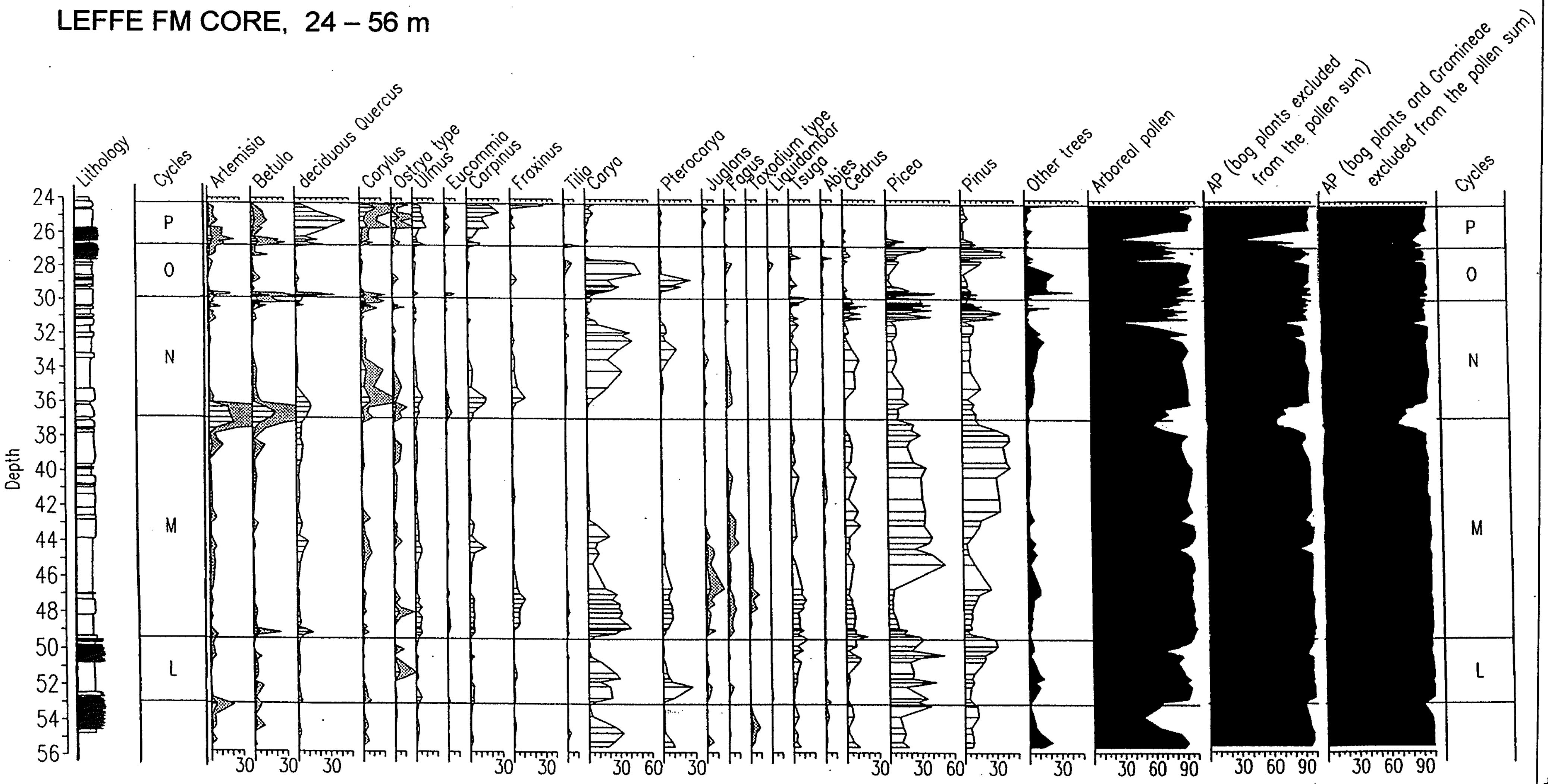
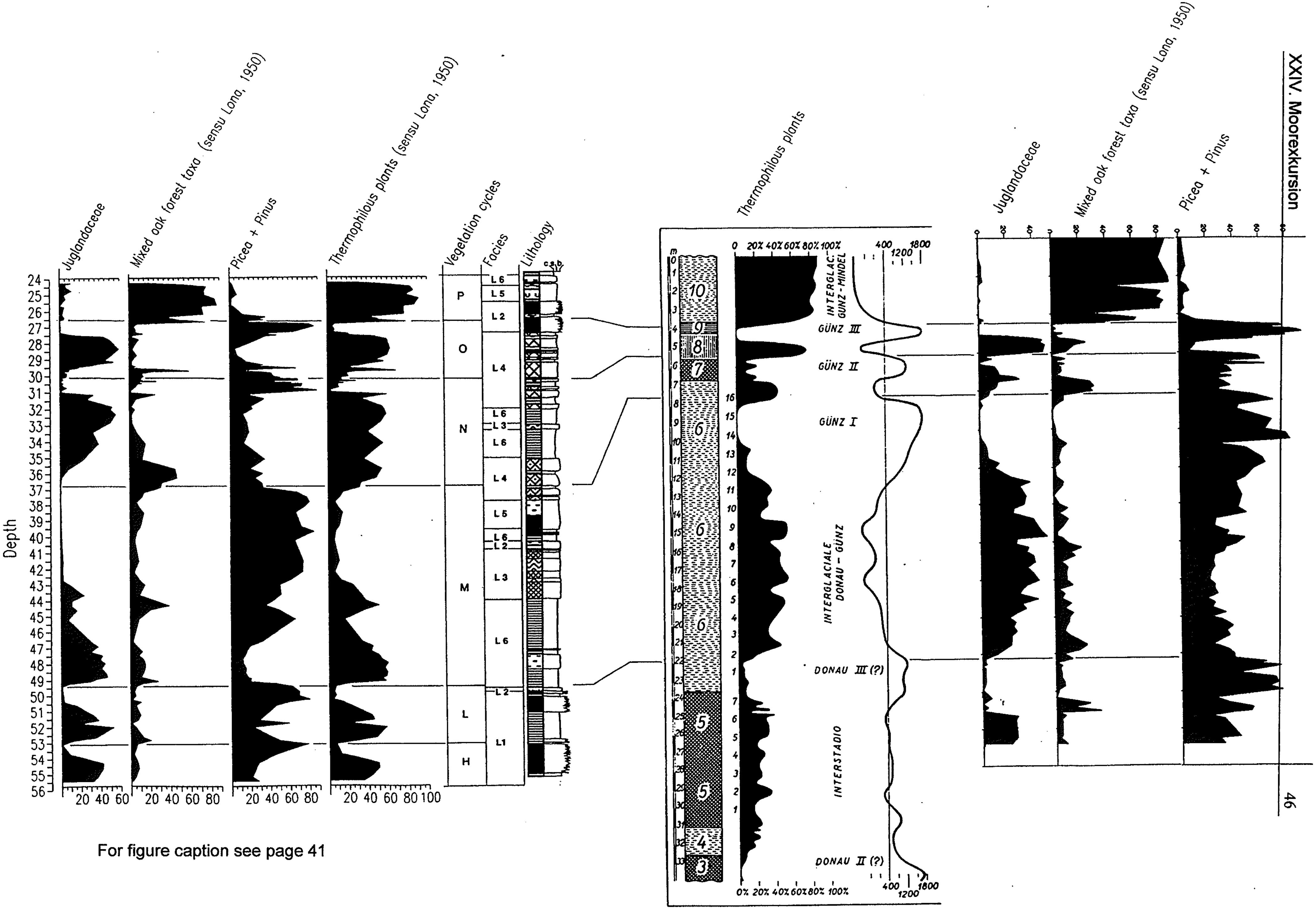


Figure 3. Scheme of sedimentary environments recongnized during the accumulation of the Biogenic Unit of the Leffe Formation (Ravazzi, 1993, with updatings). The reconstruction shows an hypothetical situation with fine detrital supply on the left shore, and with only biogenic deposits accumulation on the right shore. A - *Pterocarya-Alnus-Glyptostroboxylon* floodplain forest and lotic waterpools, with detritus gyttja and clay sedimentation. B - *Phragmites* stands (gyttja and peaty clay). C - Open water *Nymphaea-Potamogeton* communities (calcareous gyttja with shells). D - Characeae stands (lacustrine shell marls). C1 - Open water *Nymphaea-Potamogeton* communities (rythmically laminated lacustrine marls). B1 - peat; A1 - *Pterocarya-Alnus-Glyptostroboxylon-Magnolia cor* (woody peat).

Figure 4. Percentage pollen curves for the main taxa from the interval 24-56 m of the FM core, ordered according to the vegetation succession. The vegetation cycles have been indicated. The pollen sum includes all the Spermatophyta. The curves of *Eucommia, Juglans, Vitis, Fagus, Taxodium*-type have been exaggerated three times (Ravazzi & Pini, unpublished).



Analysis: Cesare Ravazzi and Roberta Pini (1993 - 1997)



For figure caption see page 41

The lacustrine succession of the Piànico-Sèllere Basin[1]

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Introduction

The excursion to the Piànico-Sèllere Basin (Lombardian Pre-Alps) provides the opportunity to observe in outcrop a 50 m thick succession of lacustrine and glacial deposits which documents environmental events of the Middle and Late Pleistocene history of the Southern Alps. It has been recently shown that this lacustrine succession contains a continuous varved record of about 15,500 years, covering an entire interglacial older than the Last Glacial advance (Rossi *et al.*, 2000). Although pre-Holocene, interglacial lacustrine deposits widely occur in Europe, none of the records so far known includes long series of annual laminations.

A pollen diagram, missed by previous investigations, is now available thanks to a PhD presently in progress at the Laboratoire de Botanique historique et Palynologie, Marseille, in co-operation with the Dipartimento di Scienze dell'Ambiente e del Territorio, University of Milano Bicocca.

Geographical setting

The Piànico-Sèllere basin (45° 48' 45" N, 10° 2' 58" E, 280-350 m a.s.l.) is located in the Borlezza Valley (Southern Alps, Bergamo), which is a western tributary of the Lake Iseo (Fig. 1). The catchment area of the Borlezza River, is entirely included in the Calcareous Southern Pre-Alps. The basin is entrenched into steep slopes formed by the Upper Triassic bedrock. Mountains surrounding the basin reach 1460 m a.s.l. (maximum elevation in the catchement 2521 m).

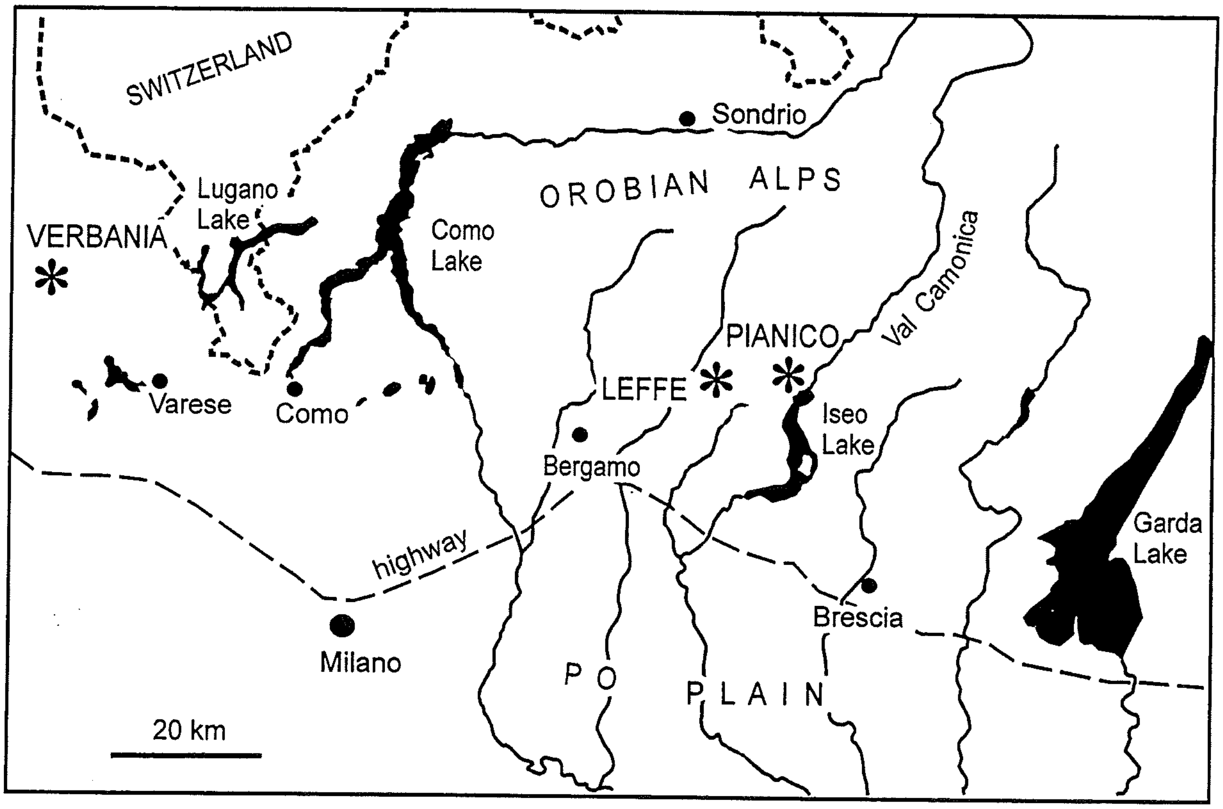

Fig. 1. Geographic location of the Piànico area.

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[1] This work includes the results presently achieved by the *Piànico-Sèllere Working Group,* with the con-tribution of: Jacques-Louis de Beaulieu, Achim Brauer, Sergio Chiesa, Clara Mangili, Andrea Mosca-riello, Cesare Ravazzi, Maurice Reille, Sabina Rossi

Present climate and vegetation

The valleys of the Lombardian Pre-Alps are characterised by temperate, wet climate with mild winters. The major prealpine lakes are included in thermic islands, extending a few km around the lake shore. Moving from the Iseo Lake towards the inner Pre-Alps, precipitation increases and winter average temperature decreases (Lovere, 1188 mm / year, 2.5° C January average; Clusone, 1524 mm / year, 1.4°C January average). Piànico is just in the middle, i.e. at the border of the thermic island region. There, natural vegetation is mainly composed of mesophilous (*Carpinus betulus-Fraxinus excelsior* woodlands) and thermophilous forests (*Ostrya carpinifolia-Fraxinus ornus* dominated, with *Taxus baccata* relict stands). Among species which claim mild winters, the abundance of *Buxus sempervirens,* on south facing slopes on basic soils, is of particular interest as a local analogue of the high pollen percentage found in the lacustrine deposits of the Piànico Formation (see later). The mountain vegetation belt (e.g. 900-1600 m altitude) is formed by *Fagus sylvatica.* The present vegetation of Southern Pre-Alps includes Illyrian / Pontic (*Chamaecytisus purpureus, Helleborus niger, Ostrya carpinifolia*) and submediterranean species (*Buxus sempervirens, Celtis australis, Quercus ilex, Vitis sylvestris*) that were already present in the region at time of deposition of the Pianico fossil assemblage.

Quaternary history of the Borlezza Valley

The Quaternary evolution of the Borlezza Valley has been driven by the multiple advances of the Oglio glacier. Glacial deposits distribution in the Piànico-Sèllere area indicates that a lateral branch of the Oglio glacier flowed upstream in the Borlezza Valley and dammed the river, leading to lakes formation. Stoppani (1857) and Penck and Brückner (1909) suggested that the Piànico-Sèllere Basin could have had a glacio-lacustrine origin. Venzo (1955), however, proposed that the lake was created by a large rockfall accumulation damming the Borlezza Valley in its lower part. After the filling-up of the lacustrine basin, the area was partially covered by an Upper Pleistocene advance of the Oglio glacier, that shaped the present morphology of the Iseo Lake. The glacier covered the Piànico-Sèllere Basin up to an altitude of about 700 m a.s.l. (Fig. 2 - 3). During a retreating phase, the glacier built a moraine lateral to the Pianico surface which dammed a new glacio-lacustrine basin. The post-glacial river cut formed an entrenched meandering gully, exposing both lacustrine sequences along the course of the river (Fig. 2 - 3).

The stratigraphic succession filling the Piànico-Sellère Basin

The stratigraphic succession of sediments outcropping along the Borlezza river may be schemed as follows (from top to bottom of the stratigraphic sequence):

- Fluvial deposits and travertine bodies
- Upper glacio-lacustrine / lacustrine succession (not formally named so far)
- Glacial deposits (not formally named so far)
- The lower lacustrine succession (named 'Piànico Formation')

The Piànico Formation

The lower lacustrine sequence (Piànico Formation, Moscariello *et al.*, in press) (Fig. 4) consists of almost 50 m of various fine-grained laminated sediments, partly deformed by the overriding glacier. The Piànico Formation forms the main part of the Piànico terrace. The lower boundary is not exposed. The upper boundary is generally not preserved because the sequence is cut by an irregular erosional surface on which deformation till and other glacigenic deposits are lying. However, large portions of intact deposits belonging to the Piànico Formation are exposed along the Borlezza River. Because of its stratigraphical position, the Piànico Formation is older than the Last Glacial Maximum.
The Piànico Formation includes four basinal, fine-grained, laminated lithostratigraphical units called (from the top to the base):

the "**Membro di La Palazzina**" (**MLP**) - La Palazzina Member
the "**Banco Varvato Carbonatico**" (**BVC**) - Carbonate Varved Bed
the "**Silt e Argille Basali**" (**SAB**) - Basal silt and clay
the "**Banco Torbiditico Basale**" (**BTB**) - Basal turbidite bed

These lacustrine deposits are coeval and laterally heteropic to the "**Unità di Ronco Lanzi**" (**URL**) consisting of talus cone/fan delta debris flow deposits accumulated within the marginal part of the lake deposits.

The BVC - Carbonate Varved Bed. The BVC consists of an about 9.5 m-thick succession of calcite varves, formed during temperate conditions dominated by endogenic calcite sedimentation.

Varves are composed by light, prismatic calcite crystal layers with rare diatom frustules, and dark allochtonous layers, formed by diatom frustules, amorphous organic matter, leaves (mainly *Buxus sempervirens*) and clay particles. The good preservation of the varves (absence of bioturbation) and the abundance of organic material suggest that the lake bottom was characterised by a poorly oxygenated environment, possibly related to a fairly deep water body and incomplete seasonal turnover.

Thick coarser, bioclast-rich brown layers occur within the varves. These are interpreted as turbidity currents deposits generated by reworking of littoral deposits.

Very fine clay/silt turbidites are also intercalated with varves. Turbidites represents well defined marker layers (t0 – t22 in Fig. 4, where t 21 d is a tephra layer). These key horizons were used to provide a composite profile from different outcrops.

Varve counting. Varve counting provided on two different varved intervals revealed that the first one contains about 15,500 varves (BVC unit - between t0 and t22 in section n. 5, Fig. 4), and the upper one (into the MLP unit) contains ca 1,120 varves (between t26 and TS0 in section n. 4, Fig 4). Below the main continuous varved sequence of BVC, further short intervals of about 600 - 700 varves altogether occur. They are separated from the long varve sequence by an erosional debris flow and slump (below the t0 marker layer, section n. 9, Fig. 4). The resulting floating chronology has been tentatively linked to the SPECMAP time scale (Brauer *et al.*, submitted).

The MLP - La Palazzina Member. The MLP is a 28 m thick succession of: (i) Calcite light/dark rythmites deposited in a a calm lacustrine environment (endogenic precipitation of calcite); (ii) Massive/finely laminated silts and sands (detrital sedimentation). In the lower part of MLP, facies (i) and (ii) forms spectacular alternances. The pollen record (Fig. 5) revealed that boundaries between (i) and (ii) are linked to sharp environmental transitions.

The pollen record (fig. 5)

Palynological analyses were carried out each 5 cm over about 20 m of the lacustrine succession to outline the general vegetation features. The synthetic pollen diagram (**Fig. 5**) reveals a complex record, characterised by alternation in the sum of broad-leaved taxa and *Pinus* and NAP values and shows 7 major vegetation phases. Abrupt changes in sediment facies and composition correspond to main changes in the pollen content. The sequence starts with a *Pinus* and *Abies* pollen assemblage (pollen zone L). These spectra come from the upper part of SAB unit, and are generally poor in pollen. The sharp transition to the pollen zone M (a long, mesic broad-leaved forest period) corresponds to the onset of endogenic varves deposition. Here high AP frequencies suggest a closed forest landscape around the site, consisting mainly of *Abies*, *Buxus*, *Carpinus* and deciduous *Quercus*. *Buxus* is extremely abundant both in pollen (15-20 %) and in fossil leaves during temperate varved intervals, suggesting that it formed extensive shurblands in the surroundings. An important decrease of mesophilous taxa is associated with a rise of *Pinus* and NAP (Zone N). Zone O is dominated by a pollen assemblage similar to one described in zone M, with even higher values of arboreal pollen. Its termination coincides with an increase of detrital supply and a discontinuous varves deposition. In the uppermost MLP unit, the detrital supply increases progressively and the alternation of endogenic calcite varves and laminates detrital intervals coincides with the alternation of meso-thermophilous-dominates phases and intervals rich in *Pinus,* NAP where a rise in *Betula* and steppic plants values is recorded.

The macrofloral and faunal content (Fig. 6)

The large amount of exceptionally well preserved fossil plants within the lacustrine sediments have attracted several researchers since the middle of the last century. Stoppani (1857) was the first to describe the remains of fishes and plants. Sordelli (1873, 1896) provided a rich collection of drawings (**Fig. 6**).The Piànico leaf flora is characterised by species nowadays living in the Mediterranean region (i.e. *Buxus sempervirens*, *Rhamnus alaternus*) together with plants of the Balkanic and Pontic regions (i.e. *Acer cappadocicum*, see Fig. 6, *Rhododendron ponticum*, see Fig. 6, *Picea omorika*, *Pinus peuce*) (Sordelli, 1896; Emmert Straubinger, 1991). Diatoms were first examined by Corti (1892, 1895), who identified 42 species, then by Ritz (1953). Trombara (1953) carried out a first description of the pollen content. Bones of *Rhinoceros merckii* Jaeg. (now *Stephanorhinus kirchbergensis*) were discovered in a quarry located near the village of Piànico (Picozzi, 1859).

Palaeoenvironmental history

Overall, the Piànico Formation shows multiple changes in sedimentary processes which indicate a transition from a peri/proglacial (BTB unit) to a temperate (SAB, BVC ad MLP unit) lacustrine environment. The pollen record documents a long, continuous interval when a complex succession of broad-leaved and conifer forest phases developed. Main changes in vegetation patterns from conifer to deciduous, warm-temperate forests on the slopes surrounding the lake, correspond in fact to changes in sediment composition (MPL units) from distal sand silt turbidites to a regular continuous succession of endogenic calcite-rich annual varves. Increased rate of erosional processes on the surrounding slopes is also indicated by the occurrence of debris flow deposits (URL unit deposits intercalated within the BVC and MPL units). The Pianico Formation includes a complex succession of minor climatic fluctuations and related environmental changes occurred before a major glaciation. This disagrees with the supposed homogeneous character of the Piànico-Sèllere interglacial flora.

Stratigraphic position and ongoing work

Despite several studies, the stratigraphic position of the Piànico-Sellère succession is still uncertain. The exposures of lacustrine sediments have been attributed to the "Riss-Würm interglacial" by recognition of two distinct glacial deposits, below and above the varved deposits (Baltzer, 1896; Penck and Brückner, 1909). This was supported by geomorphological studies and the occurrence of *Rhinoceros merckii* Jaeg. (Penck and Brückner, 1909; Venzo, 1955; Casati, 1968). After Trombara (1953) and Emmert Straubinger (1991), the abundance of laurophyllous species nowadays living in the Colchis and Balkanic mountains is considered a typical feature for the last interglacial in the Alpine region (Riss-Würm). However, the morphostratigraphical system set by Penck & Brückner has been officially abandoned (Sibrava, 1986), and the Alpine Quaternary stratigraphy is now under revision (Bini, 1997). This requires reconsideration of the stratigraphic position of the Piànico interglacial. A possible Eemian age could be supported by pedological and stratigraphical considerations (presence of only one glacial complex at the top of the sedimentary sequence and no intense weathering at the terrace surface). The pollen content shows a complex, long interglacial phase characterised by an abundance of Mediterranean floral elements, indicating persistently warmer climatic conditions than present during most of the interval. The pollen content could be distinctive for the Eemian (high percentages of *Carpinus* and *Buxus*, presence of *Taxus*) but there is not a clear correspondence with the classical reference vegetation successions known for the Eemian (e.g. Beaulieu & Reille, 1992). In this sense the vegetation composition is not a discriminant character for proving or excluding an Eemian age. Other complex interglacial-interstadial periods occurred during Middle and Late Pleistocene might fit the climatic succession of the Piànico Formation.

The ongoing work of the Piànico-Sellère Working Group aims to provide the geomagnetic stratigraphy and independent numerical dating on endogenic calcite (U/Th series, OSL), and the identified tephra (K/Ar, Ar/Ar). An high-resolution evaluation of the environmental transitions occurred during varves deposition, and their duration, is currently in progress.

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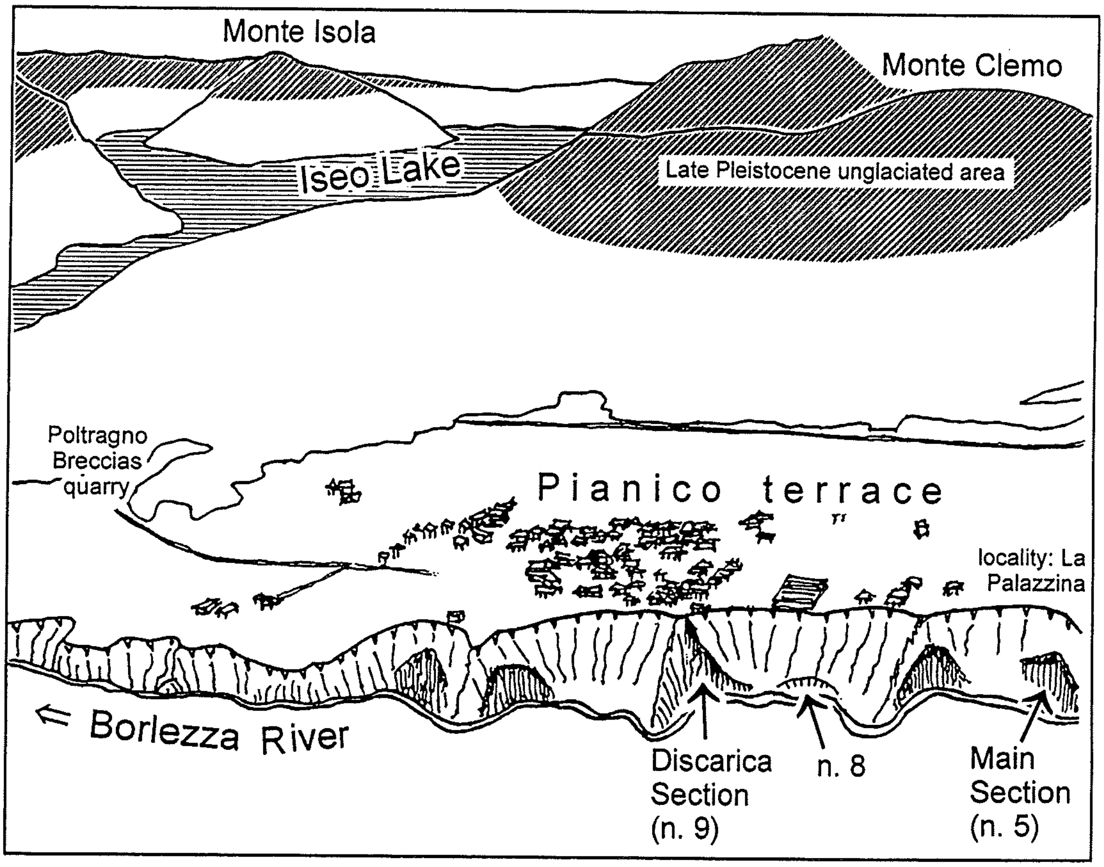

Fig. 2. Schematic topography of the Borlezza River in the Piànico-Sèllere area. The position along the river of the investigated sections is reported. The stratigraphical columns indicate the succession of sediments outcropping in the area. Refer to the text for the detailed description.

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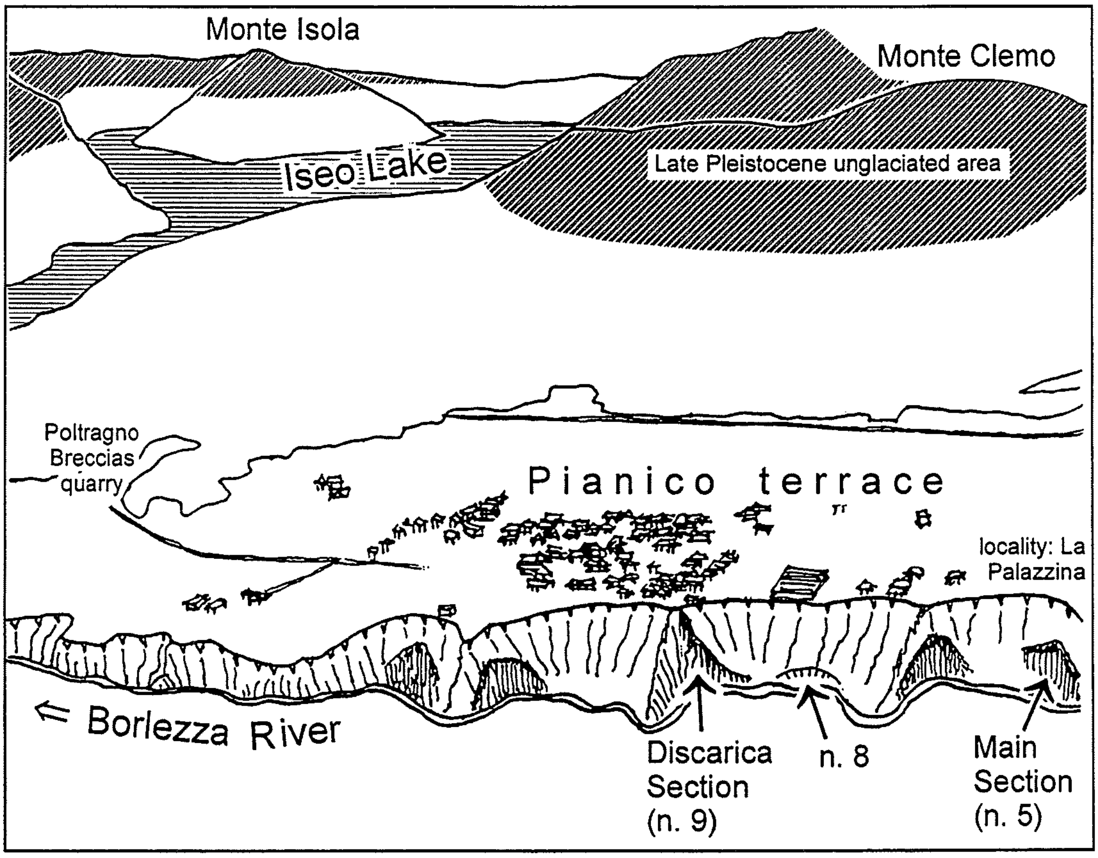
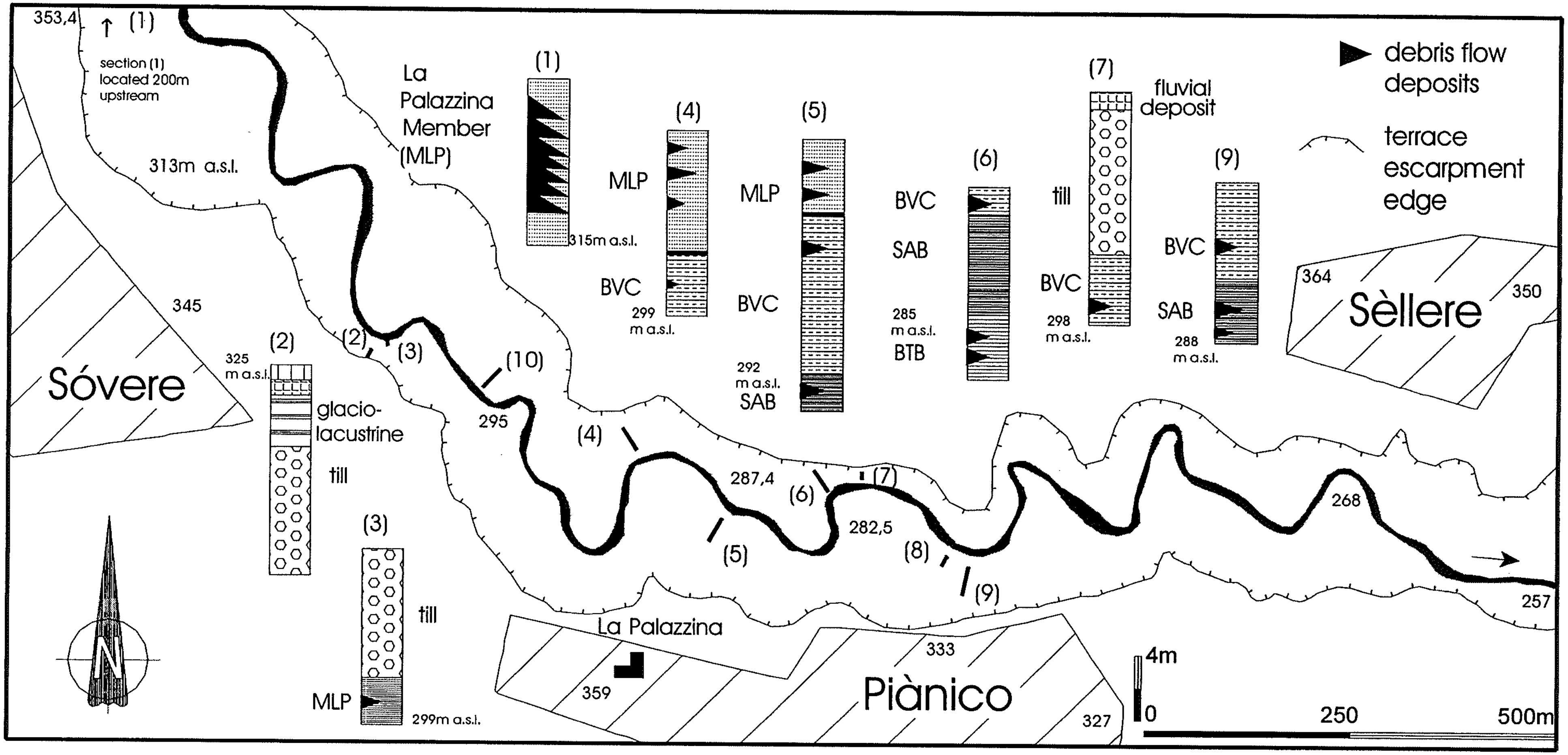


Fig. 3. View of the Piànico terrace from the Bossico plateau (from North to South). In the foreground, the escarpment eroded by the Borlezza River where the stratigraphical sections outcrop. The position of sections n. 5, 8 and 9 is reported.



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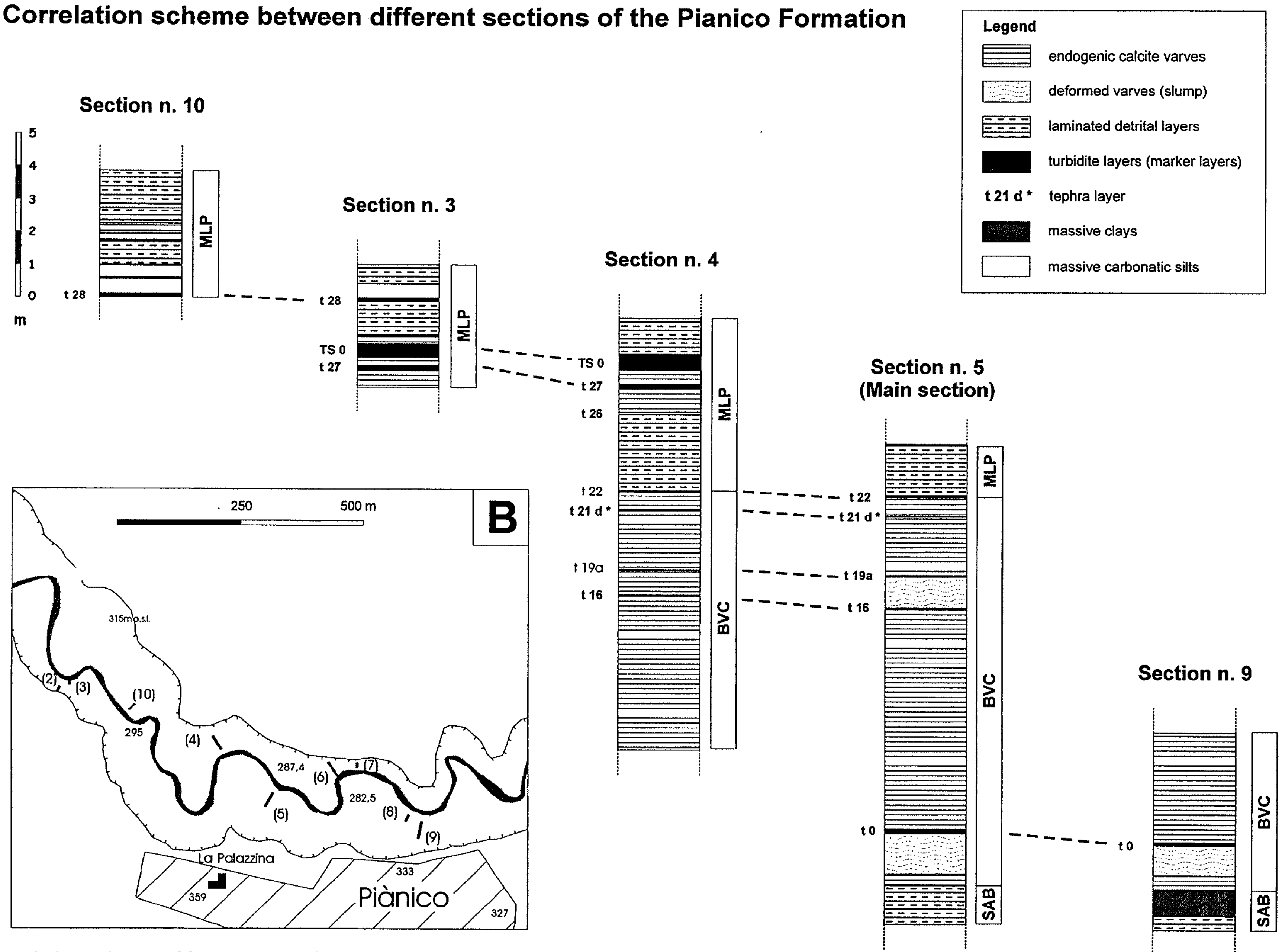
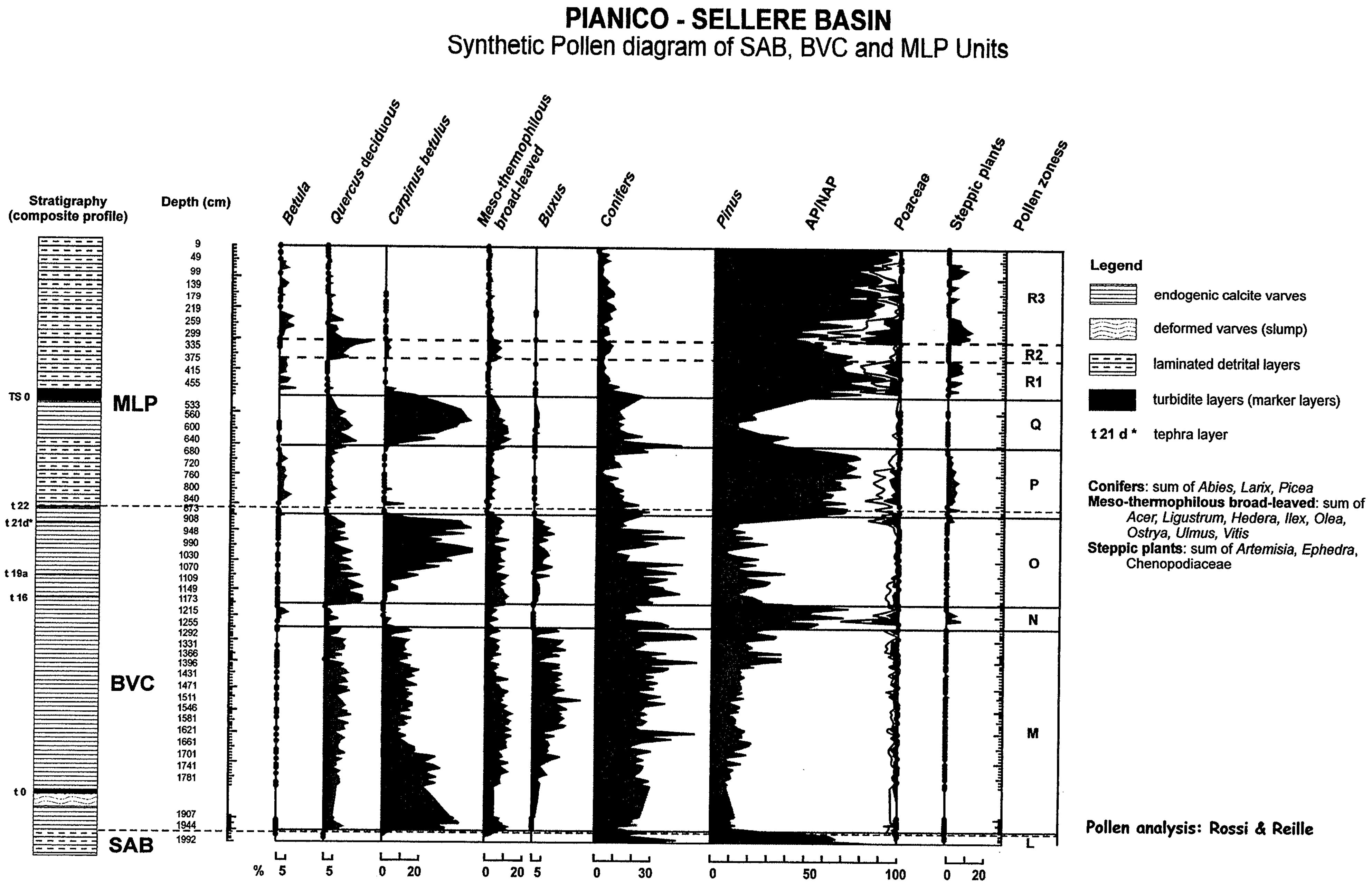


Fig. 4. Correlation scheme of five sections of the Piànico Formation covering the MLP, BVC and SAB Units, used to set a composite profile for microstratigraphical analyses. Key horizons (sand/silt turbidites) representing clear marker layers were used to correlate the outcrops. B) Position of the sections along the river.



Conifers: sum of *Abies, Larix, Picea*
Meso-thermophilous broad-leaved: sum of *Acer, Ligustrum, Hedera, Ilex, Olea, Ostrya, Ulmus, Vitis*
Steppic plants: sum of *Artemisia, Ephedra,* Chenopodiaceae

Pollen analysis: Rossi & Reille

Fig. 5. Synthetic pollen diagram and composite stratigraphical log as measured in type

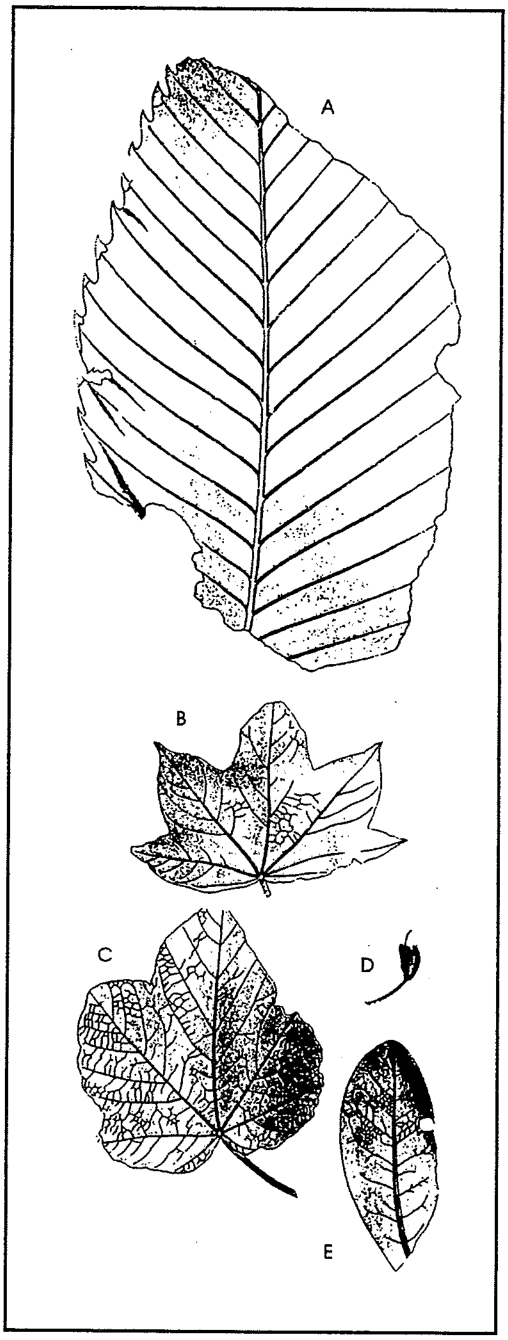
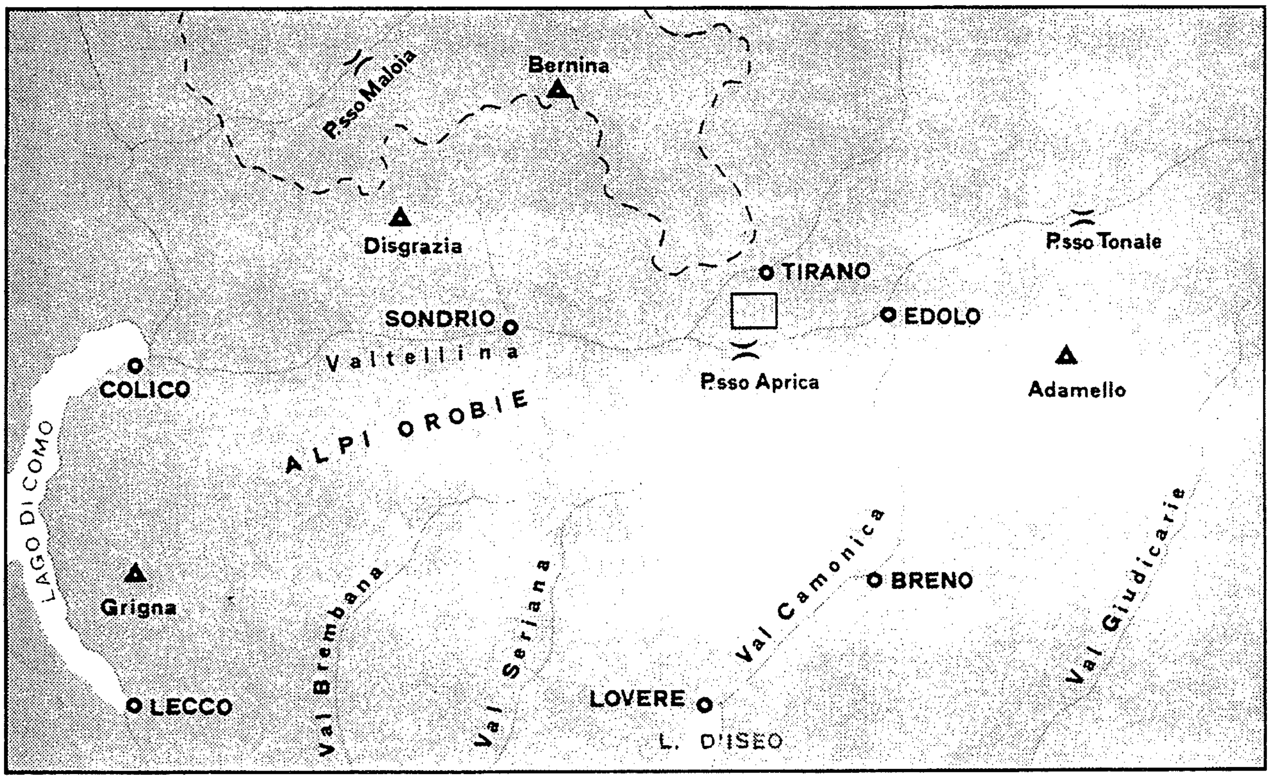


Fig. 6. Drawings done by Sordelli, an eminent Italian naturalist of the last century, who studied the Piànico fossil macroflora (from: Flora Fossilis Insubrica, Milano, 1896). A) *Castanea latifolia* Sordelli: an extinct species similar to the modern chestnut, but with larger and different shape leaves; B) *Acer sismondae* Gaudin: an extinct species similar to the group of *A. opulus s.l.*, which includes species nowadays living in the Mediterannean and Illyric regions *(A. opulifolium* Chaix, *A. obtusatum* W. & K., *A. neapolitanum* Ten.); C) *Acer laetum* Meyer (= *Acer cappadocicum* Gleditsch): a maple nowadays living in the Caucasus and Elburz forests; D-E*) Rhododendron ponticum* Baltzer var. *sebinense* Sordelli: it is a tall shrub living today in the forests in the Caucasus and in the Atlantic coasts of western Europe, under oceanic climate. It is commonly planted in the botanical gardens located around the main pre-alpine lakes.

PIAN DI GEMBRO
1350 m asl



Palaeoecological studies at Pian di Gembro (1350 m. a.s.l., Central Alps, Northern Italy)

Roberta Pini

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Geographical and geological setting:
The Pian di Gembro peat mire (1350 m a.s.l.) is located in the Italian Central Alps (prov. of Brescia, Lombardy), a few km north of the Aprica Pass. It is one of the largest peat mires of Italy: its longest axis is 2.5 km long, while the shortest one is 250-300 m long. The mire is located in a saddle deeply cut in bedrock (metamorphic rocks of the Scisti di Edolo Formation) at the watershed of Val Camonica and Valtellina: the depression is filled by glacial, lacustrine, and peaty sediments. Morainic deposits are present at the eastern border of the mire directly on bedrock.

Lithostratigraphy:

In September, 1998 3 cores were drilled in the S-W part of Pian di Gembro with a Streif Livingstone piston corer: the main one, used for pollen analysis and ^{14}C dating, is 9.5 m long. Coring operations were performed in an area never affected by peat exploitation: the stratigraphy is therefore complete. A brief sediment description of the main core is presented in the following:

0 - 4 cm:	*Sphagnum* peat
4 - 200 cm:	brown peat, from medium to high degree of decomposition, rich in Cyperaceae macroremains. Conifer needles and wood fragments are rare.
200 - 343 cm:	brown peat with very few macroremains
343 - 440 cm:	brown peat with abundant macroremains (Cyperaceae rootlets and stems, conifer needles, *Equisetum* plants, seeds, etc.)
440 - 450 cm:	wood layer, with poor matrix
450 - 570 cm:	brown peat, extremely rich in macroremains (mainly Cyperaceae)
570 - 805,5 cm:	soft but compact gyttja, which lightens with greater depth, poor in macro-remains. Sharp lower limit.
805,5 - 830 cm:	light brown silt-gyttja. Sharp lower limit.
830 - 850 cm:	grey clay, without macroremains
850 - 855 cm:	coarse sand
855 - 950 cm:	grey clay, without macroremains

Pollen analysis:

Preparation of samples for pollen analysis followed the standard method (including HF and acetolysis). 283 Samples were analyzed, each reaching at least a pollen sum of 1,000 pollen grains (few exceptions were made for Late Glacial, pollen-poor clay).

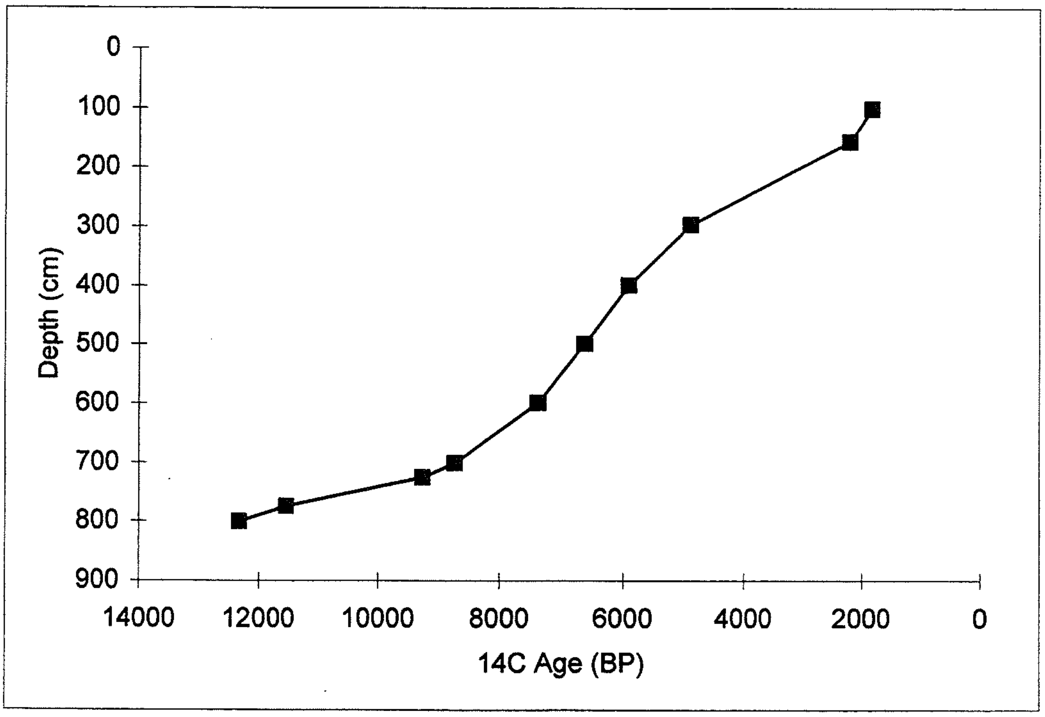
Pollen diagrams were drawn with the program TILIA 1.11 (Grimm, 1992): pollen percentages are based on a pollen sum that includes trees, shrubs, and upland herbs (Cyperaceae, aquatics, and spores are excluded). The % diagram was then divided in LPAZ (local pollen assemblages zones): chronozones follow Welten (1982), valid for the Alps and based on Mangerud et al. (1974).

Vegetation history at Pian di Gembro: a summary

A high-resolution pollen analysis at Pian di Gembro (1350 m a.s.l., Central Alps, Northern Italy) documents the history of vegetation and climate in detail, allowing comparisons with neighbouring sites at different altitudes: ^{14}C chronology offers a reliable time resolution. The results of the present research can be summarized as follows:

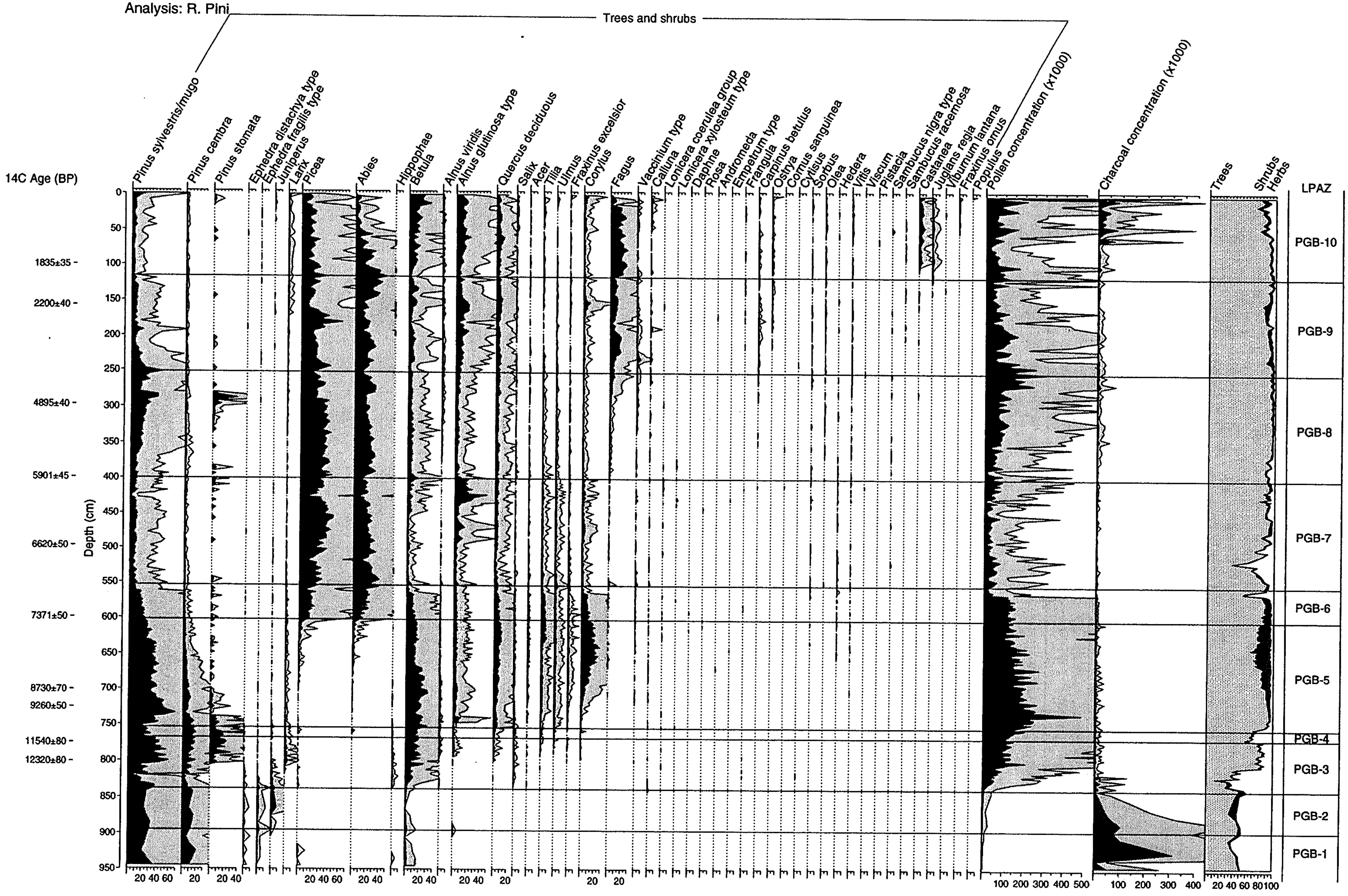
1. After the retreat of glaciers of the Last Glacial Maximum, pioneer plants (mainly herbaceous *taxa*) spread in the plain of Pian di Gembro. The first woody vegetation (*Betula*, *Hippophäe*, *Salix*, and *Alnus viridis*) expanded towards the end of the Oldest Dryas (*sensu* Welten, 1982).
2. The arrival and expansion of *Pinus sylvestris/mugo* and *Pinus cembra* in Pian di Gembro are dated to 12,320 ^{14}C yrs BP. *Quercus*, *Tilia*, *Ulmus*, and *Fraxinus excelsior* immigrated and spread during the Allerød.
3. The rapid cooling of the Younger Dryas strongly reduced the extent of *Betula-Pinus* forests, mixed oak *taxa* declined, and a new expansion of steppe vegetation occurred. Low precipitation and reduced detrital supply into the lacustrine basin can explain the low sedimentation rate during this chronozone.
4. The large and rapid expansion of mixed oak *taxa* in Pian di Gembro took place during the Preboreal. Broad-leaved tree reached higher altitudes suggesting milder winter temperatures at the beginning of Holocene.

5. The sudden and simultaneous expansion of *Picea* and *Abies* is dated to 7370 ^{14}C yrs BP, about 8,200 cal yrs BP, recording a clear, abrupt change in the structure of vegetational belts: this climatic change as evidenced in the polar ice cores was also detected through oscillations of the timberline (Wick & Tinner, 1997). Pian di Gembro offers the first palynological evidence of the wide impact of this climatic change on a middle-altitude environment.
6. The development of the lake of Pian di Gembro into a peat mire, which took place during early Atlantic, is revealed by sedimentological and local pollen-assemblage changes.
7. Human impact is well documented since middle Neolithic and increased during the Iron Age and Roman time, when pasture lands were present in the surroundings of Pian di Gembro. From the Middle Ages onwards, the activity of iron-smelting sites, wide-spread in Val Camonica, led to heavier exploitations of the forests.
8. In the last century the decrease of *Abies*, *Picea*, and *Fagus* led to a new expansion of pine forests.



Pian di Gembro (1350 m a.s.l.)

Analysis: R. Pini



Analysis: R. Pini

Pian di Gembro (1350 m a.s.l.)

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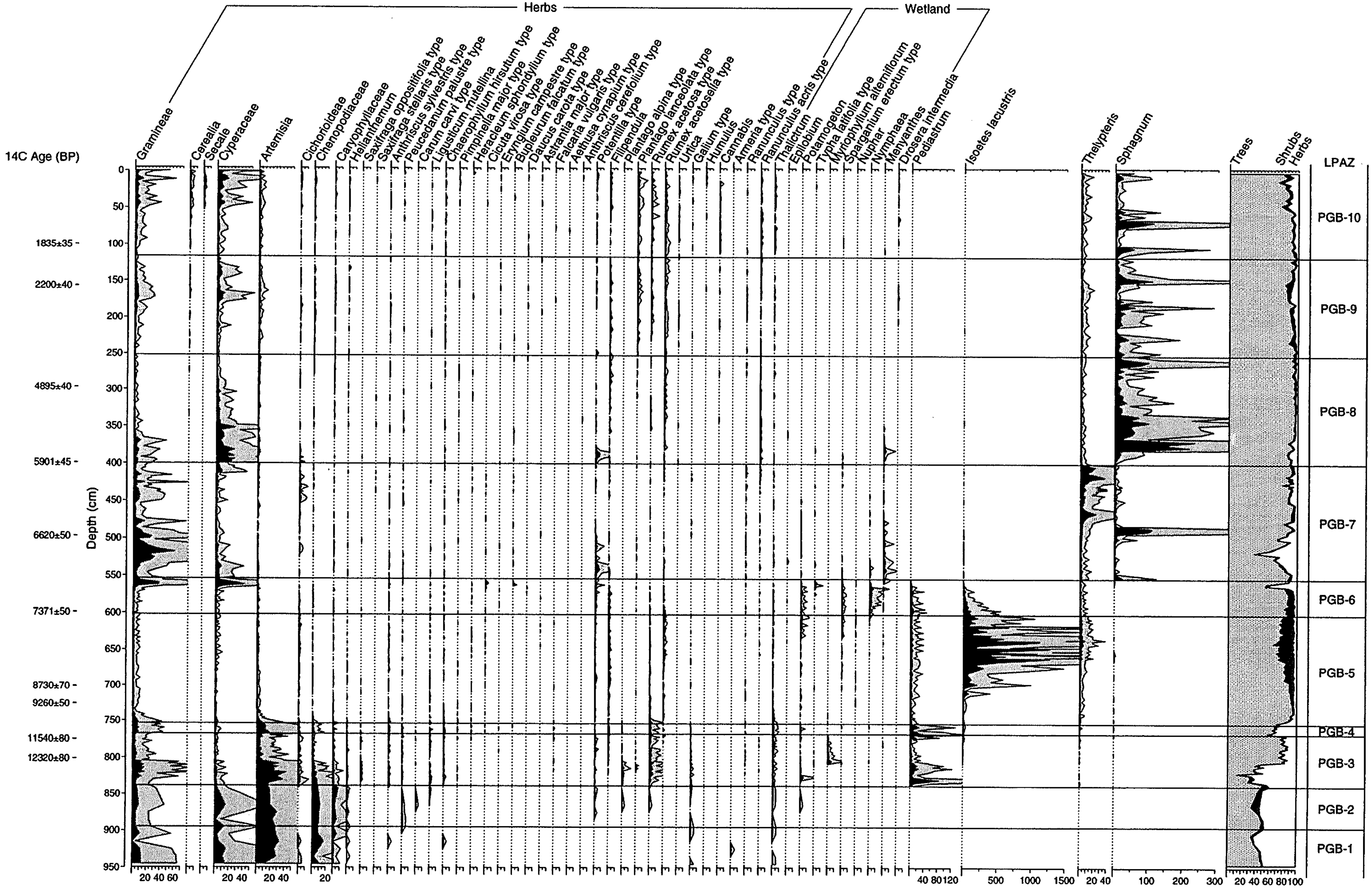

Analysis: R. Pini

Depth (cm)	LPAZ	Chronozones (sensu Welten, 1982)	Interpretation	Limit between LPAZ	Cultural periods
0 116	PGB-10	Subatlantic	Introduction of Castanea and	Cerealia and NAP ↑	Iron Age
225	PGB-9b	Subboreal/Subatlantic	Increase of human impact, several indicators of cultivation, grazing and ruderal communities. Reduction of many arboreal taxa.	AP ↓	Bronze Age
252	PGB-9a	Subboreal	Opening of the forests, due to human activities. Larix meadows spread, NAP rose.	Larix and Fagus ↑	
307	PGB-8b		*Fagus-dominated forests grew in the plain of Pian di Gembro.*	Fagus ↑, NAP ↓	Neolithic
400	PGB-8a	Atlantic	First evidences of human activity: meadows and pastures around the peat mire.	Pinus and NAP ↑	
554	PGB-7		Development of the lake into a peat mire. Conifer forests, local expansion of Alnus glutinosa type.	*Pinus and Betula* ↓	
602	PGB-6		Quick and simultaneous expansion of Picea and Abies. Slight decrease of mixed oak wood taxa.	*Picea and Abies* ↑	Mesolithic
710	PGB-5b	Atlantic/Boreal	Spread of Corylus. Pinus cembra definitely moved to higher altitudes.	Corylus ↑	
754	PGB-5a	Preboreal	Large expansion of mixed oak wood taxa. Conifers in the nearby forests, several shrubs and herbs.	QM ↑, NAP ↓	
768	PGB-4	Younger Dryas	Expansion of steppe vegetation and reduction of both conifers and mesic trees.	*Pinus*↓, *Artemisia* ↑	Paleolithic
790	PGB-3c	Allerød	*Pinus, Betula and Larix forests. First expansion of mixed oak wood taxa.*	QM ↑, Pinus ↓	
800	PGB-3b	Bølling	Mass expansion of Pinus sylvestris/mugo and P. cembra: forests with Betula and Larix.	Pinus ↑, NAP ↓	
838	PGB-3a		*Betula, Juniperus, Artemisia, Gramineae. High biodiversity among the NAP.*	*Betula*↑, *NAP* ↑	
895	PGB-2	Oldest Dryas	*Betula, Juniperus, Ephedraceae. Several herbaceous taxa.*	Shrubs ↑	
945	PGB-1		Pioneer vegetation with Artemisia, Chenopodiaceae, Ephedraceae, Gramineae, etc.		

PIAN DI GEMBRO: PRESENT VEGETATION, PAST EXPLOITATION AND PRESENT DYNAMIC TRENDS.

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Pian di Gembro's peat bog occupies a tabland of pass, partially shaped by regional tectonics (Linea Insubrica) and by glaciers.

It is sharply divided into two sectors:

→ the eastern sector - a gently slope with hygrophylous vegetation (*Junco-Molinietum* s.l.), and *Eriophorum* and *Trichophorum* grasses.

→ the western sector - a former lacustrine body, now in the last stage of infilling.

In the latter sector the most valuable elements, as for flora and for their biogeographic interest, are concentrated. They are linked to many vegetation types intercalated to constitute a transitional bog.

Pian di Gembro is an area of noticeable floristic-vegetational relevance, thanks to the presence of such relic boreo-arctic elements, as *Andromeda polifolia, Vaccinium microcarpum, Carex pauciflora* (linked to the *Oxycocco-Sphagnetea* vegetation), which are extremely rare south of the Alps.

These are joined by other valuable elements represented by peat bog puddle (*Ultricularietea intermedio-minoris*) species as *Comarum palustre, Menyanthes trifoliata, Potamogeton natans, Utricularia* spp. and *Equisetum* spp. The presence of such species characteristic for bare peat bogs, or of modest depressions (*Rhynchosporion albae*) as *Rhynchospora alba, Lepidotis inundata, Drosera intermedia, Drosera longifolia* and *Carex limosa*, is also important.

The present natural vegetation is the result of a mosaic of stages of the peat-growing and occluding series, going from the peat bog "eye" (still present) to the floating ground (*Sphagnum* dominated) intercalated by peat bog puddle and *Sphagnum* hillock, to *Rhynchospora-*, *Trichophorum-* or *Juncus-Molinia*-dominated vegetation to heat and forest woods.

It is possible to recognize:

→ "Natural" water surfaces (to be distinguished from the ones derived from excavation), that are remains of the extinct lacustrine body, belted by a monospecific *Phragmites australis* community.

→ Floating-ground constituted by carpets of *Sphagnum* (*S. papillosum, S.rubellum, S.magellanicum*) arranged in lawns or with more or less dense populations of *Phragmites australis* and graminous-like plants (*Carex lasiocarpa, C. rostrata, Rhynchospora alba, Molinia coerulea*) and modest residual natural puddles, characterized by a vegetation of one's own connotation (impressed by *Carex limosa, Drosera intermedia, D. longifolia*) that interrupt their continuity.

→ *Shagnum* community on now compacted peat soils.

→ flayed areas, with outcroping peat, including peculiar types of vegetation of independent connotation (*Rhynchospora alba, Lepidotis inundata*).

→ Locally on the floating ground, in marginal areas and even on the southern slope, sphagna constitute modest piles (some squared meters) that can anastomize to create unities of bigger dimensions (hummocks), with a peculiar structure. They are dominated by mosses and include some of the most significant elements (*Andromeda polifolia, Vaccinium microcarpum, Carex pauciflora*).

→ Secondary (artificial) hydric bodies, deriving from digging during the past decades (1900-1950).

→ Marshes dominated by *Eriophorum vaginatum, E. angustifolium, E. latifolium, Trichophorum caespitosum, Molinia coerulea*.

→ Heatland, *Calluna* and *Molinia* dominated, with *Pinus silvestris*.

→ Meadows; pastures and forest woods.

The peat bog has been exploited for more than half a century, using different techniques of excavation, that have noticeably altered the vegetation setting with the subsequent formation of excavation puddles of different depth (from 50 to 250 cm). On large areas the sphagna cover has simply been scraped.

The subsequent abandoning allowed coloning vegetation settlement. Different dynamics successions develop depending on the type of exploitation, in any single case different species play an important role.

The peat bog environment is characterized by rapid dynamics, predominantly controlled by water availability. Nevertheless, other elements play a determinant role: pH and nutrient availability.

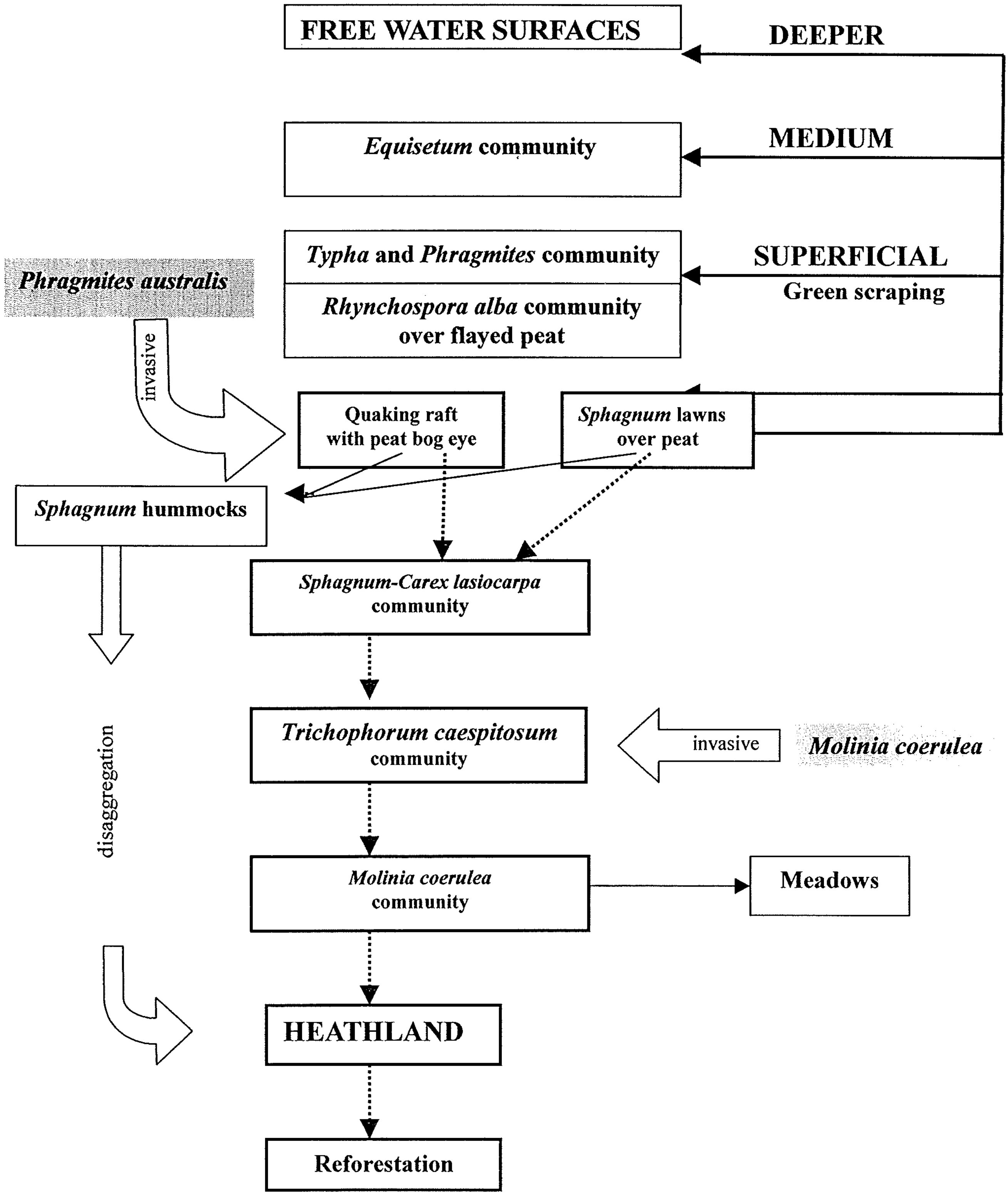
For Pian di Gembro, the comparison between the present situation and the one described at the end of the 70's by Andreis and Rodondi (1982) highlights an explosion of *Molinia* communities, an aggressive action of *Phragmites australis*, that invaded approximately every vegetation that came into contact with it, a diffusion of vegetation in highly disturbed environments, a resolute advance of forest woods, and a widespread and broad colonization of arboreal species.
Succession seems to be driven, in all vegetation types, by a rapid process of dissecation. Moreover, this depends, on the one hand, on a lowering of the water table, and on the other hand on an increase of the evapotranspiration and on the reduction in contribution coming from the hillsides. Finally the reduction, or even the stop, of the moving activities with the consequent increase of forest vegetation, supports the dissecation of peat-land.

The scheme reported below synthetically summarizes the dynamic relationships between single vegetation and natural, or induced, events. The dynamic processes, being more implicated in the maintenance of the peculiar characteristics of the peat bog, will be briefly discussed.

- *Phragmites australis* shows an invasive action practically on every surrounding vegetation: a powerful expansion, starting from the peat bog eyes, to the floating ground, invading the *Sphagnum*- and the *Carex lasiocarpa* community and occluding the mosaic of smaller residual mires pools. A different invasive activity has been observed, in a generalized way, in those areas that have recently been strongly disturbed, where *Phragmites australis* can fully express its tendency to behave like a ruderal species. This high activity of invasion is most likely linked to the oxygenation of the peat bog, given by recasting, and to the fragmentation of rhizomes, that works as a propagating means, and to the availability of nutrients, especially of nitrogen, which could derive, in this case, from processes of peat bog mineralization.
- *Molinia coerulea* shows a very invasive activity (as, at the moment, in all circumboreal peat bogs), expecially versus *Trichophorum* community. The primary cause has to be searched in the lowering of the water table. More than water availability, the table oscillation seems to play, definitely, a basic role. Nevertheless, the problem is not linked, simply, to the decrease of available water only. The actual cause may be searched also in the change in the chemical characteristics, that records an increase of acidity and of nutrients availability, as result of the acceleration of mineralization processes.
- Bare peats that are not constantly submerged, include *Trichophorum*-community and *Rhynchospora*-community with *Carex limosa* and/or *Lepidotis inundata*. They derive from scarp of sphagum coverlet without excavation. The dynamic relationship between the two of them is close: *Rhynchospora*-community evolves, following acidification and sphagnum resumption, towards neutrophyle *Trichophorum*-community to acid *Trichophorum*-community (*Sphagno-trichophoretum* and, finally, *Eriophoro-trichophoretum caespitosi*).
- Areas with wetted and/or ourcroping peat, and/or sapropel too) have independent dynamics, which is still unclear.
- *Sphagnum* community (*S. palustre, S. rubellum, S. magellanicum, S. papillosum*) are in a seat stage. Locally, nevertheless, sphagna may constitute compact regions attempting to rebuild hummocks, embryonic forms of raised bog.
- *Sphagnum* hillocks seem to be, everywhere, in an evident regressive phase. Their disaggregation seems to be rapid once they have been invaded by heat species. Reconstruction nuclei have been noticed but they seem to be destined to die.
- The terminal stage, preceding the settlement of arboreal vegetation, is controlled by *Calluna vulgaris* that colonizes *Trichophorum*- and *Molinia*-communities and attacks *Sphagnum* hummocks, disaggregating them over a period of 40 years.
- Small puddles are impressed by a hygrophylous *Molinia* community (*Molinia coerulea, Juncus* spp., *Carex panicea, Climacium dendroides*) and evolve towards the *Junco-Molinietum*.
- Medium puddles (up to 1 m) present a sedge-series (*C. rostrata, C. lasiocarpa*) and tend to the turfing-landfilling vegetations of *Magnocaricion*.
- Deeper puddles are interested by marsh-like dynamics (*Equisetum, Typha and Phragmites*).

The processes we have seen in natural vegetation are “normal”; the dynamics relating to the environments created by man through various actions, even though deviating from the scheme, at a certain point rejoin it.
As far as “natural” dynamics is concerned, we still have to consider a present-day, but still not very well-known, element: which are the effects of global change on the Pian di Gembro vegetation? On the one hand, we have to expect an acceleration of the dynamics according to the climatic warming, with the disappearance of boreo-arctic species linked to more cold temperature conditions. On the other

hand, it is not unlikely that this second cause has an even more devastating effect, we can not forget the variation of nutrient availability linked to fall-out (acid rains also?) that seems to have a significant effect on the chemical composition, contributing to the eutrophication and acidification processes.



VEGETATION DINAMIC TREND IN PIAN DI GEMBRO PEAT-BOG

COL DI VAL BIGHERA (2087 m asl)
and
PASSO DEL TONALE (1883 m asl)

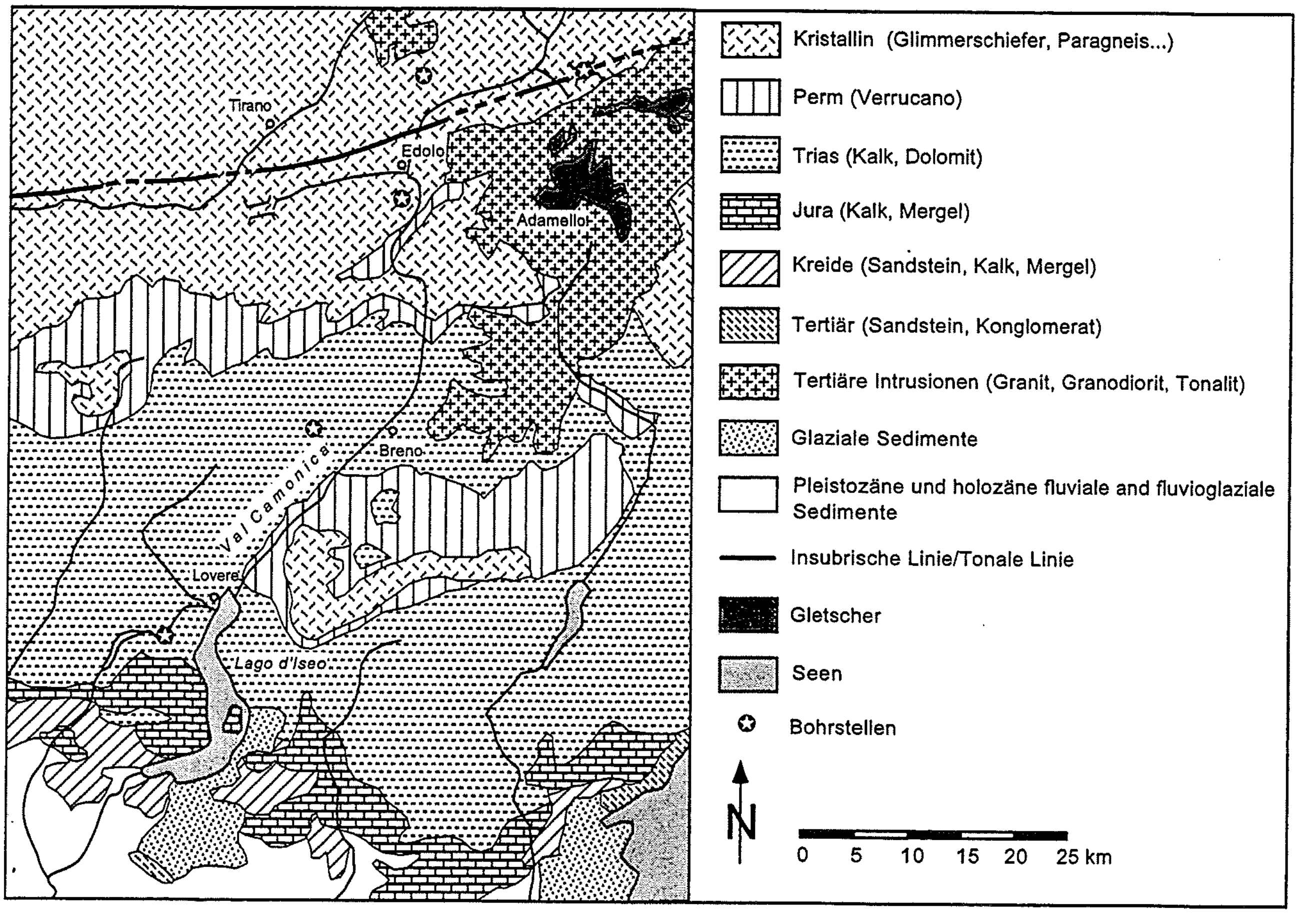


Abb. 3: Geologische Übersicht (nach Carta Geologico d'Italia 1:500 000)

Gehrig, R., 1997: Pollenanalytische Untersuchungen zur Vegetations- und Klimageschichte des Val Camonica (Norditalien). Dissertationes Botanicae 276, 1-152.

DAS POLLENPROFIL COL DI VAL BIGHERA

Geographische Lage

Der Col di Val Bighera (2087 m ü. M.) ist ein kleiner Passübergang, der vom Valle del Mortirolo ins Val Grande führt. In der Passmulde hat sich aus einem ehemaligen See ein Übergangsmoor entwickeln können, welches in zwei Richtungen entwässert: nach SW ins Val di Grom und nach NE ins Val Parolo, einem Seitental des Val Grande.

Der Col di Val Bighera liegt in einer Entfernung von nur knapp 5 km Luftlinie vom Passo del Mortirolo (1896 m) und Passo della Foppa (1852 m), Übergängen vom Val Camonica ins Veltlin, die vermutlich schon in prähistorischer Zeit benutzt worden sind. Am Eingang des Val Varadega konnten einige Schalensteine gefunden werden, die bestätigten, dass das Gebiet bereits von prähistorischen Jägern besucht wurden (Ferrari 1992).

Vegetation

Das Moor am Col di Val Bighera ist ein typisches Übergangsmoor, welches hauptsächlich durch Regen- und Schmelzwasser genährt wird. Es ist 900 m lang und misst an der breitesten Stelle rund 200 m (vgl. Karte).
Heute zeigt sich das Moor in einem degradierten Zustand. Gründe für die Zerstörung der Vegetationsdecke sind erstens die Beweidung und zweitens Entwässerungen.

Lokale Pollenzonen (LPAZ)

LPAZ B-1
Poaceae-*Artemisia-Juniperus*-Zone (985-825 cm)
Grenze: *Pinus sylvestris/mugo*-Anstieg, *Pinus*-cembra-Anstieg, Abfall der meisten NBP- und STP-Kurven
Sediment: anorganisch, im unteren Bereich sandig, gegen oben immer feinkörniger werdend
Alter: älter als 12 755 B.P.

LPAZ B-2a
Pinus-Zone (825-778 cm)
Grenze: Abfall der *Pinus*-Kurve, Anstieg von NBP und *Juniperus*
Sediment: tonhaltige Feindetritusgyttja mit Diatomeae
Alter: 12 750-11 400 B.P.

LPAZ B-2b
Pinus-NBP-Zone (778-768 cm)
Grenze: Anstieg der *Pinus*-Kurve, Abfall der NBP
Sediment: tonhaltige Feindetritusgyttja mit Diatomeae
Alter: 11 400-11 200 B.P.

LPAZ B-2c
Pinus-Zone (768-757 cm)
Grenze: Abfall der *Pinus*-Kurve, Anstieg der NBP, *Juniperus* und *Salix*
Sediment: tonhaltige Feindetritusgyttja mit Diatomeae
Alter: 11 200-10 800 B.P.

LPAZ B-3
Pinus-NBP-Zone (757-717 cm)
Grenze: Ansteigen der *Pinus*-, *Larix*- und EMW-Kurven, Abfallen der NBP
Sediment: siltige Tongyttja mit Diatomeae und sandigen Einschwemmungen
Alter: 10 800-10 000 B.P.

LPAZ B-4
Pinus-Larix-NBP-Zone (717-660 cm)
Grenze: Absinken der NBP, Ansteigen von *Corylus*.
Sediment: Übergang von leicht toniger Feindetritusgyttja zu Grobdetritusgyttja mit Diatomeae
Alter: 10 000-9000 B.P.

LPAZ B-5
Pinus sylvestris/mugo-Larix-Pinus cembra-Corylus-EMW-Zone (660-630 cm)
Grenze: Ansteigen von *Picea* auf über 10%.
Sediment: Grobdetritusgyttja mit Diatomeae.
Alter: 9000-8400 B.P.

LPAZ B-6
Pinus cembra-Pinus sylvestris/mugo-Picea-Zone (630-575 cm)
Grenze: Anstieg von *Picea* auf >20%, Anstieg von *Alnus viridis* von <1% auf >3%
Sediment: Grobdetritusgyttja
Alter: 8400-7600 B.P.

LPAZ B-7
Picea-Abies-Pinus-Zone (575-460 cm)
Grenze: Abfall von *Picea*, Anstieg von *Alnus viridis* über 5%
Sediment: Grobdetritusgyttja mit Diatomeae
Alter: 7600-6500 B.P.

LPAZ B-8
Picea-Alnus viridis-Pinus-Zone (460-270 cm)
Grenze: Anstieg der NBP über 10%
Sediment: Übergang von Grobdetritusgyttja mit Diatomeae zu Torf (hauptsächlich *Sphagnum*, Laubmoos)
Alter: 6500-4700 B.P.

LPAZ B-9
Picea-Alnus viridis-Pinus- NBP-Zone (270-240 cm)
Grenze: Rückgang von *Alnus viridis* und der NBP
Sediment: *Sphagnum*-Cyperaceae-Torf
Alter: 4700-4200 B.P.

LPAZ B-10
Picea-Pinus cembra-Alnus viridis-Zone (240-180 cm)
Grenze: Zunahme der NBP, Abfall von *Pinus cembra*
Sediment: *Sphagnum*-Cyperaceae-Torf
Alter: 4200-3100 B.P.

LPAZ B-11
Alnus viridis-Picea-NBP-Zone (180-110 cm)
Grenze: Anstieg der BP, Beginn der Kurven von *Castanea* und *Juglans*
Sediment: Cyperaceae-*Sphagnum*-Torf
Alter: 3100-1800 B.P.

LPAZ B-12
Alnus viridis- Picea-Zone (110-60 cm)
Grenze: Anstieg der NBP, *Castanea, Olea* und Rückgang von *Alnus viridis*
Sediment: Cyperaceae-*Sphagnum*-Torf
Alter: 1800-1000 B.P.

LPAZ B-13
NBP-*Castanea*-Zone (60-40 cm)
Grenze: Anstieg von *Alnus viridis*, leichter Rückgang der NBP
Sediment: Cyperaceae-*Sphagnum*-Torf
Alter: 1000- 600? B.P.

LPAZ B-14
NBP- *Alnus viridis- Picea*-Zone (40-0 cm)
Sediment: Cyperaceae-*Sphagnum*-Torf
Alter: 600? B.P.-heute

PASSO DEL TONALE

Geographische Lage

Der Passo del Tonale (1883 m) ist ein wichtiger Übergang des nördlichen Val Camonica ins Trentino. Tektonisch angelegt ist der Passo del Tonale durch die Tonale-Linie, welche aus dem Veltlin über den Passo d'Aprica (1176 m), Edolo zum Tonale und dann weiter nach Osten zieht. Entlang der Tonale-Linie findet man Passübergänge, welche aufgrund ihrer niedrigen Höhe recht einfach zu überqueren sind. Dies ermöglicht Verbindungswege zwischen verschiedenen Haupttälern, welche sicher auch schon in prähistorischer Zeit genutzt worden sind.

Lokale Pollenzonen (LPAZ)

LPAZ T-1a
Pinus-NBP-Zone (400-339 cm)
Grenze: Abnahme von *Pinus sylvestris/mugo, Pinus cembra*, Zunahme von *Artemisia*
Sediment: Übergang von Sand, Kies über Silt zu tonhaltigem Cyperaceae-Laubmoos-Torf
Alter: 12 800-11 400 B.P.

LPAZ T-1b
Pinus-NBP-Zone (339-335 cm)
Grenze: Anstieg von *Pinus*, Rückgang der NBP
Sediment: Zunahme des anorganischen Anteils im Cyperaceae-Laubmoos-Torf
Alter: 11 400-11 200 B.P.

LPAZ T-1c
Pinus-NBP-Zone (335-327 cm)
Grenze: Rückgang der BP, Zunahme der NBP
Sediment: tonhaltiger Cyperaceae-Laubmoos-Torf
Alter: 11 200-10 800 B.P.

LPAZ T-2
NBP-*Pinus*-Zone (327-292 cm)
Grenze: Zunahme der BP, Anstieg des EMW
Sediment: Feinkies, Sand, Silt, Ton z.T. mit organischen Lagen
Alter: 10 800-10 000 B.P.

LPAZ T-3
Pinus-Zone (292-245 cm)
Grenze: Anstieg von *Alnus* und *Picea*
Sediment: bis 280 cm anorganische Einschwemmungen, dann Cyperaceae-Torf
Alter: 10 000-8800 B.P.

LPAZ T-4
Pinus-Alnus-Corylus-Picea-Zone (245-210 cm)
Grenze: Rückgang von *Alnus* und *Corylus*, Dominanzwechsel *Pinus* zu *Picea*
Sediment: gut zersetzter Cyperaceae-Torf
Alter: 8800-8000 B.P.

LPAZ T-5
Picea-Zone (210-170 cm)
Grenze: Anstieg von *Abies* >10%, Anstieg von *Alnus viridis* >1%
Sediment: mittel bis gut zersetzter Cyperaceae-Torf
Alter: 8000-7200 B.P.

LPAZ T-6
Picea-Abies-Zone (170-142 cm)
Grenze: Anstieg von *Alnus viridis* >5%, erstes Auftreten des *Cerealia*-Typs
Sediment: mittel zersetzter Cyperaceae-Moos-Torf
Alter: 7200-6600 B.P.

LPAZ T-7
Picea-Abies-Alnus viridis-Zone (142-117 cm)
Grenze: Rückgang von *Picea*, Anstieg der NBP
Sediment: mittel zersetzter Cyperaceae-Moos-Torf
Alter: 6600-6100 B.P.

LPAZ T-8
Picea-Alnus viridis-NBP-Zone (117-102 cm)

Grenze: Anstieg von *Picea*, Rückgang der NBP
Sediment: mittel bis gut zersetzter Cyperaceae-Moos-Torf
Alter: 6100-5500 B.P.

LPAZ T-9
Picea-Zone (102-87 cm)
Grenze: Anstieg von *Alnus viridis* >10%, Anstieg der NBP
Sediment: gut zersetzter Cyperaceae-Moos-Torf
Alter: 5500-4700 B.P.

LPAZ T-10
Picea-Alnus viridis-NBP-Zone (87-77 cm)
Grenze: Rückgang der NBP
Sediment: gut zersetzter Cyperaceae-Moos-Torf
Alter: 4700-4200 B.P.

LPAZ T-11
Picea-Alnus viridis-Zone (77-57 cm)
Grenze: Zunahme der NBP und von *Alnus viridis*
Sediment: gut zersetzter *Sphagnum*-Cyperaceae-Torf
Alter: 4200-3100 B.P.

LPAZ T-12
NBP-*Alnus viridis*-Zone (57-37 cm)
Grenze: Anstieg von *Picea*, Kurvenbeginn von *Castanea* und *Juglans*
Sediment: anorganische Einschwemmung (Sand) im sehr gut zersetzten Torf
Alter: 3100-2000 B.P.

LPAZ T-13
NBP-*Alnus viridis-Picea*-Zone (37-22 cm)
Grenze: Anstieg von *Castanea* und *Juglans*
Sediment: mittel zersetzter Cyperaceae-Torf mit leichten siltigen Einschwemmungen
Alter: 2000-1300/1200 B.P.

LPAZ T-14
NBP-*Alnus viridis-Picea-Castanea*-Zone (22-0 cm)
Sediment: mittel zersetzter Cyperaceae-Torf mit siltigen Einschwemmungen
Alter: 1300/1200 B.P. - heute

Die regionale Vegetationsentwicklung im Val Comonica:

Die Vegetation zur Zeit der Ältesten Dryas, soweit sie in den untersuchten Profilen dokumentiert ist, ist hauptsächlich durch Pionierkräuter geprägt, die ihre Verbreitung auf Rohschuttböden haben. Die tiefer liegenden Lokalitäten sind durch höhere Strauchpollenanteile und vor allem durch hohe *Juniperus*-Werte gekennzeichnet, wie dies für Profile Norditaliens charakteristisch ist.

Mit der Wiedererwärmung zu Beginn des Bøllings begann die Einwanderung verschiedener Bäume ins Val Camonica. Als erste Arten wanderten um 13 000 B.P. *Betula* und kurz darauf *Larix* ein. Nur wenig später breiteten sich *Pinus sylvestris/mugo* und *Pinus cembra* aus. Die Waldgrenze dürfte im Verlauf des Bøllings eine Meereshöhe von rund 1300-1500 m erreicht haben.

Das Allerød zeigt im Val Camonica eine Entwicklung hin zu einem dichteren Schluss der Waldvegetation. Es handelte sich dabei um offene Föhrenwälder, deren Anteile an Birken, Arven und Lärchen mit zunehmender Höhe anstiegen. Die Waldgrenze verlief auf rund 1500-1700 m ü. M. Die beiden Lokalitäten Passo del Tonale und Col di Val Bighera waren noch waldfrei, obwohl Hinweise vorhanden sind, dass Einzelbäume von Birken oder eventuell Lärchen an geschützten Stellen diese Höhenlagen nahezu erreichen konnten.

Zu Beginn des Allerøds wanderte der EMW ins Val Camonica ein. Bereits gegen Ende dieser Zone gelangte wahrscheinlich *Quercus* in die Gegend von Edolo, während die andern EMW-Arten nur den tiefer liegenden Teil des Tals besiedelten.

In der zweiten Hälfte des Allerøds zeichnet sich in den drei Diagrammen Palù, Passo del Tonale und Col di Val Bighera ein Rückgang von *Pinus*, ein Anstieg von *Betula* und der NBP, sowie ein stärkerer minerogener Eintrag ins Sediment ab. Die rund 200 Jahre dauernde Schwankung kann stratigraphisch mit der Gerzenseeschwankung des Schweizer Mittellands verglichen werden. Diese Klimaschwankung wurde mit dem Lokalnamen "Bighera-Schwankung" bezeichnet.

Während der Jüngeren Dryas lichtete sich die Waldvegetation auf. Die Pionierkräuter breiteten sich wieder stärker aus, die Bäume zeigen rückläufige Kurven. Im Sediment ist in allen Profilen ein Ansteigen des mineralischen Eintrags sichtbar, welches auf eine offenere Vegetation und einen stärkeren oberflächlichen Abtrag hindeutet.

Mit der Erwärmung zu Beginn des Präboreals begannen sich die Föhrenwälder wieder zu schliessen. Der EMW breitete sich gleichzeitig mit dem Wiederanstieg der Föhrenkurve bis auf Höhen von über 1300 m aus. In den beiden Profilen der heutigen subalpinen Stufe (Passo del Tonale, Col di Val Bighera) begann die Wiederbewaldung mit *Larix* und *Betula* ebenfalls zu Beginn des Präboreals. Offene Lärchen-Arven-Birkenbestände erreichten während diesem Zeitabschnitt sicher Höhen von 2100 m. Aufgrund der Artenzusammensetzung und des hohen Anteils der NBP in allen Diagrammen zeigt sich, dass das Klima wenigstens in der ersten Hälfte des Präboreals kontinental getönt und vermutlich recht trocken war.

Während des Boreals breiteten sich die EMW-Arten stärker aus. Der Wald schloss sich zunehmend im gesamten Val Camonica. Die Wälder der tieferen Lagen bestanden aus Föhren-Eichenmischwäldern, jene der höheren Lagen weiterhin aus nun etwas dichteren Lärchen-Arven-Birkenwäldern.

Ab rund 8300 B.P. begann die Ausbreitung von *Picea* im nördlichen Val Camonica. Die Fichte wanderte von Osten aus dem Trentino über den Passo del Tonale ein und breitete sich in der Folge südwärts ins Tal und weiter über den Passo d'Aprica und Passo del Mortirolo nach Westen aus. Durch das Höhersteigen der Fichte ab 7500 B.P. wurde der Lärchen-Arvengürtel an der Waldgrenze auf einen schmalen Saum eingeengt.

In Lagen bis auf rund 1300 m ü. M. begann ab 8000 B.P. die optimale Ausbreitung des EMW mit hohen Anteilen an *Tilia*, *Ulmus*, *Fraxinus* und *Acer*. Die thermophilen Elemente *Hedera*, *Viscum* und *Vitis* sind regelmässig nachzuweisen.

Ab 7300 B.P. breitete sich *Abies* im gesamten Tal aus. Die günstigsten Ausbreitungsbedingungen fand *Abies* in der heutigen montanen Stufe, wie das Diagramm Lago di Lova zeigt. Die Tanne hatte im Atlantikum aber eine viel grössere Höhenerstreckung als heute, denn ihre Standorte reichten von der kollinen bis zur subalpinen Stufe.

Die frühesten, noch undeutlichen Hinweise für anthropogene Eingriffe sind im Val Camonica zwischen 6500 und 6000 B.P. zu finden. Erste Pollenkörner des *Cerealia*-Typs treten auf, und gleichzeitig nehmen Kräuter zu, die auf Beweidung hindeuten können.

Ab rund 6000 B.P. wandelten sich die Eichenmischwälder vorwiegend in Eichenwälder. Das 6. Jahrtausend B.P. weist deutlichere Nutzungshinweise auf, welche auf Weidebetrieb und kleinflächigen Getreideanbau schliessen lassen. Selbst in der subalpinen Stufe zeichnen sich NBP-Phasen ab, die wahrscheinlich auf eine saisonale Alpweidenutzung in Waldgrenzlagen hinweisen.

Das Subboreal war im Val Camonica ein Abschnitt mit grossem Vegetationswandel. Als wichtige Ereignisse sind der Rückgang von *Abies*, die Ausbreitung von *Fagus* und die Verstärkung des anthropogenen Eingriffs zu nennen.

Der *Abies*-Rückgang verlief im Val Camonica nicht überall gleichzeitig. Während in der kollinen Stufe die Tanne bereits um rund 4600 B.P. zurückging und durch die Buche ersetzt wurde, vermochte sie sich in der montanen und unteren subalpinen Stufe bis um rund 3000 B.P. zu halten. Ihr Rückgang in den hoch gelegenen Diagrammen lässt sich deutlich mit Rodungen in Verbindung setzen.

Die Ausbreitung der Buche fand im ganzen Tal um rund 4000-4200 B.P. statt. Hinweise zu einer stärkeren menschlichen Nutzung der Wälder, Wiesen und Weiden sind in Verbindung mit der Buchenausbreitung vorhanden.

Während der Kupferzeit (4700/4300-3800 B.P.) bildet sich der menschliche Einfluss in allen Diagrammen verstärkt ab. Die Zeitmarke 4700 B.P. zeichnet sich in allen Profilen deutlich durch eine Zunahme der NBP und des Kohle-Influxes ab. Getreide wurde im gesamten Tal angebaut, und es sind weiter auch Hinweise für eine Weidenutzung vorhanden. Auch in den subalpinen Profilen des Val Camonica nehmen ab diesem Zeitpunkt die Weide- und Kulturzeiger sowie der Kohle-Influx zu. Es ist aber möglich, dass sich in den Profilen klimatisch bedingte Waldgrenzabsenkungen mit Weideeinflüssen überlagern, und die Menschen die Gebiete nutzten, welche durch die Klimabedingungen aufgelockert wurden.

Ab 3600 B.P. verstärkte sich der anthropogene Eingriff in der kollinen Stufe deutlich. Es wurden hauptsächlich Eichen- und Erlenstandorte gerodet. Die Kulturpollen weisen auf Getreideanbau, Weidewirtschaft und Ruderalstandorte hin. Ab rund 3000 B.P. wurde auch die Buche durch Rodungen zurückgedrängt.

Die Nutzung der subalpinen Stufe verstärkte sich in der frühen und mittleren Bronzezeit nur undeutlich. Erst ab 3100 B.P. sind massive Rodungen dokumentiert, während denen grosse Flächen des Fichten- und Arvenwalds zerstört wurden. Die Arve, die heute im Val Camonica praktisch nicht mehr vorkommt, war bis um rund 3100 B.P. oberhalb des Fichtengürtels verbreitet. Durch bronzezeitliche und jüngere Rodungen, vor allem auch durch römerzeitliche Nutzungen, wurden die Arven im Val Camonica fast vollständig vernichtet. Neben dem Menschen hat aber wahrscheinlich auch das feuchter werdende Klima ab rund 3000 B.P. dazu beigetragen, dass das Val Camonica heute kein Arvenareal mehr aufweist.

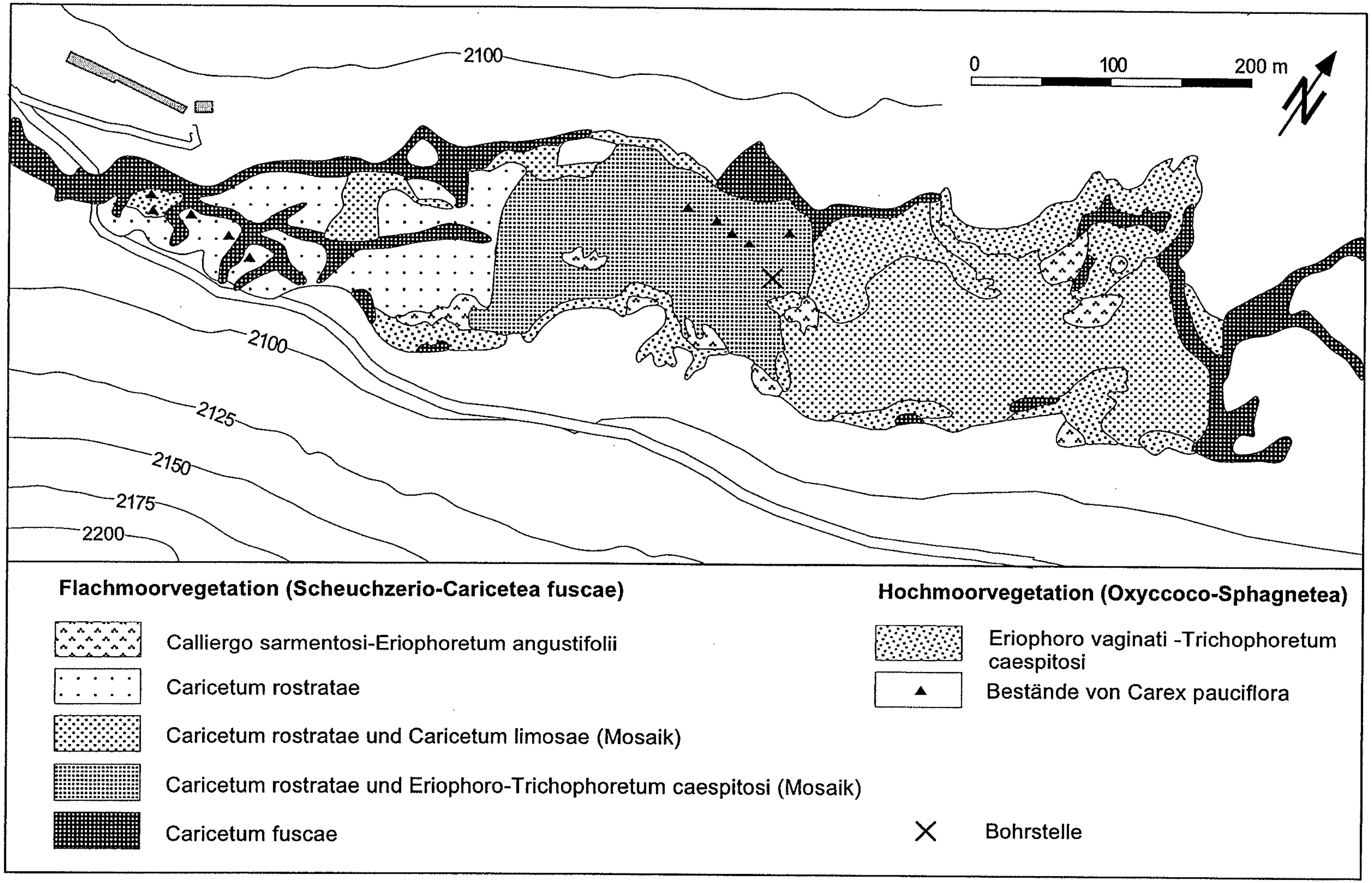
Die eisenzeitlichen Rodungen zeichnen sich im gesamten Val Camonica sehr deutlich ab. In der kollinen Stufe weisen alle Kultur-, Ruderal- und Weidezeiger steigende Kurven auf. Der Getreideanbau wurde vermutlich ausgedehnt. Mannaeschen-Hopfenbuchenwälder konnten sich ausbreiten, wahrscheinlich begünstigt durch die Niederwaldbewirtschaftung. In der subalpinen Stufe wurden die Rodungen vor allem am Passo del Tonale weiter verstärkt, während am Col di Val Bighera Hinweise für Lärchenwiesen bestehen. Am Passo del Tonale konnte sich der Wald nach der Eisenzeit nie mehr schliessen. Das Passgebiet und die sanft einfallenden Hänge auf der Nordseite des Passes wurden vermutlich während den letzten 3000 Jahren durchgehend beweidet.

Der Beginn der Römerzeit lässt sich in den Pollendiagrammen gut durch die Ausbreitung von *Juglans* und *Castanea* abgrenzen. Die Nutzungsintensität während der Römerzeit nahm im Vergleich zur Eisenzeit eher ab. In der kollinen Stufe wurde *Quercus* gefördert. Die hohen *Juniperus*-Werte weisen auf extensive Beweidung hin. Neu wurde nun auch *Secale* angebaut. Die Kastanie spielte während dieser Zeit eine bedeutende Rolle. Auch in der subalpinen Stufe nahm der menschliche Einfluss auf die Vegetation während der Römerzeit etwas ab. *Picea* breitete sich kurzfristig wieder etwas aus, und *Alnus viridis* ging zurück. Der Wald blieb dabei aber offen, die Gebiete wurden weiterhin beweidet.

Ab rund 1600 B.P. entstanden in der kollinen Stufe wiederum mehr offene Flächen. Die Ackerbaugebiete wurden ausgedehnt, im Getreideanbau spielte der Roggen eine wesentliche Rolle. Es sind auch vermehrt Weide- und Ruderalzeiger vorhanden. Ab dem Mittelalter wurden die Rodungen intensiviert und die meisten Bäume bis auf unbedeutende Prozentwerte zurückgedrängt. Insbesondere wurde die Buche dezimiert, so dass sie heute im Tal nur noch wenige Standorte bestockt.

Am Col di Val Bighera sind im Mittelalter intensive Rodungen dokumentiert. Der Nutzungsdruck auf die Wälder war wohl vor allem wegen des grossen Brennholzbedarfs der Eisenschmelzöfen des Tals sehr gross. Erst in den letzen Proben des Profils zeichnet sich eine Erholung des Fichten-Lärchenwalds ab.

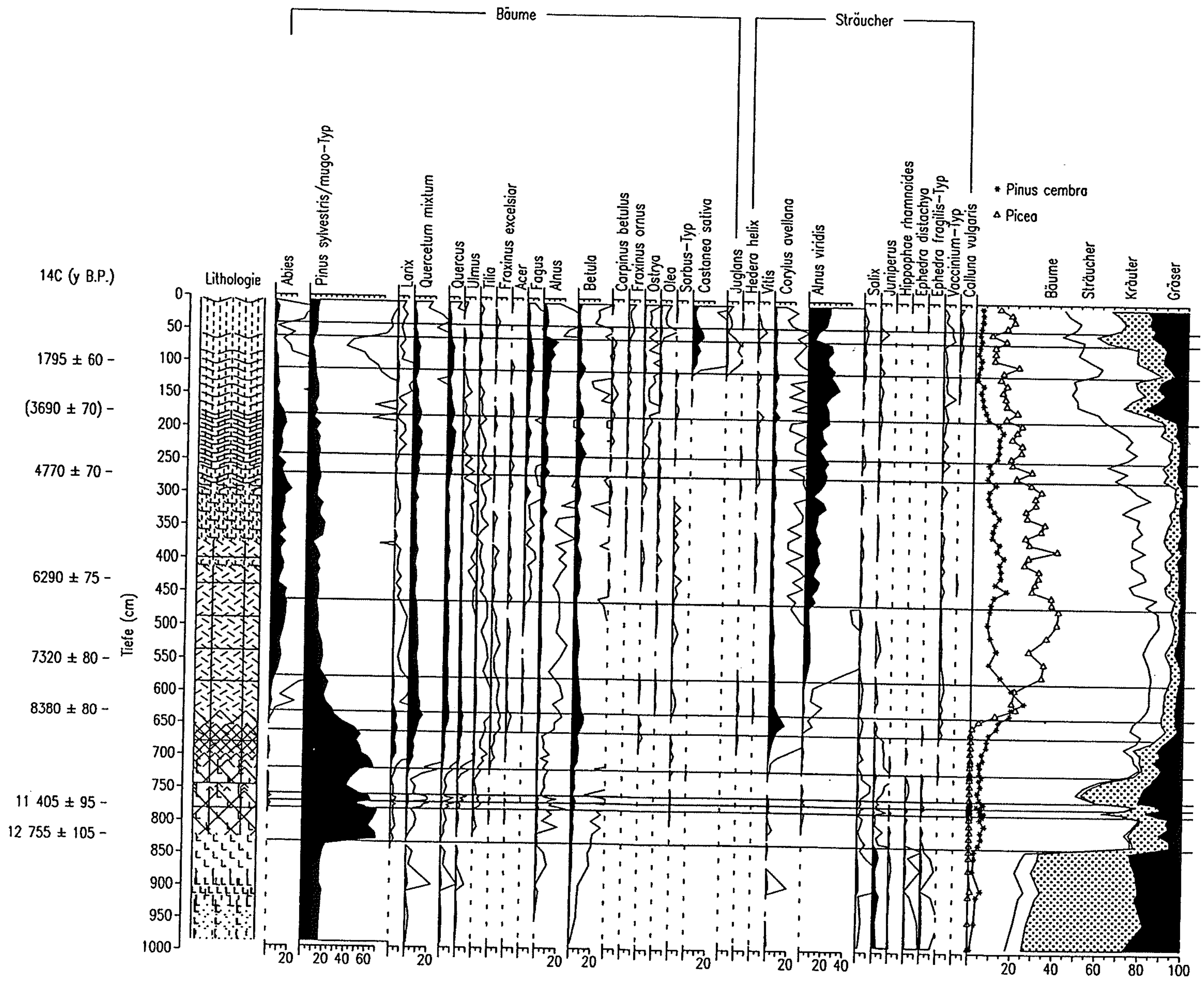
Die heutige Lärchendominanz an der Waldgrenze ist sicher anthropogen bedingt. Die Lärche konnte sich im Val Camonica erst durch die Schaffung von Lärchenwiesen, zuerst kleinflächig ab 3800 B.P. und dann in grösserem Stil ab der Eisen- und Römerzeit ausbreiten.



Vegetationskarte des Moors Col di Val Bighera nach Venanzoni (1988)

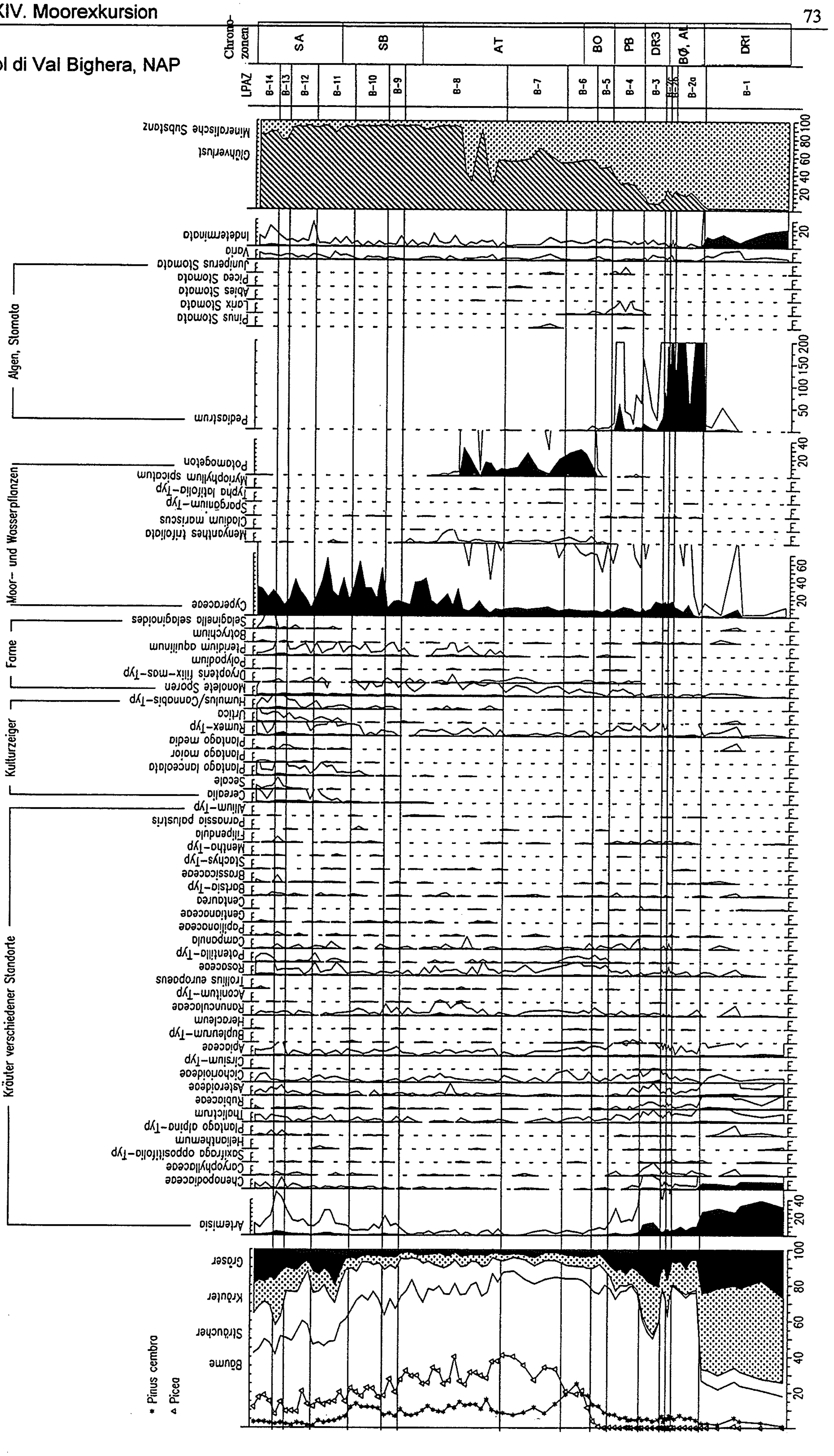
Col di Val Bighera (2087 m ü. M.)

Analysiert: Regula Gehrig

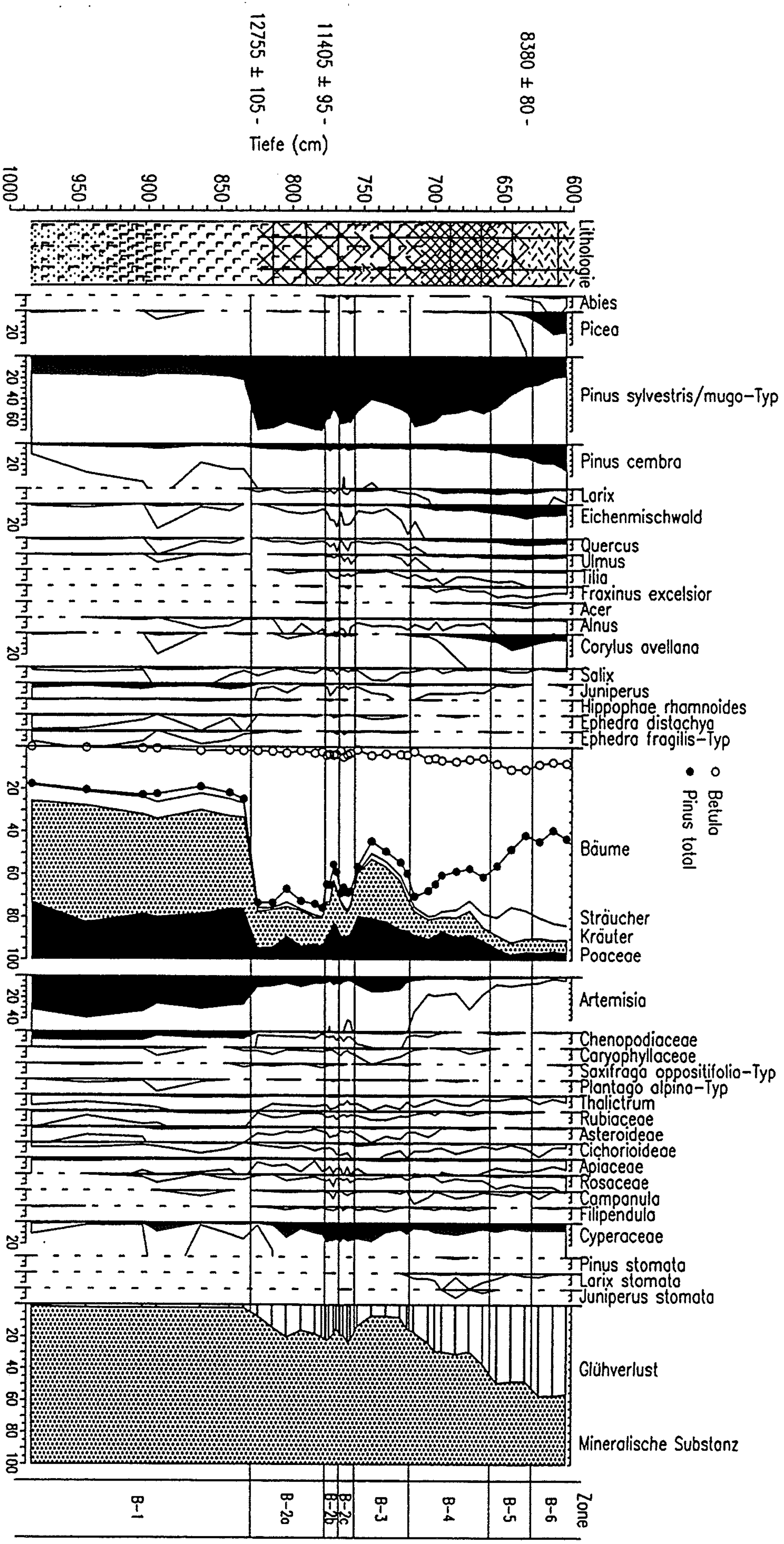


Pollendiagramm Col di Val Bighera

Col di Val Bighera, NAP

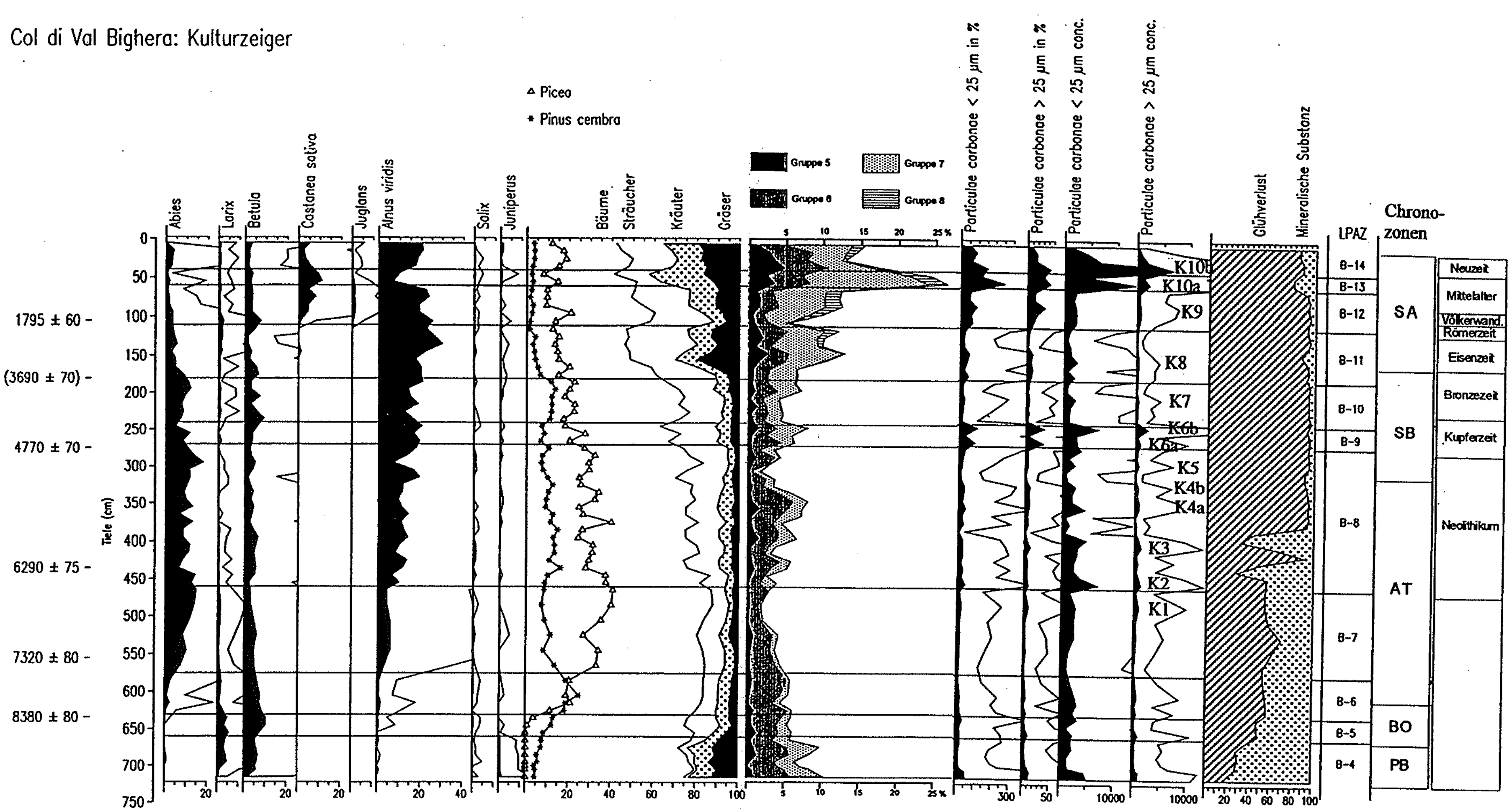


Col di Val Bighera (2087 m): Spätglazial

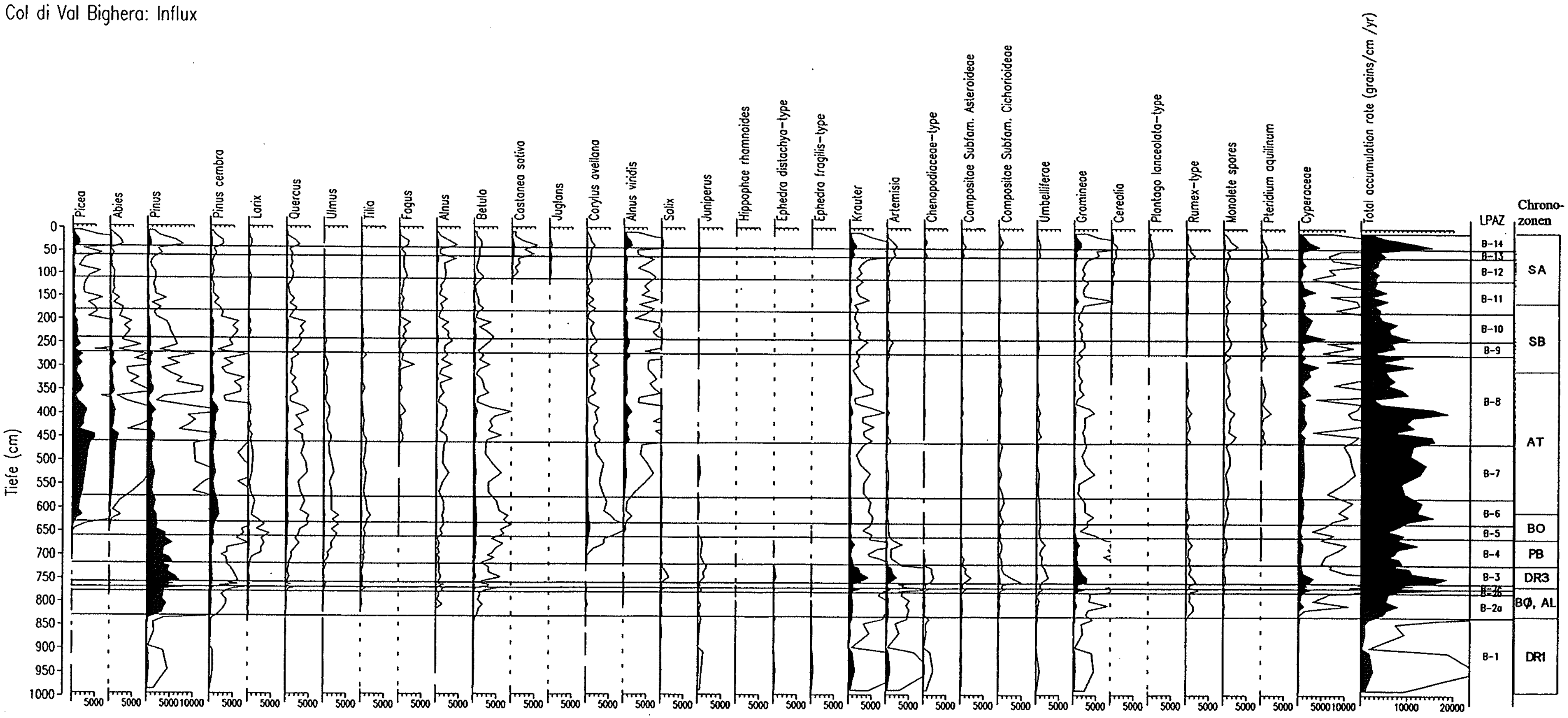


Spätglazialdiagramm Col di Val Bighera

Col di Val Bighera: Kulturzeiger



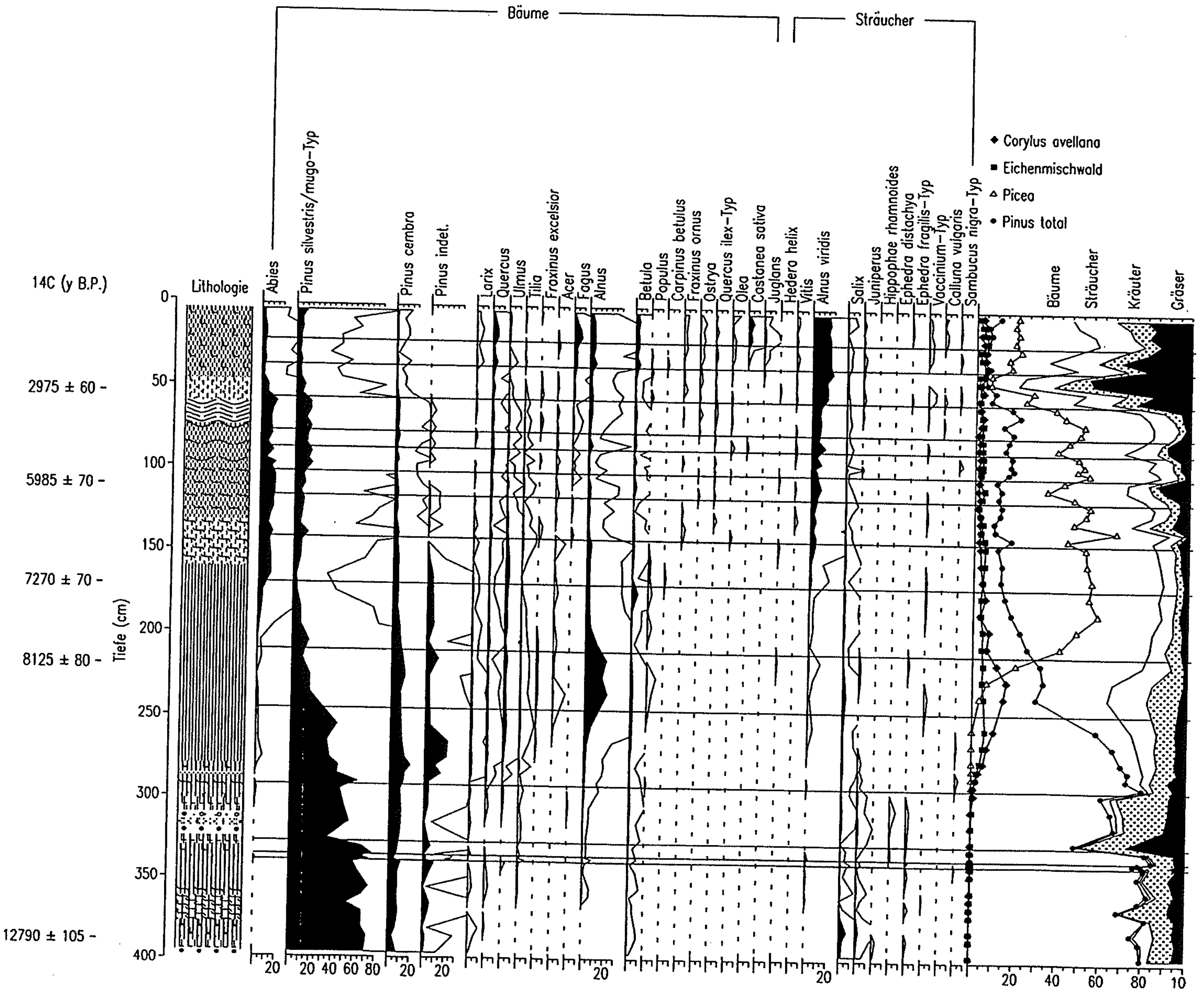
Kulturzeiger-Diagramm Col di Val Bighera
Gruppe 5: Weidezeiger, lichtliebende Arten
Gruppe 6: Artenreiche Familien aus Rasen und Weiden mit beschränkten Aussagemöglichkeiten als Weidezeiger
Gruppe 7: Ruderalpflanzen und Kulturzeiger aus tieferen Lagen
Gruppe 8: Cerealia



Influx-Diagramm Col di Val Bighera

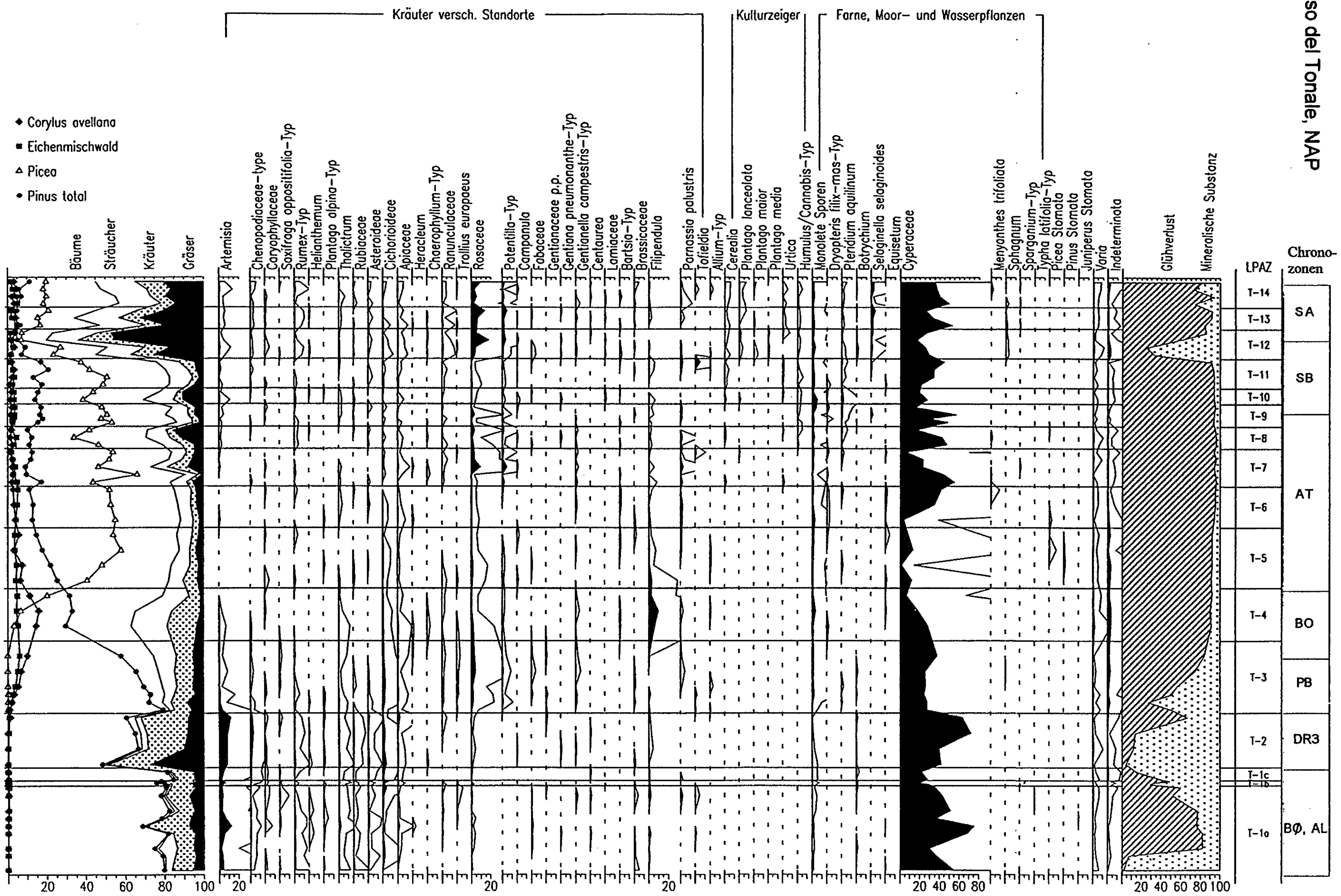
Passo del Tonale (1883 m ü. M)

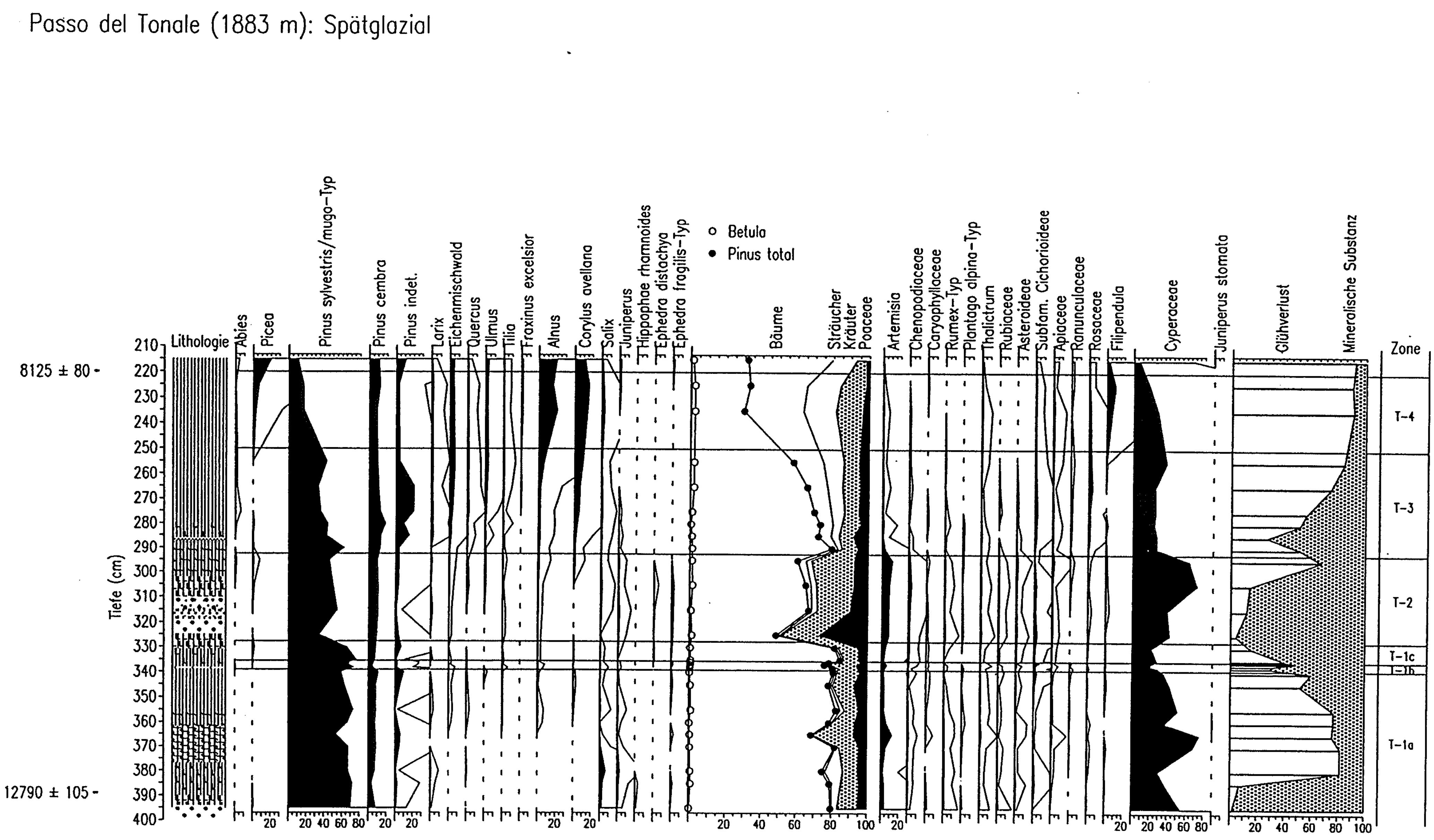
Analysiert: Regula Gehrig



Pollendiagramm Passo del Tonale

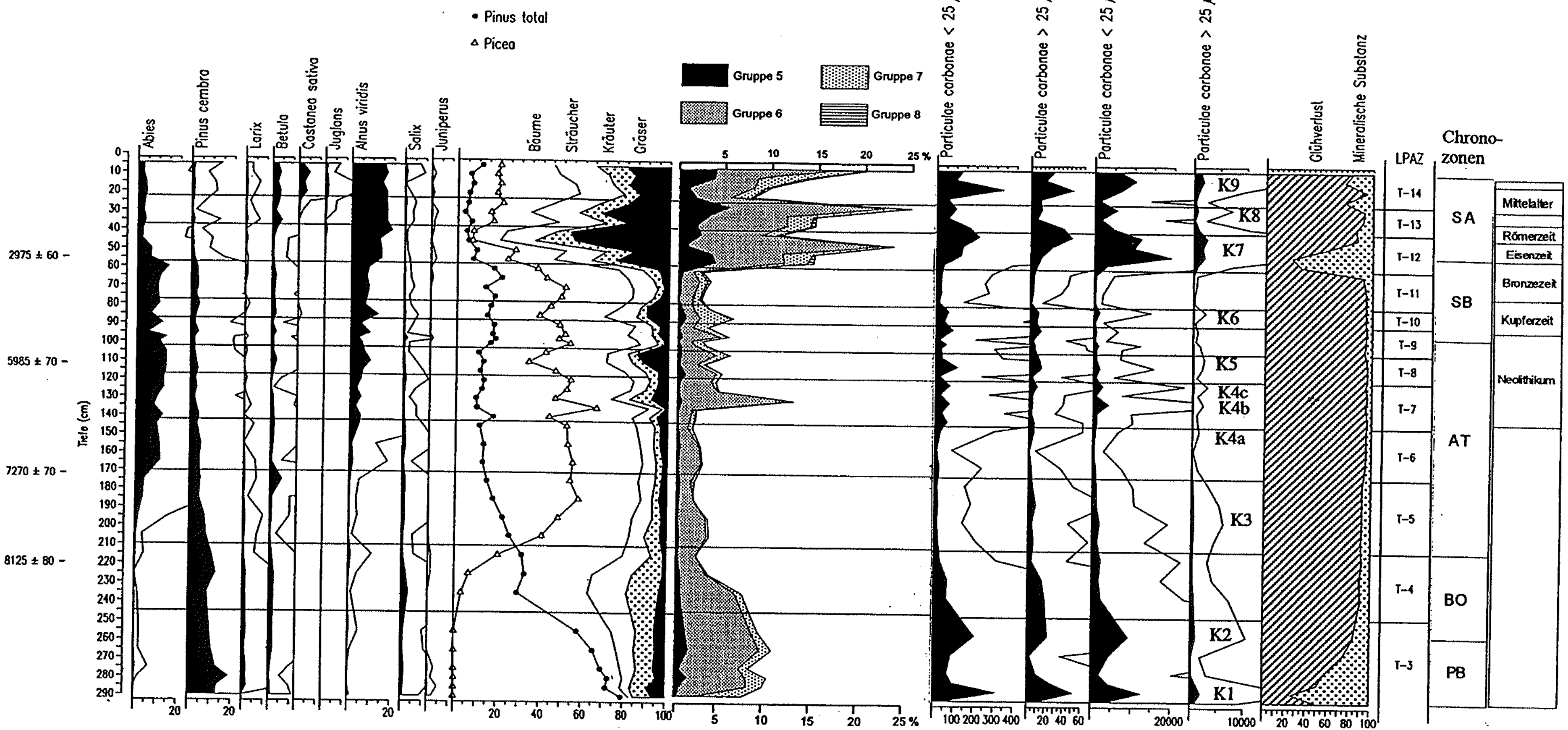
Passo del Tonale, NAP





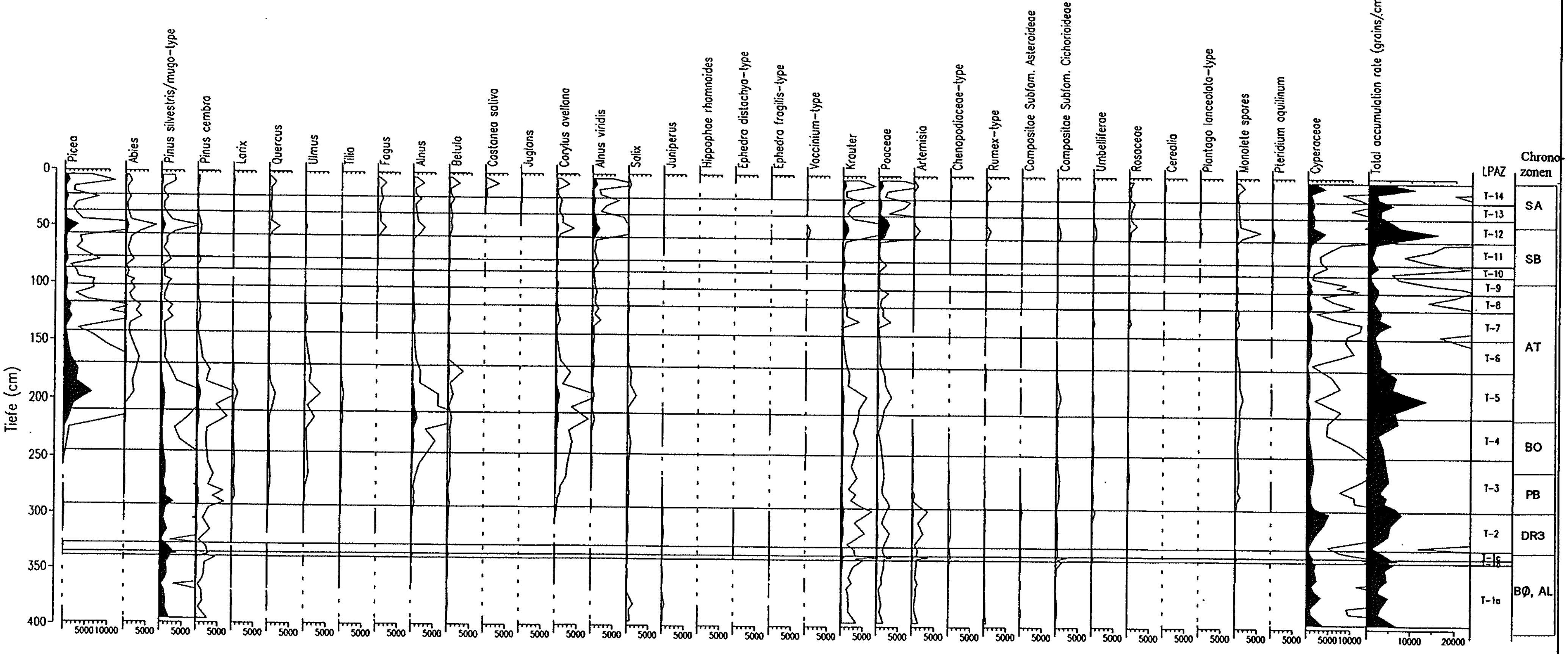
Spätglazialdiagramm Passo del Tonale

Passo del Tonale: Kulturzeiger

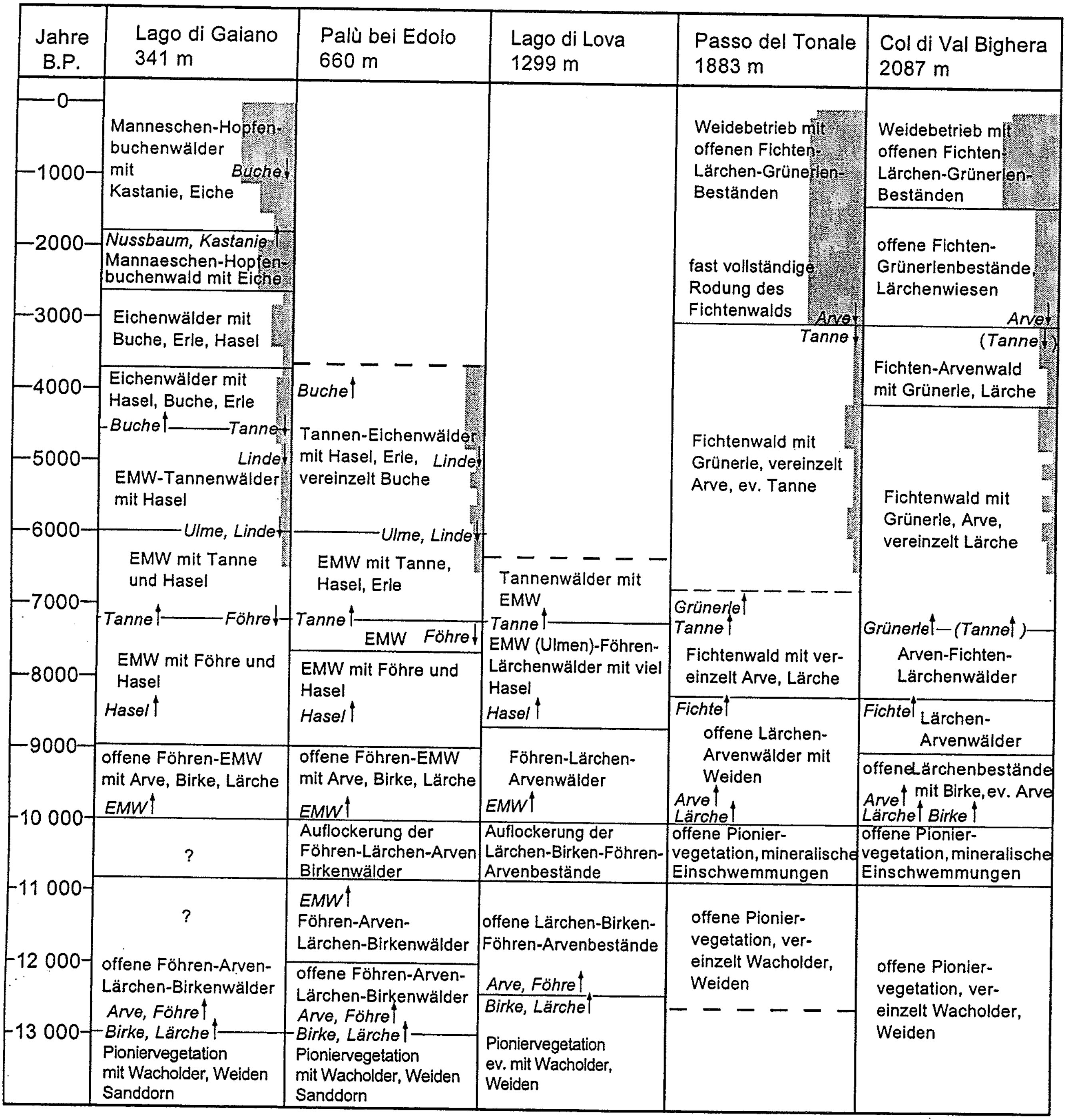


Kulturzeiger-Diagramm Passo del Tonale
Gruppe 5: Weidezeiger, lichtliebende Arten
Gruppe 6: Artenreiche Familien aus Rasen und Weiden mit beschränkten Aussagemöglichkeiten als Weidezeiger
Gruppe 7: Ruderalpflanzen und Kulturzeiger aus tieferen Lagen
Gruppe 8: Cerealia

Passo del Tonale: Influx

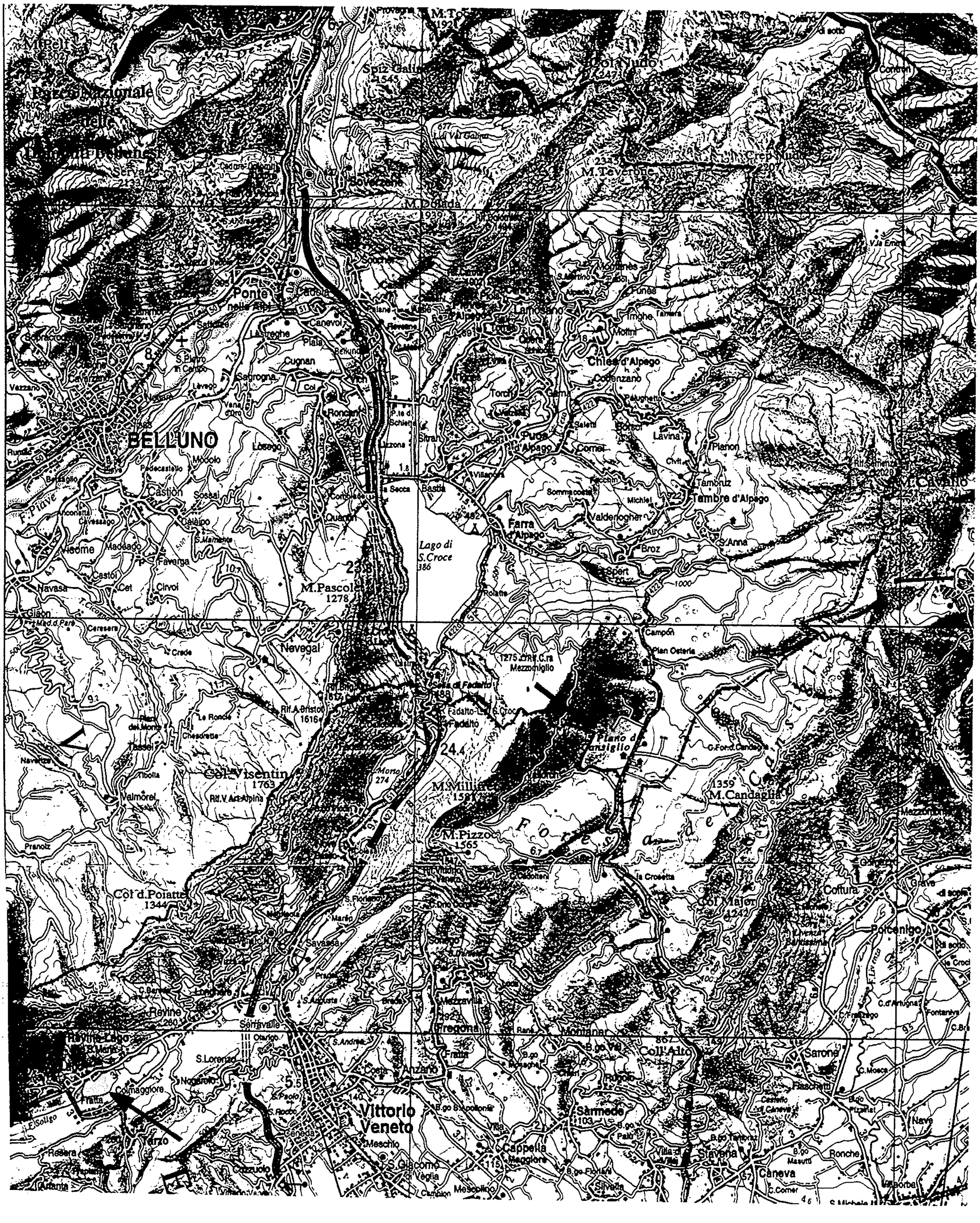


Influx-Diagramm Passo del Tonale



Vergleich der Vegetationsentwicklung in den Polllendiagrammen des Val Camonica. Die grau schattierten Flächen zeigen den anthropogenen Einfluss: je breiter die Fläche, umso stärker ist der menschliche Eingriff in die Vegetation.

PIAN DI CANSIGLIO
and
LAGO DI REVINE (224 m asl)



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A new late glacial to early Holocene palaeobotanical and archaeological record in the Eastern Pre-Alps: the Palughetto basin (Cansiglio Plateau, Italy)

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ABSTRACT: A late glacial to early Holocene lacustrine and peat succession, rich in conifer remains and including some palaeolithic flint artefacts, has been investigated in the Palughetto intermorainic basin (Venetian Pre-Alps). The geomorphological and stratigraphical relationships, ^{14}C dates and pollen analyses allow a reconstruction of the environmental history of the basin and provide significant insights into the reforestation and peopling of the Pre-Alps. The onset of peat accumulation is dated to 14.4–14.1 kyr cal. BP, coinciding with reforestation at middle altitudes that immediately post-dates the immigration of *Larix decidua* and *Picea abies* subsp. *europaea*. Plant macrofossils point to the expansion of spruce about 14.3 kyr cal. BP, so far one of the earliest directly dated in the late glacial period of southern Europe. The previous hypothesis of an early Holocene spruce immigration in the Southern Alps from Slovenia needs reconsideration. Organic sedimentation stopped at the end of the Younger Dryas and was followed by the evolution of hydromorphic soils containing lithic artefacts, anthropic structures and wood charcoal. The typological features of the flint implements refer human occupation of the site to the end of the recent Epigravettian. Charcoals yielded dates either consistent with, or younger than, the archaeological chronology, in the early and middle Holocene. Copyright © 2000 John Wiley & Sons, Ltd.

KEYWORDS: vegetation history; archaeology; late glacial; Eastern Pre-Alps.

Introduction

Studies on the environmental and climatic history of the Eastern Alps from the Last Glacial Maximum (LGM) to the Holocene are commonly incomplete because of the rarity of well-preserved deposits at middle and high altitudes and the lack of high-resolution records with an adequate set of radiometric dates (see Schneider (1985) and Sercelj (1996) for a comprehensive overview). In the Italian Pre-Alps karstic development is an important geomorphological process that strongly affects the formation and preservation of lacustrine and peat-filled basins. Some problems are not yet solved, above all the stages of late glacial reforestation and the effects of the Younger Dryas event (YD) in intermediate elevation montane environments and its influence on the Epigravettian peopling of this region. Regarding this last point, the reconstruction of settlement patterns suffers from lack of sites and the impoverishment of the archaeological records, which have been greatly affected by post-depositional processes. Uncertainty in placing the cultural boundary between the Upper Palaeolithic and Early Mesolithic represents a further problem, for this transition is not yet documented by radiometric dating and relevant archaeological evidence.

A contribution to the late glacial environmental history and the peopling of the Pre-Alps is provided by palaeobotanical and archaeological finds recovered during excavations at an Upper Palaeolithic site on the Cansiglio Plateau (Venetian Pre-Alps, Figs 1 and 2). The geo-archaeological

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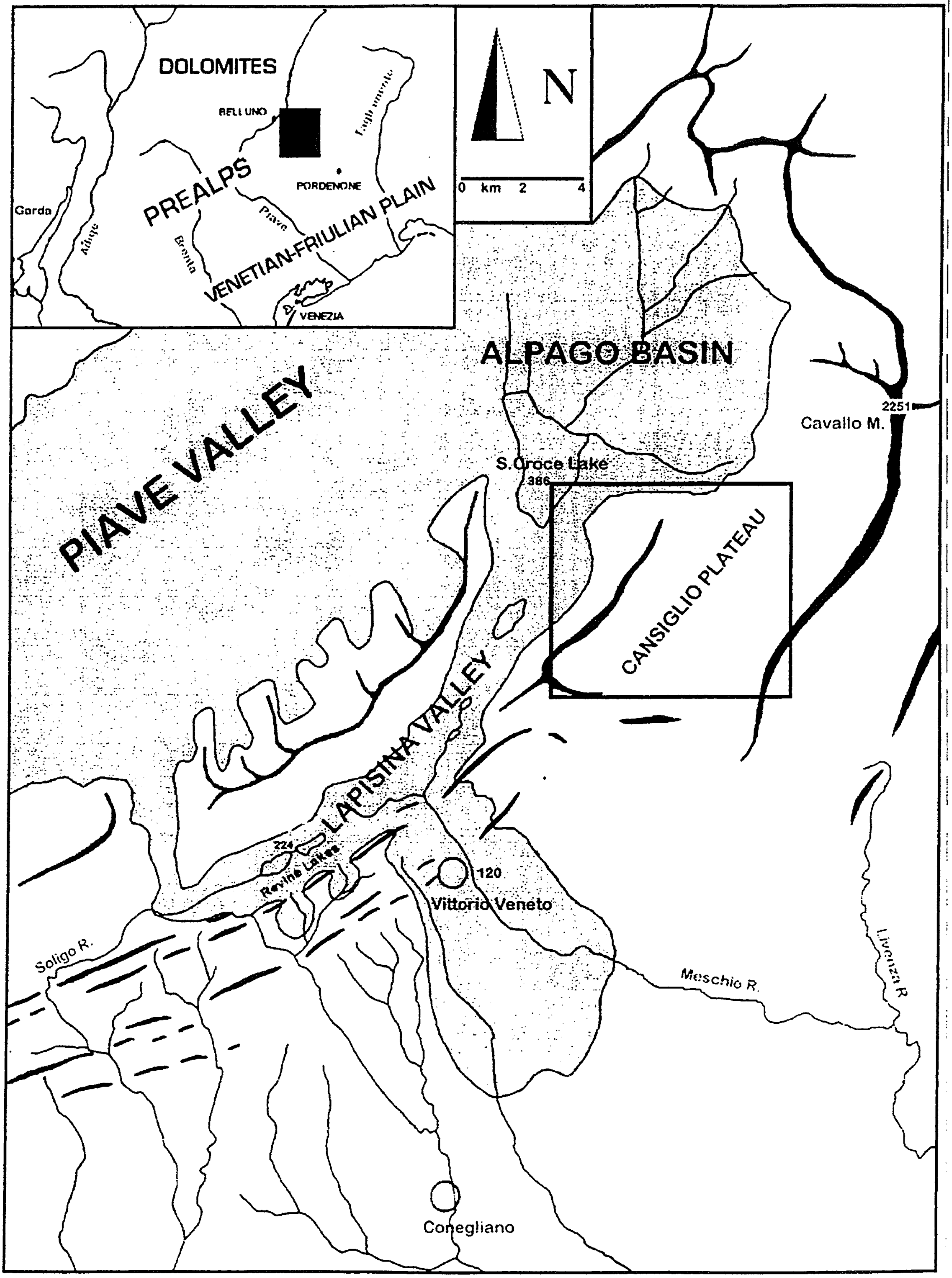

Figure 1 Map of a part of Venetian Pre-Alps showing the extent of the Piave glacier (shaded) during the LGM (after Casadoro *et al.*, 1976; Mantovani *et al.*, 1976). The inset shows in black the location of the larger map within the region. The rectangle shows the area covered by Fig. 2.

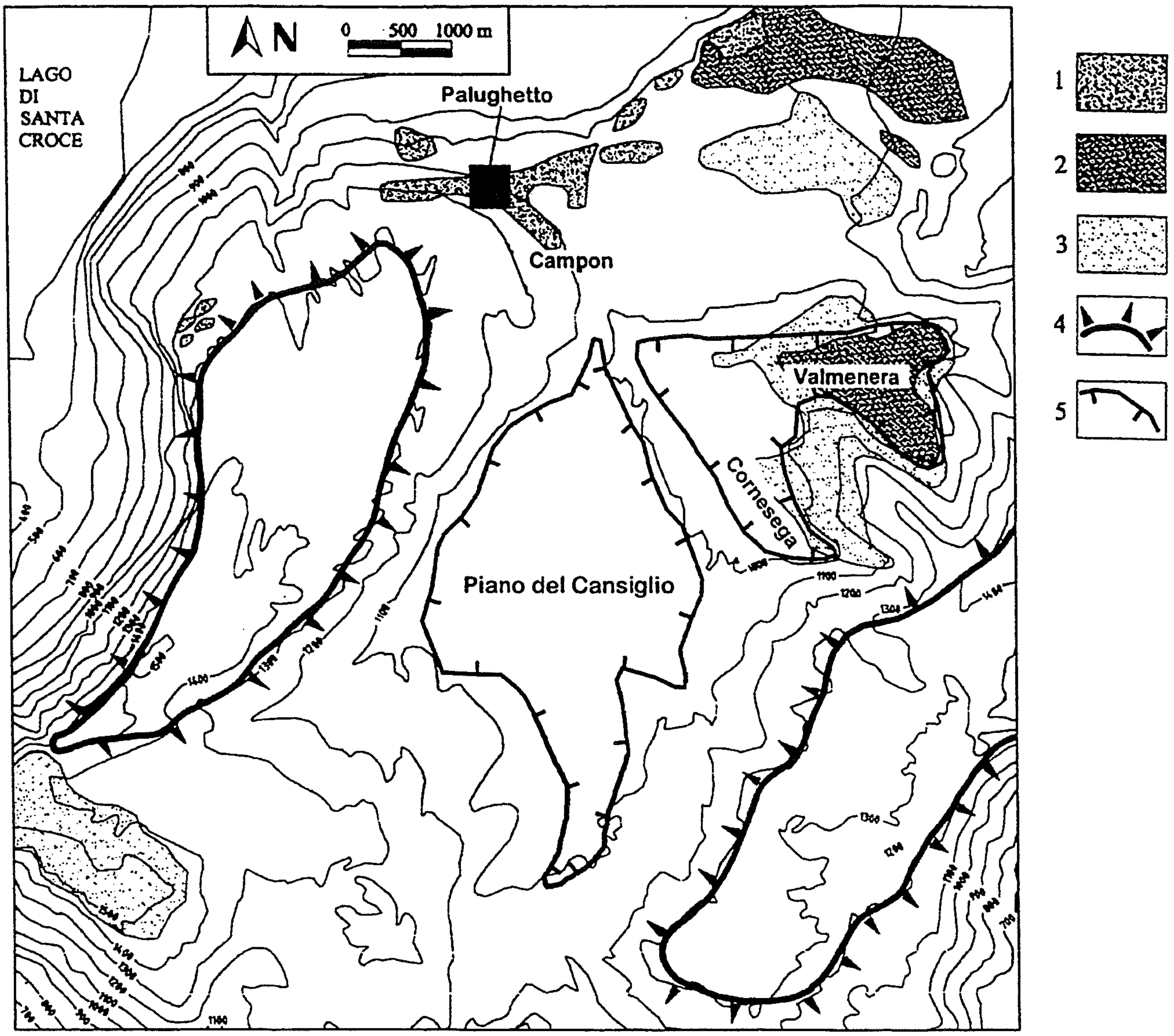

Figure 2 Simplified geological-geomorphological map of the Cansiglio Plateau showing the distribution of glacial units belonging to the LGM and related periglacial deposits. Key: 1, Piave glacier till; 2, local glacier till; 3, loess cover > 1 m thick; 4, border of morphotectonic slope; 5, polje and main *uvala*.

investigation was first made in 1993–1994 at a site with Palaeolithic artefacts discovered in 1985 by M. Cremaschi. This site lies on the top of a small hill next to a bog (the Palughetto basin, Figs 3 and 4). In 1995 and 1997 the excavation was supplemented by palaeobotanical analyses. This paper describes and discusses the geomorphological features, stratigraphy, ^{14}C dating and plant and archaeological remains. A preliminary environmental history of this area is proposed, emphasising the scientific potential of the Palughetto record and its implications for future regional studies.

Methods and nomenclature

We adopt here the late glacial and Holocene chronostratigraphical subdivisions proposed by Mangerud *et al.* (1974) and Mangerud (1982). Radiometric dates are presented both as conventional (^{14}C yr BP) and calibrated ages according to Stuiver *et al.* (1998). Archaeological evidence follows the chronocultural subdivisions of the Late Upper Palaeolithic and Early Mesolithic by Broglio (1992).

The succession at Palughetto was described and sampled by means of several trenches, pits (1 m^2) and boreholes (Fig. 4). Two NW–SE trenches, one 16 m long (trench 94) and a shorter one (trench 97), were excavated to investigate the soil stratigraphy of the moraine (B) slope and the basin boundary. Additional information was provided by three pits dug in the marginal part of the peat-bog (PIT 94, PIT 95 and PIT 97) and by cores taken with a Russian sampler (DRILLING 99). Pedological features have been described according to FAO (1990) and Sanesi (1977) guidelines; colours refer to Munsell Soil Colour Charts.

The pits were dug to sample peat layers about 3 cm thick in order to examine the stratigraphical distribution of cones, seeds, branchlets and needles. One wall of each pit was prepared to remove a column with a tin box of 10 × 10 × 50 (or 100) cm. Organic material to be dated was also collected from the same column or during the excavation of the pit. Pollen analysis was carried out on a section of the PIT 95 column. Samples at 1 cm intervals were treated with HCl, HF and warm HCl, and were acetolysed and

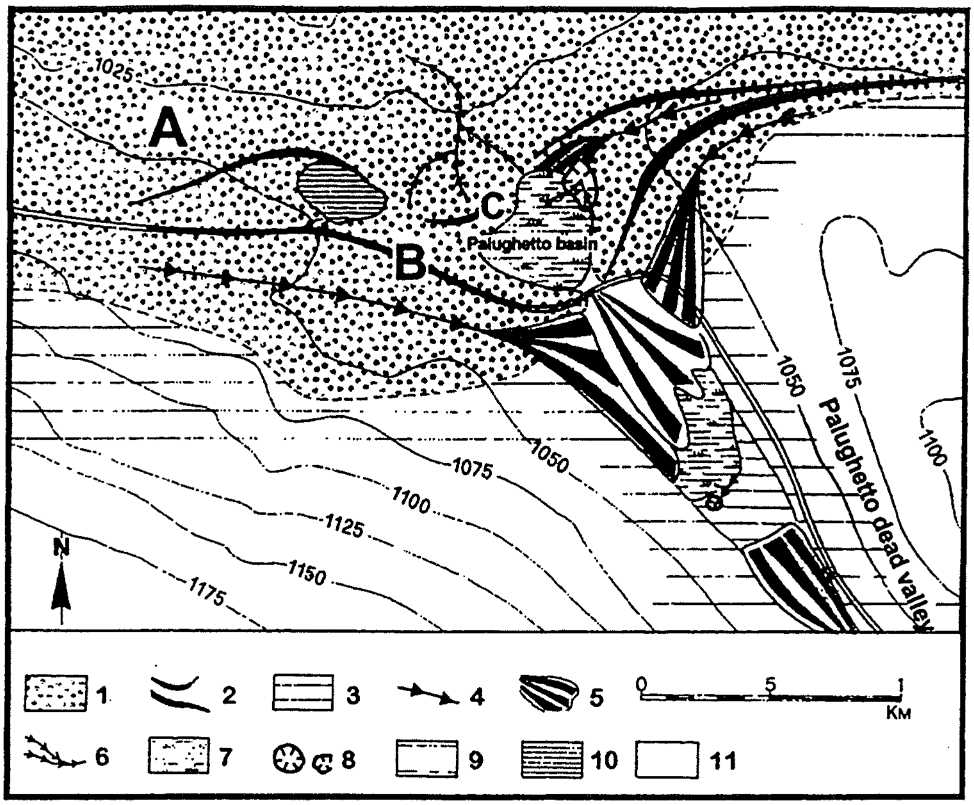

Figure 3 The Palughetto area with the three glacial episodes (A, B and C) recognised. Key: 1, glacial deposit; 2, moraine ridge; 3, eluvial–colluvial and slope waste deposit; 4, fluvioglacial stream trace; 5, fluvioglacial fan; 6, present-day drainage; 7, silty clay and peat deposits; 8, dolines and sinkholes; 10, bedrock (survey by R. Avigliano, drawn by F. Nalin).

mounted in glycerine. The minimum pollen sum was 400 grains. During the archaeological investigation within the peat bog, wood charcoal and artefact positions were referred to the fundamental grid (1 m^2). Sediment was wet-sieved (2 mm mesh size) to collect charcoal and smaller artefacts.

The Cansiglio Plateau: main geographical and geomorphological features

The Cansiglio Plateau lies in the Eastern Venetian Pre-Alps (Fig. 1) above the Venetian–Friulian Plain to the south and the Lapisina valley to the West, the Alpago Basin to the north and the Cavallo Mountain (2251 m a.s.l.) to the northeast. The plateau has a subrectangular shape, extending along a NE–SW axis, with one main central depression, the Piano del Cansiglio, around 1000 m a.s.l., regarded as a *Gesteinsgrenzenpolje* (Lehmann, 1959), and smaller depressions (Cornesega Bassa and Valmenera) at around 900 m altitude (Fig. 2). Smooth ridges rising to about 1300–1400 m border the plateau. Palaeogeographical placement of the Cansiglio massif was on the western border of the Jurassic–Cretaceous carbonaceous Friulian Platform. On its lower part it consists of a Late Jurassic inner platform calcareous sequence (Calcare del Cellina; Oxfordian–Albian), followed by open platform calcareous deposits (Calcari del Cavallo; Cenomanian–Senonian) (Cancian *et al.*, 1985). During the Upper Cretaceous this sector of the carbonaceous Friulian Platform drowned and was partially covered by basin terrigenous sequences represented by the Scaglia and Flysch facies (Sartorio, 1987; Antonelli *et al.*, 1990). As in other carbonaceous prealpine plateaux, the Cansiglio morphological features show deep tectonic and karstic influence.

The LGM ice advance (Fig. 1) marginally affected the Cansiglio Plateau. The ablation till at its northern edge can be referred to the Piave valley glacier (Castiglioni, 1964; Di Anastasio, 1995), one of the largest in the Eastern Alps (Brückner, 1909; Dal Piaz, 1896; Dall'Arche *et al.*, 1979; Pellegrini, 1979; Surian, 1996), and to a local glacier originating in the Cavallo Mountain (Fig. 2).

The south-facing slopes of the ridges surrounding the Piano del Cansiglio, as well as the doline bottoms, are extensively covered by brownish silt-loams rich in quartz and micas, regarded as loess and loess-like sediments (Fig. 2) (Di Anastasio, 1995). Silt-loam deposits consisting of reworked older palaeosols and loess cover the *Gesteinsgrenzenpolje*.

The Palughetto site

Geological and geomorphological background

The toponym 'Palughetto' refers to a basin situated on the northern edge of the Cansiglio Plateau (Fig. 2) between 1030 and 1040 m a.s.l., on the left side of the Perosa stream valley, just at the northern extreme of a short cut (the 'Palughetto dead valley') between Campon and Palughetto (Fig. 3). This valley is NW–SE orientated and separates Col Campon to the east from Lama del Porzel to the west. At present it is not crossed by any stream. The origin and evolution of the 'Palughetto dead valley' will not be considered here. Castiglioni (1964) claims fluvial processes for its formation.

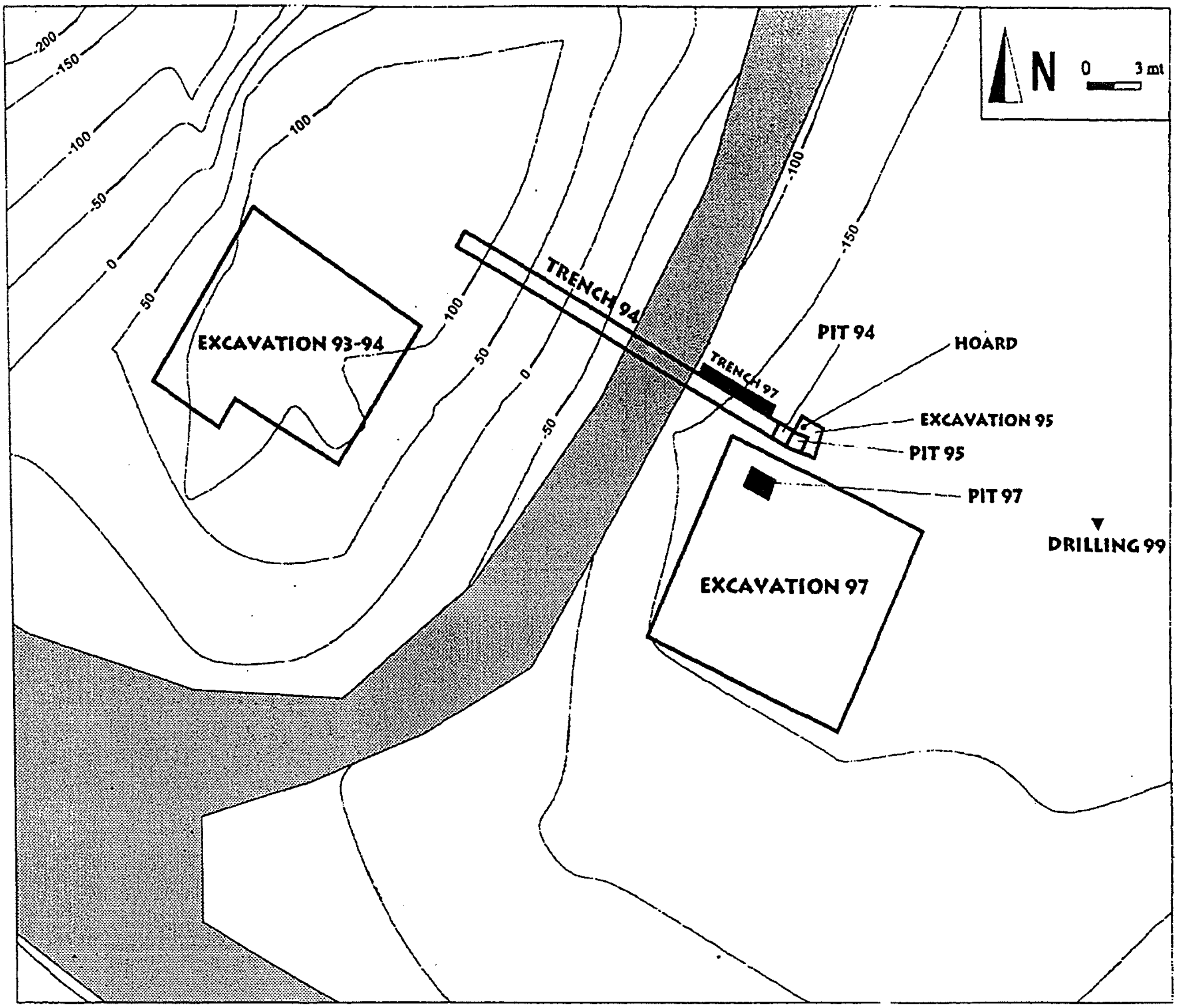

Figure 4 Map of the northern part of the Palughetto basin showing the position of the trenches, pits, boreholes and excavations undertaken between 1993 and 1999. The find spot of the hoard of unworked flints is also indicated.

The superficial deposits and landforms of Palughetto are attributed to the Piave glacier. It is possible to recognise at least three episodes (called A, B and C in Fig. 3) and their related glacial and fluvioglacial sediments. Two well-preserved moraine ridges are referred to the C (younger) and B (intermediate) episodes; the latter and outer contains an incision probably produced by water excavation on the east flank of the Palughetto dead valley.

The older A episode is represented by diffuse altered diamicton containing 'allochthonous' rocks (quartzites, sandstones, volcanoclastic sandstones, quartzitic phyllites, siltstones, mica schists, igneous rocks, chert nodules) typical of the Piave alpine basin.

Some fluvioglacial landforms may also be attributed to B and C episodes. They consist of clast-supported gravels with lithologically different pebbles (quartzite, schist, sandstone and carbonate) and sand. Channels and alluvial cones beyond the moraine ridges provide evidence of glacial meltwater. Outside the moraine ridge B two fans fed by fluvioglacial streams are visible. A lobate and partially terraced cone, probably a flowtill, is present between the streams. Beyond the fan there is a flat area with impermeable fine deposits on which peat accumulated. Silt-loam non-calcareous slope deposits with abundant micas gently join the bottom of the Palughetto dead valley.

The shaping of the Palughetto basin must probably be attributed to the C episode, when the moraine ridge dammed the area to the north (Fig. 3). Karst greatly influenced the superficial hydrographic pattern and favoured a limited reshaping of the landforms. The basin was partially drained by a sinkhole at the northeastern edge, which determined a drainage pattern that forms an anomalous funnel shape to the basin. A similar, but smaller, pattern (perhaps due to the lithology of the deposits) occurs in the centre of the Palughetto dead valley, where a line of small dolines corresponds to a change in the valley-bottom gradient.

The stratigraphical sequence

As shown in Fig. 5, trench 94 exposed a steep contact between moraine and the basin fill, which unconformably overlies a basal diamicton and gently inclines southeastwards, rapidly thickening towards the inner basin. The

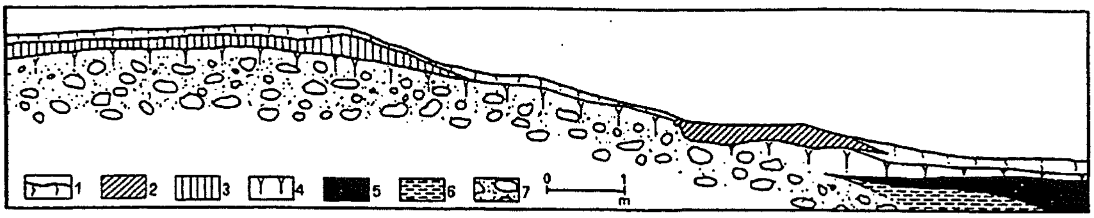

Figure 5 Simplified section between the moraine slope and the basin margin. Key: 1, topsoil; 2, road; 3, recent anthropogenic deposits; 4, truncated palaeosol in diamicton and weathered silt; 5, peat; 6, silty clays; 7, till.

basin fill can be subdivided into three main groups of litho- and pedostratigraphical units (Fig. 6).

The lower clay-silt deposits (units T14-T11)

The lowest unit (T14) consists of light-grey clayey silt and silt laminae rich in detrital carbonate, forming horizontal couplets several millimetres thick. Rare striated pebbles or even decimetric blocks lithologically exotic to the Cansiglio are embedded in these deposits. No plant remains were observed. Unit T14 is covered by a dark-grey silt (unit T13) with thin discontinuous sandy laminae a few millimetres thick. Unit T12 is a massive light-grey clay poor in organic matter with sporadic dwarf pine (*Pinus mugo*) cones. Unit T11 shows a gradual coarsening from silty clay to silt, with discontinuous sandy laminae and organic matter increasing upwards (thin organic debris, sporadic birch leaves and larch cones still in connection with their bearing branchlets, sporadic dwarf pine cones). At its top are thin laminae rich in organic debris, i.e., deciduous leaves (*Alnus* and *Betula*) and conifer needles (*Larix*). Units T13–T11 are non-calcareous. The upper contact with the overlying organic deposits is transitional. This boundary is about 5 cm thick, gently inclining to the inner basin, and is marked by a rapid increase in leaves and cones and other organic debris. At its base is a thin discontinuous silty–sandy–peaty level containing larch cones with abraded scales.

The middle organic deposits (units T10-T7)

A thick organic layer extends above the clay–silt succession throughout the basin. This layer is about 60 cm thick in the marginal part of the basin (PIT 95 and PIT 97), but increases to more than 180 cm in the centre (Fig. 5). The base layer is an organic mud (gyttja) rich in plant debris (conifer needles, Characeae oogones, mosses, sporadic cones), and is overlain by autochthonous peat deposits, extremely rich in conifer needles, cones, twigs, and wood, *Betula* and *Alnus* catkin scales and seeds (Di Anastasio *et al.*, 1998). Three units have been distinguished (T10 to T7) on the basis of peat composition and degree of decomposition. Unit T10 (15–20 cm thick) is a moderately humified litter (i.e. humositas level 3 according to von Post (1924; in Aaby, 1986)) consisting of needles and very rich in cones and branchlets. *Larix decidua* is the main peat-forming plant. Unit T9 (35–45 cm thick) is a highly humified peat consisting of wood, bark, branches, roots, needles, fruits, and thin interbeds rich in mosses. Cones, abundant at the base, become rare in the uppermost part. Vegetative parts of trees (both conifers and broad-leaved plants) are abundant throughout unit T9, but its middle part is dominated by woody material, such as branches, compressed trunks and *in situ* stumps. Unit T8 is a thin layer (about 3 cm thick) of reddish little-decomposed laminated moss-peat rich in *Picea* and *Larix* needles, covering unit T9 with a sharp boundary. Unit T7 consists of a thin layer (2–5 cm thick) consisting of moderately decomposed *Cyperaceae*-peat, laminated, including sporadic *Picea* needles and *Larix* branchlets at its base. It gradually thickens towards the basin centre, where it is in direct contact with the overlying unit T5.

The upper palaeosols

The upper part of the succession shows several pedogenic features. At its base a sharp, strongly undulating boundary separates units T7 and T6 (Figure 7). The boundary surface has frequent circular and elongated depressions, sometimes large and arranged horizontally on the surface, often formed as casts of decomposed wood remains (trunks and branches) (Figs 8 and 9). Unit T6, a grey clay silt with rarely preserved plant remains (*Picea* needles and charred particles), shows well-developed hydromorphic features with fine organic matter increasing upwards (Fig. 8). It forms a wedge-shaped layer thinning towards the basin centre, where it disappears: cores show unit T7 directly overlapping unit T5. Its archaeological content will be discussed later. Unit T5 is a massive clay bed, 20–30 cm thick, covered by four thin layers of organic silt (units T4 to T1). Unit T4 contains modern remains (sixteenth to eighteenth centuries).

Radiocarbon dating

Table 1 reports ^{14}C ages obtained on charcoal, plant remains (branches, cones) and bulk peat. Samples PL61, PL75–80 and PL107 are from the PIT 94 column, and PL52, PL67–69, PL96–97 and PL111 are from the PIT 95 column (Fig. 10). Sample PL130 was collected during the PIT 97 excavation in unit T11. As PITS 94 and 95 are adjacent to each other (Fig. 4), a simple visual correlation allowed the definition of the stratigraphical succession of dated layers. The discussion of calibrated ages (according to Stuiver *et al.*, 1998) is restricted here to the time after 12.2 kyr ^{14}C BP. In the older part of the record the occurrence of a radiocarbon plateau makes the calibration precision too weak to provide information valuable for detailed calendar-age calculation (Stuiver *et al.*, 1998).

The eight samples collected from the pits show a sequence of calibrated ages consistent with their stratigraphical position. This set places the dated succession between the beginning of the Bølling and the Preboreal chronozones. The age ranges provided by three samples in a 10 cm

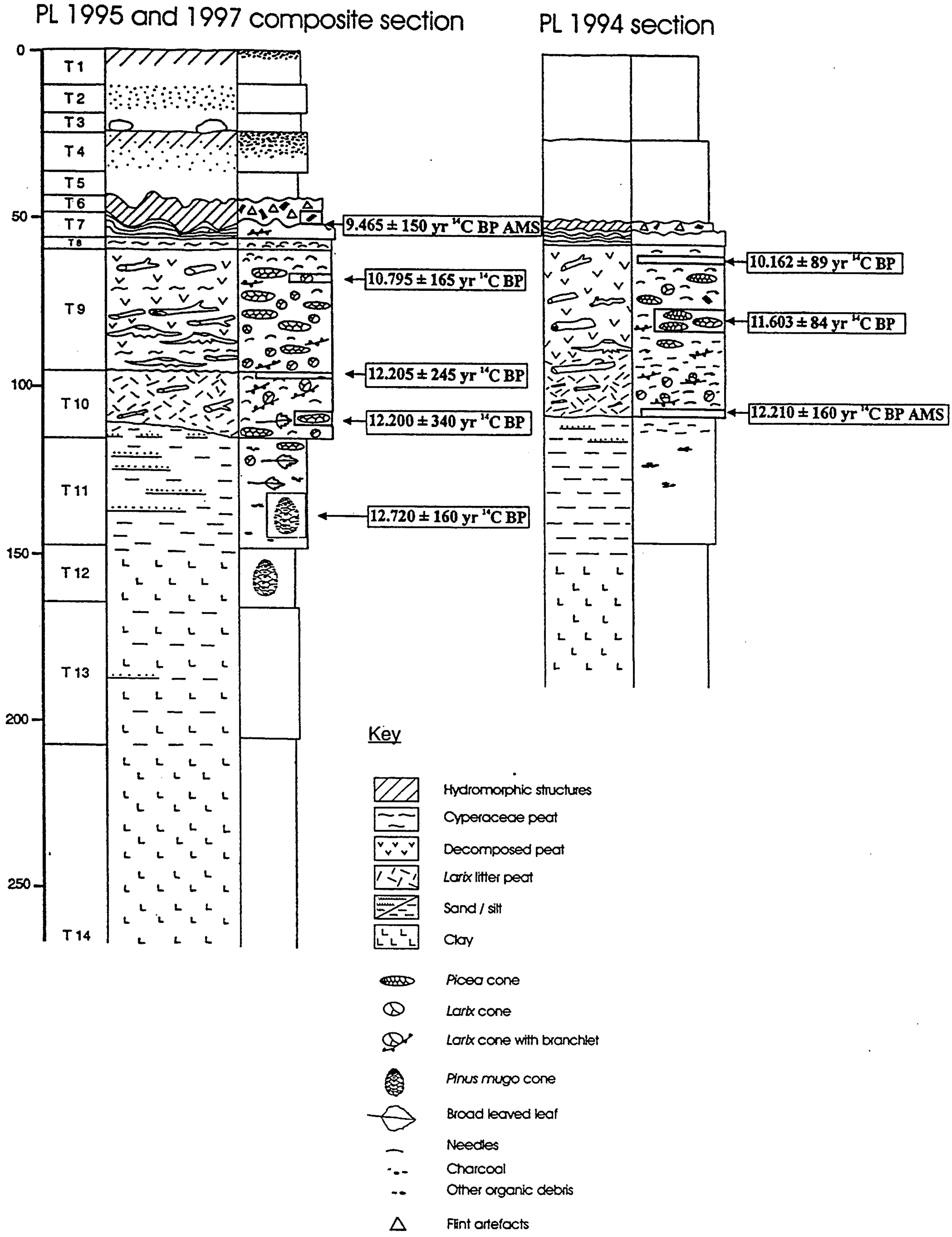

Figure 6 The stratigraphical succession of the northern border of the Palughetto basin (PITS 94, 95 and 97, stratigraphical units T12 to T1). The positions of ^{14}C samples are indicated.

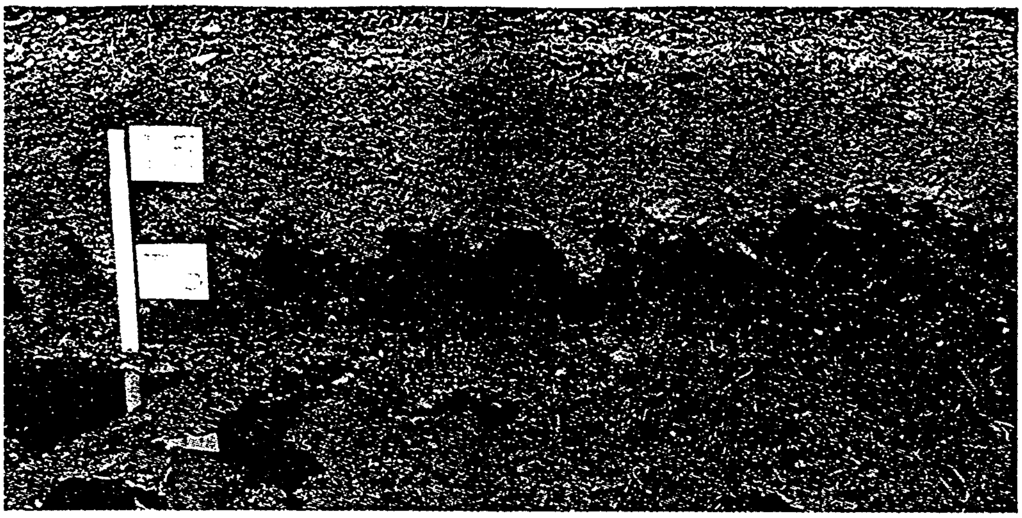

Figure 7 Detail of the boundary between units T6 and T5. Note the undulating boundary on the face and the upper surface of the underlying unit T7 on the ground.

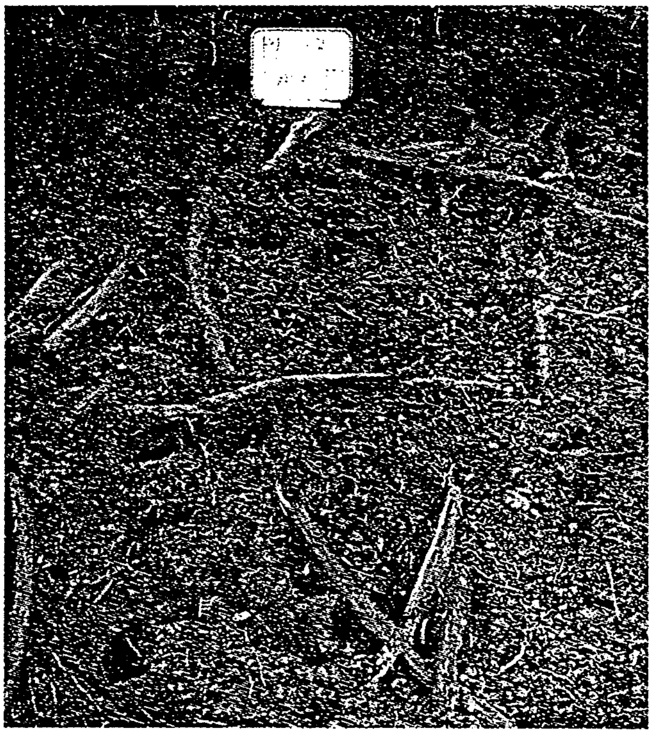

Figure 8 The basal surface of unit T6 showing *in situ* roots and stumps, trunks and branches.

Figure 9 The morphology of the upper surface of unit T7—strongly affected by bioturbation—as observed after removing the woody material at the base of unit T6. Note on the section face unit T6 overlapped by unit T5.

sublayer of the basal peat (GX-20588, GX-21230 and H-4757) are largely overlapping. A chi-squared test of differences among them revealed that they are compatible with a single-sample population. This allowed the calibration of the average of these dates. In Fig. 11 the relative area under the probability curve for the average is calculated (Stuiver *et al.*, 1998). Three different ranges are intercepted (1 sigma ranges), but the interval 12412–12080 yr cal. BC (mean uncalibrated age: 12174 yr ^{14}C BP) covers 0.61 relative area. This is the best age estimation so far available for the beginning of peat accumulation at the Palughetto site.

The seven ages from unit T6, collected in PIT 95 and in different squares of the 97 excavation (Fig. 10), cannot be placed in a stratigraphical sequence. Two types of material have been dated: charcoal and wood. The five charcoal samples yielded dates covering a wide range: the oldest one (GX-21231) was obtained from a single charcoal fragment collected in the lower part of the unit and therefore gives a minimum age for its deposition. The remaining dates are distributed between 8159 and 5085 yr BC, within a time span younger than calibrated GX-21231. Their intervals only partially overlap. Together these dates fall within a wide time span of more than 4400 yr during the early–middle Holocene. Contamination from younger deposits seems unlikely because the xilothomic determination (A. Maspero, personal communication) did not reveal the presence of tree species present in this area during middle–upper Holocene (Culiberg *et al.*, 1981; Kral, 1982, 1989) and/or presently dominating the forest vegetation (*Abies* and *Fagus*). We suggest the charcoal incorporation in unit T6 occurred during a long, intermittent human occupation. Unfortunately the cultural context of this phase cannot yet be defined (see the following section).

The R-3107 and R-3108 dates (respectively S1 and S2 in Fig. 10) are from wood collected at the base of unit T6. They range from the Allerod to the YD chronozones and are even older than R-2587, which was taken below unit T6. This stratigraphical incoherence may be explained by considering several mechanisms that may place wood of different ages in the same stratigraphical position: (i) fallen trees may be rooted at different depth; (ii) fallen trees may

Table 1 The series of radiocarbon dates from the Palughetto bog. The first four columns refer to the stratigraphic position of the samples (see methods). Samples measured at the laboratory in Rome were pre-treated following the standard procedure (HCl–NaOH–HCl). Appreciable quantities of humic acid were observed and eliminated, then the residual organic matter was burnt. The samples were stored in glass containers for more than one month, with the aim of removing radon gas traces by natural decay. Conventional ages were obtained by comparison with ANU (Australian National University) Sucrose Standard; background is measured routinely using CO_2 from a stock of Carrara Marble previously tested (IAEA, 'Consultants' Group Meeting on ^{14}C Reference Material for radiocarbon laboratories', Vienna, 18–20 February 1991).

Sample code and stratigraphic references				Field unit	Material	Species	Laboratory code[a]	Conventional age (^{14}C yr BP)	Calibrated range (cal. yr BC)[b]	δ ^{13}C (‰)
PIT 94	PIT 95	PIT 97	EXC. 97							
			sq. G7	T6	Charcoal	Undetermined	R-3130	6414 ± 203	5606–5085	−26.21
			sq. C4	T6	Charcoal	Undetermined	R-3129	7633 ± 85	6525–6420	−26.93
			sq. C5	T6	Charcoal	Undetermined	R-3122	8585 ± 75	7647–7554	−24.52
			Sq. I4	T6	Charcoal	Undetermined	R-3123	8800 ± 63	8159–7748	−26.49
	PL52			T6	Charcoal	Undetermined	GX-21231	9495 ± 150	9165–8608	−24.4
			S1 sq. C8	T6base	Branch	Undetermined	R-3107	10640 ± 95	10949–10475	−25.01
			S2 sq. I3	T6base	Branch	Undetermined	R-3108	11679 ± 91	11881–11520	−26.37
PL61				T9top	Peat		R-2587	10162 ± 89	10158–9617	−27.09
	PL67-69			T9	Peat		H-4755	10795 ± 165	11042–10696	
PL75-80				T9	3 cones	*Picea abies*	R-2591	11603 ± 84	11862–11494	−24.47
	PL96-97			T10	Peat		H-4757	12205 ± 245	13320–11898	
	PL111			T10	Cone	*Picea abies*	GX-21230	12000 ± 340	13174–11568	−25.2
PL107				T10base	Peat		GX-20588-AMS	12260 ± 160	13289–12128	
		PL130		T11	Cone	*Pinus mugo*	H-2148	12720 ± 160	13638–12442	

[a] Laboratory codes: GX for Krueger, H for Paris Orsai.

[b] Dates calibrated with INTCAL98 (Stuiver *et al.*, 1998) with 1σ ranges.

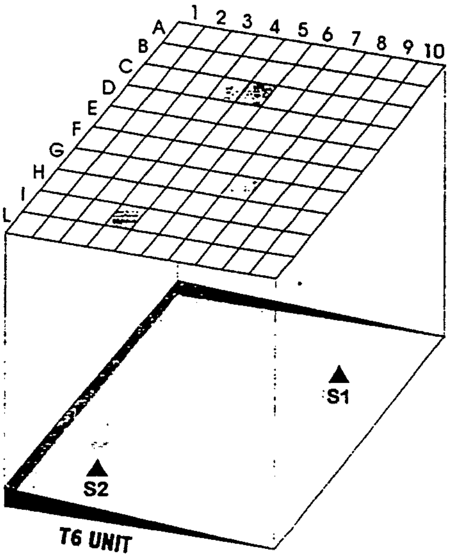

Figure 10 Schematic representation of the 97 excavation area with the grid system and T6 unit thinning towards the basin. The gray colour indicates the squares where the four charcoal samples submitted for ^{14}C measurement (R-3130, R-3123, R-3129 and R-3122) were collected. The positions of the two dated branches (S1 and S2, respectively, for dates R-3107 and R-3108) are also shown.

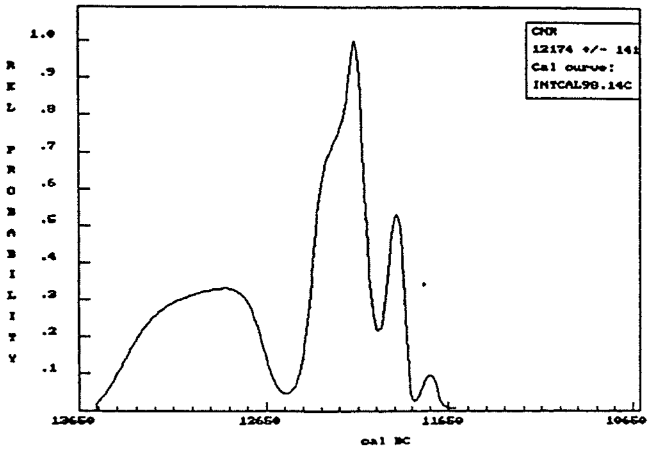

Figure 11 Normalised probability distribution for an average calibration of three radiocarbon dates from the basal peat of the Palughetto succession.

be of very different ages; (iii) trees may stand *in situ* even after death for hundreds of years, leaving woody portions on the bottom of unit T6. For these reasons, R-3107 and R-3108 ages are considered to be of little stratigraphical interest.

The archaeological data

Two archaeological sectors were identified in the area investigated, the first one on moraine B, the second one within the peat-bog near its northwest boundary (Fig. 4).

The 1993–1994 excavation on moraine ridge B yielded hundreds of flint artefacts recovered within a truncated Holocene brown alfisol developed on a matrix-supported massive diamicton. As post-depositional processes scattered the finds, it is not possible to define the stratigraphical relationships between the site and the evolution of the soil. Moreover, the number and seasonality of human occupations remain unknown, owing both to the weathering of the original palaeo-occupation floor and to the dissolution of animal remains. Techno-typological features of the lithic assemblage probably can be referred to the final phase of the recent Epigravettian (Peresani *et al.*, in press).

Investigations carried out in unit T6 brought to light several flint artefacts, one cache of flint tested for suitability (Fig. 12; for more details see Bertola *et al.*, 1997), and abundant charcoal fragments. In this situation, the preserved stratigraphical context is significant for the neighbouring open-air site, the dating of which remains problematic. The presence, however, among the artefacts, of retouched tools, armatures

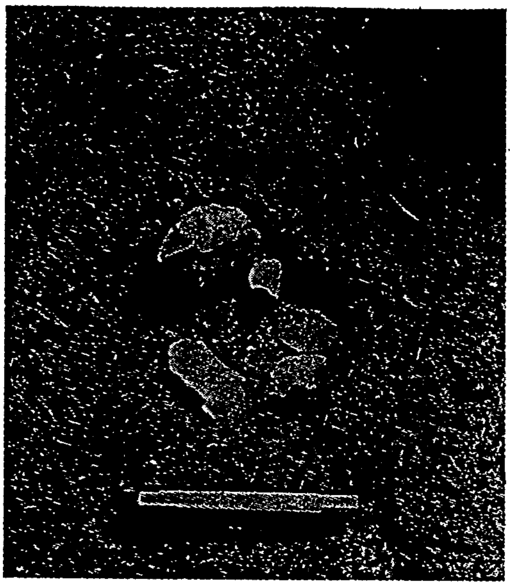

Figure 12 The hoard of unworked flint discovered in unit T6.

and microliths, as well as the technological features (bladelet production), seems to indicate a final phase of the recent Epigravettian. A correlation between the two zones of Palughetto seems to be probable, but it will be possible to confirm it only at the end of the investigation.

The GX-21231 date therefore is consistent with the cultural context of this lithic assemblage. Accordingly, although with some reservations, due to the small sample size, unit T6 may have yielded the first date for a final Epigravettian assemblage of northeast Italy. The measured time span falls within the interval defined by the oldest Mesolithic dates in the Trento Basin and in the Dolomites (Table 2), but it also could confirm Broglio's (1992) hypothesis that these industries may fall within a broadly defined time range encompassing the end of the YD and the beginning of the Preboreal. As regards the R-3122, R-3123 and R-3129 dates, they are consistent with several known Mesolithic site occupations (Sauveterrian and Castelnovian; Alessio *et al.*, 1983), but there is no archaeology of this age within the area investigated. Similarly, there are no archaeological remains associated with the R-3130 date (late Neolithic).

The record of conifer remains

We present here a report on the conifer record derived from the macrofossils collected during the excavation of PIT 94, PIT 95 and PIT 97, and from pollen analysis. Only the interval relevant to document the conifer immigration (i.e. 105–128 cm depth) is presented in the simplified pollen diagram (Fig. 13). A complete pollen record of the Palughetto section will be presented in a separate paper.

Pinus mugo Turra

Two cones of dwarf pine, perfectly preserved, were found in units T11 and T12 embedded in clay (Fig. 14). Cones are symmetric and display flattened scales. No other organic material was recognised in this unit. Dwarf pine colonised in the surroundings of the basin at the beginning of the Bølling chronozone, as indicated by the date (12720 ± 160 ^{14}C yr BP) on a *Pinus mugo* cone from unit T11. In the upper part of the section, *Pinus* is absent in the macrofossil assemblage. Its pollen percentage is meaningless for interpreting local and extralocal vegetation.

Larix decidua Miller

The macrofossil record of larch extends from the upper part of unit T11 up to the base of unit T6 (a small branch with brachyblasts). Larch cones are older than 12210 ± 160 ^{14}C yr BP (GX-20588), whereas the youngest branch has about the same age as the charcoal from unit T6, dated to 9495 ± 150 ^{14}C yr BP (GX-21231-AMS). The distribution and abundance of larch remains between units T11 and T7 show taphonomic variations along the section. The deepest fossils are branchlets, bearing perfectly preserved cones, and isolated cones embedded in silt in the upper part of the unit. Needles are not common in these sediments, but they were found 3–5 cm below the contact with the basal peat. Two cones recovered at the base of unit T10 lack their bearing branchlets and show strongly abraded scales. The lower part of the peat succession (unit T10) is composed of a poorly decomposed litter made up of larch needles and

Table 2 Set of dates available for the earlier Mesolithic of northeast Italy (sources: Alessio *et al.*, 1983, 1994).

Site	Field unit	Material	Laboratory code	Conventional age (^{14}C yr BP)	Calibrated age (cal. yr BC)
Romagnano III	IIIAE1–5	Charcoal	R-1146Aα	9580 ± 250	9254–8560
Romagnano III	IIIAE1–5	Charcoal	R-1146α	9420 ± 60	8785–8610
Romagnano III	IIIAE	Charcoal	R-1146B	9490 ± 80	9115–8634
Romagnano III	IIIAF	Charcoal	R-1147	9830 ± 90	9308–9223
Plan de Frea IV	3BIII	Charcoal	R-2565	9558 ± 90	9205–8741
Plan de Frea IV	3BIV	Charcoal	R-2715	9663 ± 392	9606–8479
Plan de Frea IV	3BIV	Charcoal	R'2713	9883 ± 68	9385–9250
Plan de Frea IV	5	Charcoal	R-2566	9377 ± 198	9116–8300
Colbricon 1		Charcoal	R-895α	9370 ± 130	8790–8344
Palughetto	T6	Charcoal	GX-21231	9495 ± 150	9165–8608

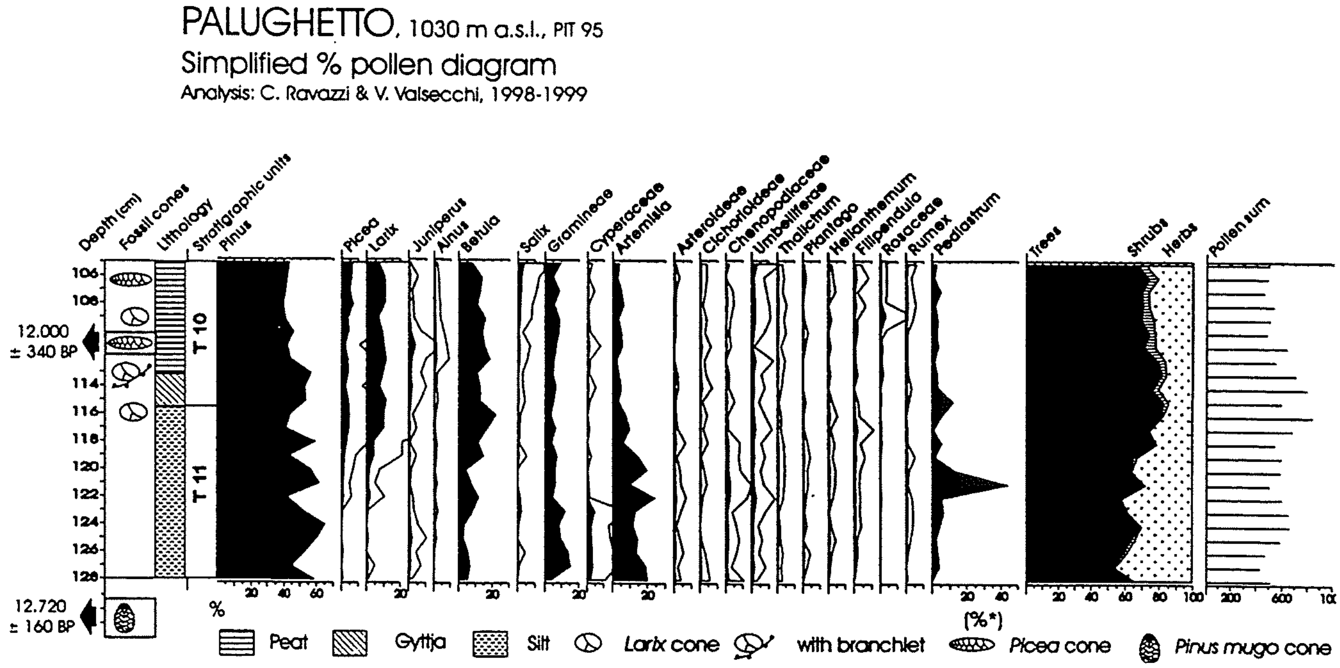

Figure 13 Selected percentage pollen curves from the top of unit T11 (silt clay) and T10 (lower part of organic deposits).

Figure 14 Photograph showing the dwarf pine cone dated 12720 ± 160 ^{14}C yr BP *in situ* in silt (unit T11, PIT 97).

branchlets with sporadic cones, perfectly preserved. The upper part (units T9 to T7) is still very rich in larch remains, but spruce and birch are also common in the macrofossil assemblage. The maximum larch-cone concentration is found in the middle unit T9 (about 0.5 cones per dm^3).

This macrofossil record of *Larix* indicates its local importance at the beginning of organic deposition on the border of the Palughetto bog. The pollen diagram suggests that at this time (i.e. levels at a depth of 116–114 cm in Fig. 13), *Larix* was dominant even in the extralocal vegetation. In fact, considering the overrepresentation of larch macrofossils and the underrepresentation of its pollen (de Beaulieu, 1977; Oeggl and Wahlmüller, 1992; Ammann and Wick, 1994; Lang, 1994), it seems that 40–45% *Pinus* pollen, 10–16% *Larix* pollen and 5–9% *Picea* pollen represents a *Larix* (or, possibly, *Larix–Pinus*) dominated vegetation in the Palughetto area.

On the other hand, the pollen and macrofossil record of *Larix* consistently suggests its presence in levels at a depth of 122–115 cm, shortly before the beginning of local organic deposition, as well as later at 12720 ± 160 ^{14}C yr BP.

Picea abies Karst

More than 50 cones have been analysed and identified as *Picea abies* var. *europaea* Jurkev. et Parf., according to the cone-scale shape and cone dimensions (Schmidt-Vogt, 1977; Schmidt, 1989). The stratigraphically earliest spruce cone was found in PIT 95 in the transitional zone between the clay silt (unit T11, upper part), 2 cm below the basal contact of the organic deposits. A perfectly preserved cone collected 5 cm above the basal contact of organic deposits (unit T10) in PIT 95, yielded a date of 12000 ± 340 ^{14}C yr BP (GX-21230). The calibration range of this age overlaps with those obtained for the bulk peat. As discussed previously, the interval between 12412 and 12080 cal. yr BC, provided by a calibrated averaged sample, most probably estimates the calendar age of the beginning of organic deposition and also of this spruce cone. This is one of the oldest late glacial macrofossil records of *Picea abies* Karst. directly dated so far in southern Europe. The only older macrofossil reports are from the Slovenian Pre-Alps, where a spruce trunk was dated to 18970 ^{14}C yr BP (Sercelj, 1981). The spruce pollen record from units T11 and T10 (Fig. 13) suggests that the beginning of peat accumulation was coincident with, or shortly later than, the immigration of spruce into the site (i.e. level 118 cm depth in Fig. 13). Upwards, spruce and larch pollen curves display similar increasing trends, but spruce is strongly subordinate. In the lower part of the peat succession (unit T10), spruce remains (small branchlets, needles, and cones) are consistent but sporadic, and cones are much more rare than larch (less than 0.1 cones per dm^3). They increase in unit T9 up to a cone concentration of about 0.3–0.5 cones per dm^3 in the middle of unit T9. Three cones from this level (i.e. 75–80 cm depth in PIT 94) have been dated to 11603 ± 84 ^{14}C yr BP (R-2591). Upwards, spruce dominates in the macrofossil assemblage, although only needles (no cones) were found above unit T9. Spruce needles are still abundant in the charcoal-rich level with flint artefacts, and they totally disappear at the base of the hydromorphic soil (unit T5) sealing the organic succession. We conclude that:

(1) spruce expanded into the site during the second half of the Bølling chronozone;
(2) it was a subordinate component of the larch forest on the lake shore at the beginning of peat accumulation;
(3) it was still present in the peat bog about 10.9–10.3 kyr cal. BP.

A preliminary reconstruction of the palaeoenvironmental history of the Palughetto basin

In spite of its marginal position with respect to the inner basin, the succession investigated nevertheless provides a detailed palaeoenvironmental data set and ages for the late glacial period in the Southern Pre-Alps. A preliminary reconstruction of the environmental evolution is proposed here; it is hoped that this will improve with further excavations and boreholes.

The oldest basin-fill deposits, exposed at the base of PITS 94 and 97, indicate rhythmic detrital sedimentation of thin clay and silt laminae, consistent with a lacustrine environment. Unit T14 may be interpreted as the result of seasonal fine carbonate detrital inputs washed from moraine B during the melting season. Pebbles embedded in unit T14 may have fallen from the moraine slope, accumulated on the frozen lake surface, rafted, and eventually dropped. Afterwards, sedimentation changed towards non-calcareous, partially laminated clay (units T13–T11), probably deposited under calm and poorly oxygenated shallow waters. Unabraded cones of dwarf pine, embedded in these deposits, document the occurrence of this plant in the surroundings about 12.7 kyr ^{14}C BP.

The typology of litter embedded in the uppermost unit T11 (unsorted, unwashed, unabraded and made of many different parts fallen from larch trees), its degree of preservation, and its position at the basin shore suggest a local production and sedimentation in a neighbouring, limnic environment. In fact, larch is a good pruner (Kozlowski, 1973) producing abundant litter. Larch litter is commonly distributed over the frozen surface of a lake border by melting snow patches (C. Ravazzi, personal observations in the Alps). These remains, and the pollen record, suggest that, shortly before 14.4–14.1 kyr cal. BP, larch stands were present on the Palughetto lake shore a few metres away from the excavated area. Cones with abraded scales, occurring only at the base of the organic succession (i.e. 116 cm depth in Fig. 13), may be interpreted as an effect of wave action. The dramatic increase in organic content at the unit T11–T10 transition was produced by the progression of the forest towards the lake, allowing larch to establish in the area excavated in 1997 at about 14.4–14.1 kyr cal. BP.

Poorly humified larch needles comprise the litter matrix of unit T10. The sedimentation rate cannot be inferred from the ^{14}C ages, but it is suggested that the larch litter accumulated very quickly. This may be related to a long frost season, as observed today in boreal forests in the Alps at very humid sites. The palaeobotanical record suggests that at the end of Bølling chronozone, local and extralocal vegetation was dominated by *Larix*, with subordinate spruce, pine and broad-leaved trees and shrubs (*Betula* and *Alnus*). The Allerød interval is characterised by enhanced decomposition and an increase of wood abundance, including *in situ* stumps, suggesting that forest invaded the lowland.

As far as we can judge from the presence of larch and spruce needles throughout the late glacial succession (e.g. in the levels dated 10795 ± 165 and 10162 ± 89 ^{14}C yr BP), there is no evidence of a complete *Larix* and *Picea* absence from the site during the YD.

The Cyperaceae expansion and tree macrofossil decline in unit T7 point to forest withdrawal linked to an important hydrological variation (i.e. waterlogging) that affected the mire after 10162 ± 89 ^{14}C yr BP. This change may have reduced soil oxygenation and killed the forest. Extensive investigations on the Taiga biome have shown that falling productivity and eventually the death of the trees are linked to wetter climatic conditions and increasing soil waterlogging (Persson, 1980; Walter and Breckle, 1986). The amount of woody material, including *in situ* stumps, found at the base of unit T6 (Fig. 8) may be linked to death by waterlogging. Dead trees may stand in boreal forests and especially near the tree line for several centuries (Shiyatov, 1979, 1994; Walter and Breckle, 1986; Andreis *et al.*, 1996), but they quickly fall down in wet sites. Therefore a waterlogging event may have led living and dead trees of different age to fall down at the same time. Accordingly, these trunks, although incorporated in the same stratigraphic level, span a wide ^{14}C time range, from 11881 to 10475 cal. yr BC. The accumulation of abundant woody material is also responsible for the observed undulate morphology of the surface at the boundary of units T7 and T6 (Fig. 7): root bioturbation and load casts folded and compressed the originally flat peat surface. However, no evidence of erosion has been detected on this surface.

Subsequently, peat accumulation stopped and inorganic silty sediments (unit T6) were deposited at the border of the basin. This event may be related to colluviation on a shallow local slope, combined with the water-table oscillation evolving towards subaerial conditions. In turn, this may be linked to the reactivation of the drainage pattern of the doline on the northeastern edge of the basin. This is believed to have stopped peat accumulation and links the evolution of hydromorphic soils to the colluvial deposits. The archaeological record, and in particular the hoard of unworked flint, suggests a subaerial surface, close to a fluctuating water-table zone, which probably remained exposed for more than 4500 yr between the Preboreal and Atlantic chronozones.

After human occupation, a sequence of moderately hydromorphic soils developed until the present day (units T5–T2), suggesting a low sedimentation rate. The decrease in aggradational processes may be related to the lack of an important tributary, to an increasing karstic drainage over the entire area, which tended to hamper stagnant waters, and to the dense forest cover that persisted during most of the Holocene.

The Palughetto record within the regional framework: a discussion

The Palughetto record provides several starting points for reconstructing the environmental evolution of the mountainous Eastern Pre-Alps during the late glacial period and around the Pleistocene–Holocene boundary. It also reveals some aspects of the relationships between the environment and human occupation. Without any apparent depositional discontinuity, the basin fill documents a palaeoenvironmental succession probably starting with the LGM. This evidence can be related to prehistoric human occupation and to other palaeobotanical records known from lower altitudes along the southern Alpine margin.

After the LGM (about 17000 yr BP; Bondesan, 1999) the withdrawal of the Piave glacier from the Vallone Bellunese and the Treviso Pre-Alps (Fig. 1) was accompanied by intermorainic lake formation (i.e. Revine lake) and indirectly influenced the occurrence of several landslide events responsible for other lacustrine basins (Pellegrini, 1992; Pellegrini and Surian, 1994, 1996). At some sites at the southern Alpine margin, the beginning of the late glacial period is marked by the occurrence of open larch stands (Casadoro *et al.*, 1976; Schneider, 1978). Larch trunks were found at Fornaci di Revine in the Soligo valley bottom (Fig. 1), only 6 km west of Palughetto, but at a lower altitude (260 m a.s.l.). These trunks have been dated to 14765 ± 135 and 14370 ± 115 yr ^{14}C BP (Casadoro *et al.*, 1976). The conifer forests expanded from these open formations during the Bølling chronozone, and the tree limit reached about 1500 m a.s.l. or even higher in the inner Italian Alps, as suggested by the comparison of pollen records at different altitudes (Schneider, 1985; Gehrig, 1997) and by microscopic charcoal presence in pollen slides (Kofler, 1994). We present evidence here that demonstrates that the tree line was well above the altitude of Palughetto (1050 m a.s.l.) at the end of the Bølling. Many pollen records along the southern margin of the Alps show a mass expansion of trees at 12300–12200 ^{14}C yr BP (Brugiapaglia, 1996; Wick, 1996). This event may be coincident or very close to the age of the basal peat at Palughetto (mean conventional age: 12174 ± 141 ^{14}C yr BP) and shortly post-dates forest immigration there. The beginning of peat accumulation is dated between 12.3 and 12.2 kyr ^{14}C BP at several other sites along the southern border of the Italian Alps (Orombelli and Ravazzi, 1995) and in the inner Italian Alps (Cavallin *et al.*, 1997; Gehrig, 1997). These data provide evidence that the beginning of peat accumulation at low and middle altitudes in the Southern Alps was close to the age of forest expansion within a short time interval during the second part of the Bølling chronozone. In terms of conventional ^{14}C age, alpine reforestation in the south occurs earlier than pine increase in the Swiss Plateau (dated 12 kyr ^{14}C BP: Welten, 1982; Ammann and Lotter, 1989; Lotter *et al.*, 1992). The onset of peat formation at Palughetto has a calibrated age (14.3–14 kyr cal. BP) that might correlate better with the Meiendorf phase than with the beginning of the Bølling climatic phase (*sensu* Iversen, 1954) in the newly revised absolute varve chronologies from central Europe (Litt *et al.*, 1998). Unfortunately, an independent absolute chronology is not possible for the sections studied at Palughetto and high-resolution correlation remains speculative. Local reforestation also corresponds to the expansion of spruce in the Cansiglio Plateau. The spruce record from Palughetto prompts a reconsideration of the hypothesis, so far commonly accepted, of an early Holocene immigration of spruce from Slovenia (Kral, 1980, 1982, 1989; Huntley and Birks, 1983; Lang, 1994).

Forest expansion during the Bølling–Allerød, as well as the stabilisation of mountain slopes, promoted the peopling of the Eastern Pre-Alps and Southern Dolomites. This is documented by seasonal residential camps in valley bottoms and in open mountain areas at altitudes ranging from about 1000 to 1500 m a.s.l. (Broglio, 1992; Broglio and Lanzinger, 1996).

The impact of the YD climatic event on the pre-alpine landscape is documented by palynological diagrams (Schneider and Tobolski, 1985; Wick, 1996). They show a moderate retreat of forest vegetation at the pre-alpine border (300–500 m a.s.l.). The Palughetto conifer record shows that the forest did not decline from an altitude over 1000 m a.s.l. during the YD in the Pre-Alps. In fact, the Palughetto record of *Picea* and *Larix* macrofossil remains, embedded in peat, extends even over the interval between 10.7 and 10.1 kyr uncal. BP. No significant environmental changes have been identified in the macrofossil record from this site during the YD. The complete pollen diagram, presently in progress, will provide further details.

During the early Holocene, the Venetian Pre-Alps were still characterised by slope deposition and alluvial plain aggradation (e.g. Vallone Bellunese and Piave River; Pellegrini and Surian, 1994). The end of these events coincides with the incision of valley-bottom deposits and the consequent formation of fluvial terraces in inner areas of the Vallone (Surian, 1996). Definitive stabilisation of mountain slopes occurred during or at the end of the Atlantic, as observed in the Adige valley (Bartolomei, 1974).

In concert with these palaeoenvironmental changes, a new phase of human occupation of the mountains occurred.

The early Mesolithic site distribution seems to be concentrated in two morpho-altitudinal contexts: caves and rock shelters in the valley bottoms and seasonal altitudinal camps between 1900 and 2400 m a.s.l. (Broglio and Lanzinger, 1996). However, this is not the case of the Cansiglio Plateau (Peresani *et al.*, in press), for which future research probably will provide evidence for human occupation connected with its peculiar settlement pattern.

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REVINE

Casadoro, G., Castiglioni, G.B., Corona, E., Massari, F., Moretto, M., Paganelli, A., Terenziani, F. and Toniello V., 1976: Un deposito tardowürmiano con tronchi subfossili alle fornaci di Revine (Treviso). Bollettino del Comitato Glaciologico Italiano 24, 22-63.

SUMMARY

CASADORO G., CASTIGLIONI G. B., CORONA E., MASSARI F., MORETTO M. G., PAGANELLI A., TERENZIANI F. & TONIELLO V., *A late-glacial deposit with subfossil wood stems from Fornaci, near Revine (Treviso, Italy)* (IT ISSN 0084-8948, 1975). A late-Pleistocene deposit excavated in a quarry near the lakes of Revine in the Venetians Prealps is described. By means of an interdisciplinary analysis, an attempt was made to reconstruct the palaeo-environmental context of the deposition.

Two age determinations carried out in the Hannover Laboratory on wood stems coming from the lower and upper parts of the deposit gave ages of 14765 ± 135 and 14370 ± 115 years respectively, allowing us to date the deposit in the *old Dryas*, immediately after the last Würmian glacial Maximum. This agrees with the geomorphological data, the deposit being situated in a basin interior to the terminal moraines of Würm age.

The remains of 76 subfossil trees were discovered in the quarry between September 1972 and February 1976; all data for their characterization are reported. All the stems observed in place before any artificial disturbance were found in growth position at different levels.

The deposit containing the trunks rests locally on glacio-fluvial gravels and is not covered by other glacial deposit. It can be considered as a colluvial deposit interfingering with lacustrine sediments. In the first phases of the Würm deglaciation a lacustrine valley basin existed, bounded along its SW side by the terminal moraine of Gai and perhaps dammed to the NE by a thick residual glacial mass.

The deposit investigated consists of alternating, generally regular and parallel, thin-bedded pelitic, sandy and gravelly layers, characterized by increase in average size towards the top and by rarity of erosional structures. In the lower part of the quarry the deposit interfingers with grey, locally varved, pelitic sediments, interpreted as lacustrine deposits. The interfingering causes the recurrence of such fine-grained facies up to a probable altitude of 242 m.

An analysis of the composition and structures shows that the deposit probably formed in a periglacial environment. It was mostly fed by frost shattering at the expense of the Tertiary rocks outcropping on the slope above the deposit and, to a lesser extent, by a reworking of Würmian till. The evenness of most of the layers also suggests that the sediment was distributed over wide areas at the foot of the slope by non-concentrated slope wash during melting of the snowcover.

A histological analysis of the stems shows that they belonged to a monophytic plant community of *Larix decidua Miller*; some differences in morphological features can be explained by particular climatic and exposure conditions.

Many stems in the lower part of the quarry show a sharp increase of tree ring width after a previously small radial growth. This could demonstrate the thinning-out of initially close peopling following the death of stems at downslope, and could be the consequence of lake level oscillations during the first phase of existence of the basin itself.

The state of the wood demonstrates prolonged immersion in a damp environment with little oxygen, unfavourable to the activity of fungi and bacteria.

A dendrochronological research was carried out on some transverse cross-sections of 11 submerged trunks, and it was shown that the tree ring series cover a 260-year period. The tree ring data demonstrate a progressive reduction of the influence of a nearby lake, which could justify high moisture at lower slope levels.

Dendroclimatic analysis indicates conditions between continental and oceanic types with a tendency towards the latter, and cold seasons. The ring characteristics and, above all, the morphology, indicate that the monophytic stand at Revine was heavily conditioned by overlapping relations, the mechanical action of wind, snow, etc., and a frost season at the beginning of cambial activity. The root apparatus at different levels of the stems shows a particular adaptation, to be abscribed to progressive accumulation ot sediment around the trunks.

Pollen analyses were carried out on sandy clay samples taken from 249 to 266 m.

The pollen spectrum is characterized by trees which may be considered typical representatives of a « cold » vegetation, i.e. *Betula* and *Salix*, probably also occurring with shrubby dwarf species. *Corylus* and *Alnus*, together with temperate species belonging to *Quercetum mixtum*, were also recorded.

These species were probably present in nearby areas on very sunny slopes. Such sites could represent refuge areas and centers from which the reforestation process could originate.

The co-existence of cold and thermophilous species can also be explained by the climatic instability of the period in which the Revine deposit formed, perhaps in connection with a temperate pulsation recently reported at between 12900 and 12000 B.C.

The pollens of *Ephedra, Juniperus* and *Hippophaë*, presumably autocthonous species, together with those of various herbaceous species (*Artemisia, Gramineae, Chenopodiaceae, Thalictrum, Helianthemum*, and so on) and *Selaginella selaginoides*, indicate an environment of a moist park tundra type (*Juncaceae, Cyperaceae, Filipendula*).

Finally, it can be presumed that, owing to the particular microclimatic conditions linked also to the possible persistence of a glacial mass nearby, the flora of the valley underwent a climatic inversion, with consequent inversion of the zoning of the vegetation too.

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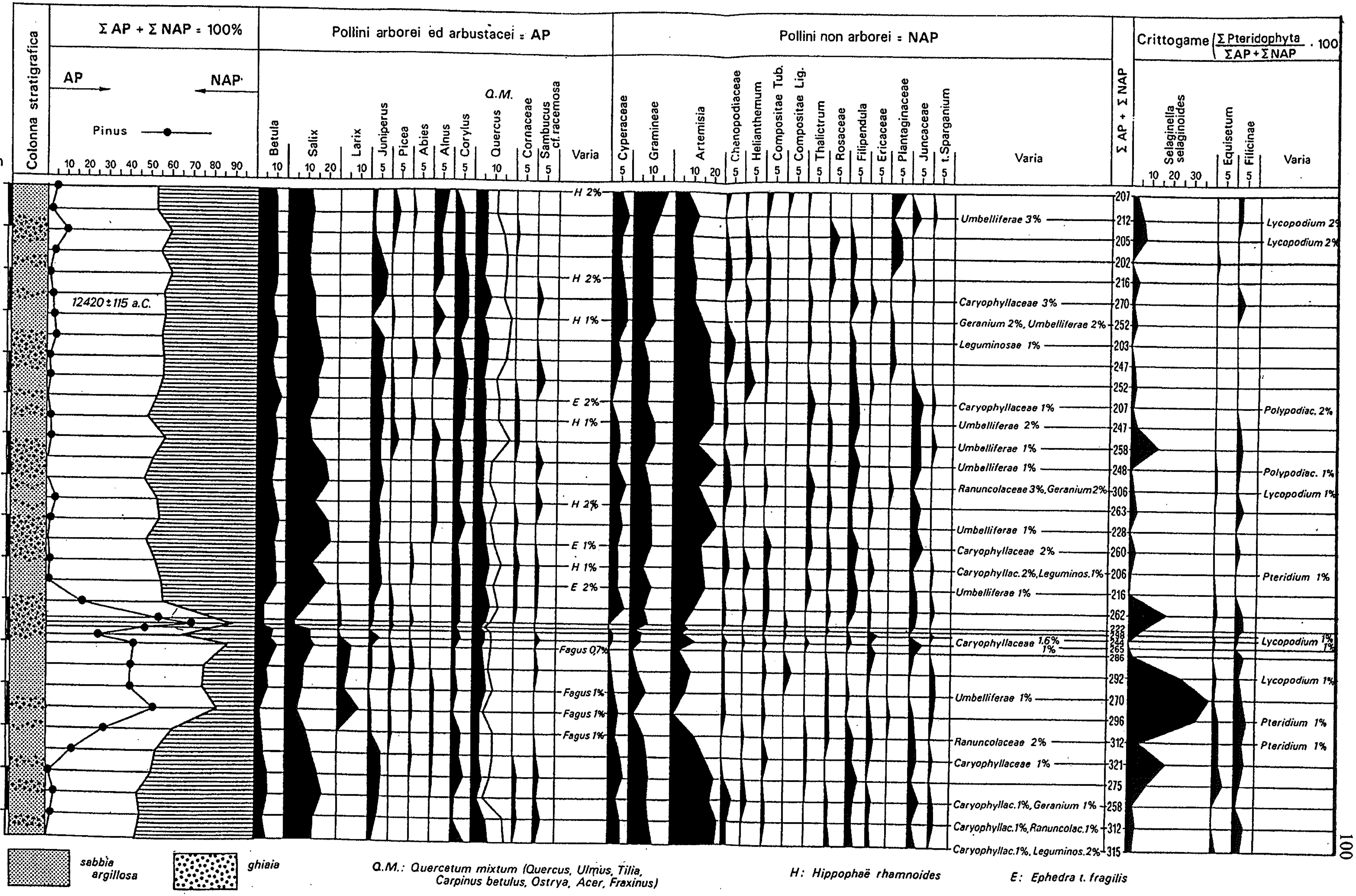
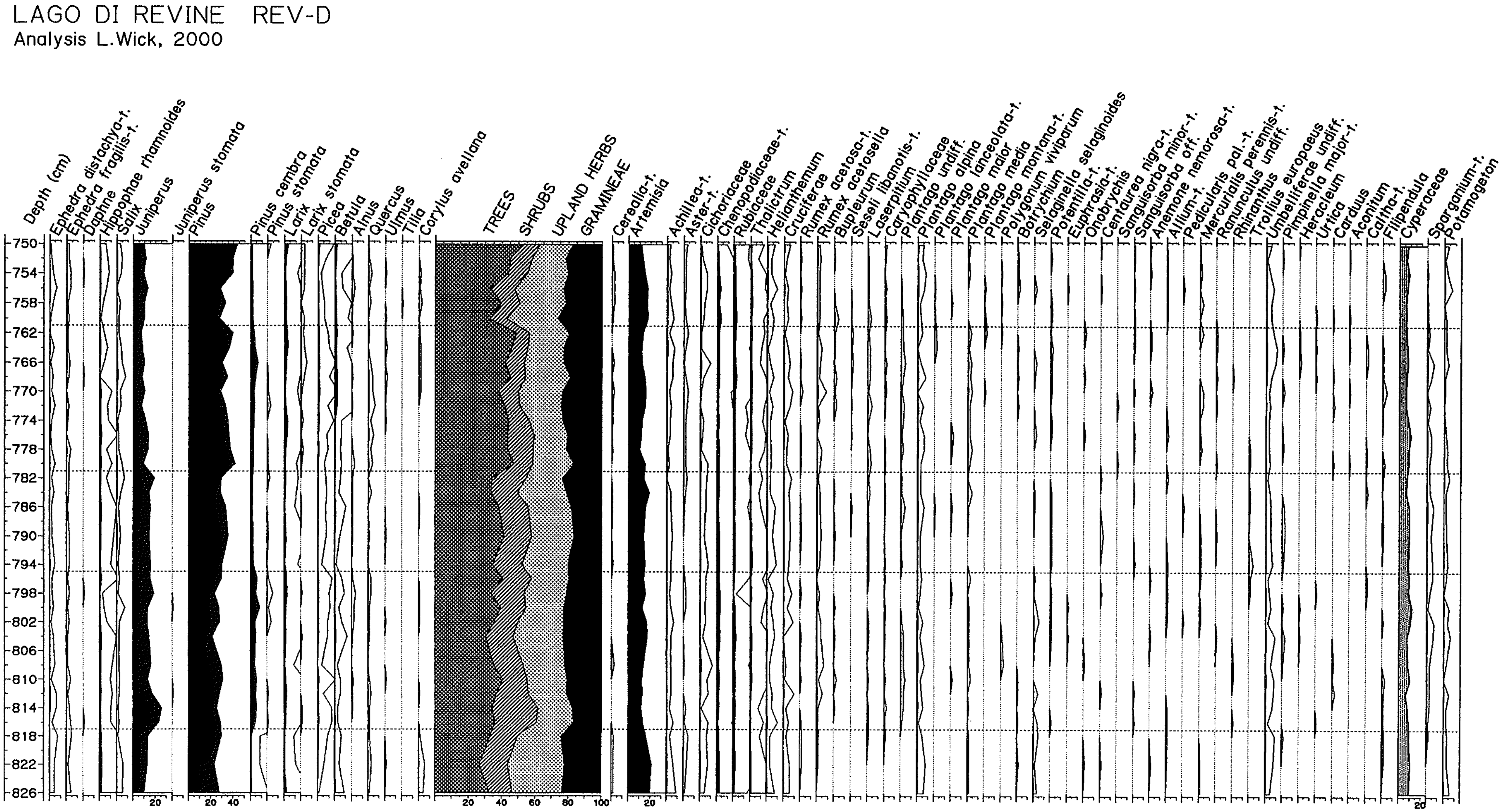


Q.M.: Quercetum mixtum (Quercus, Ulmus, Tilia, Carpinus betulus, Ostrya, Acer, Fraxinus)

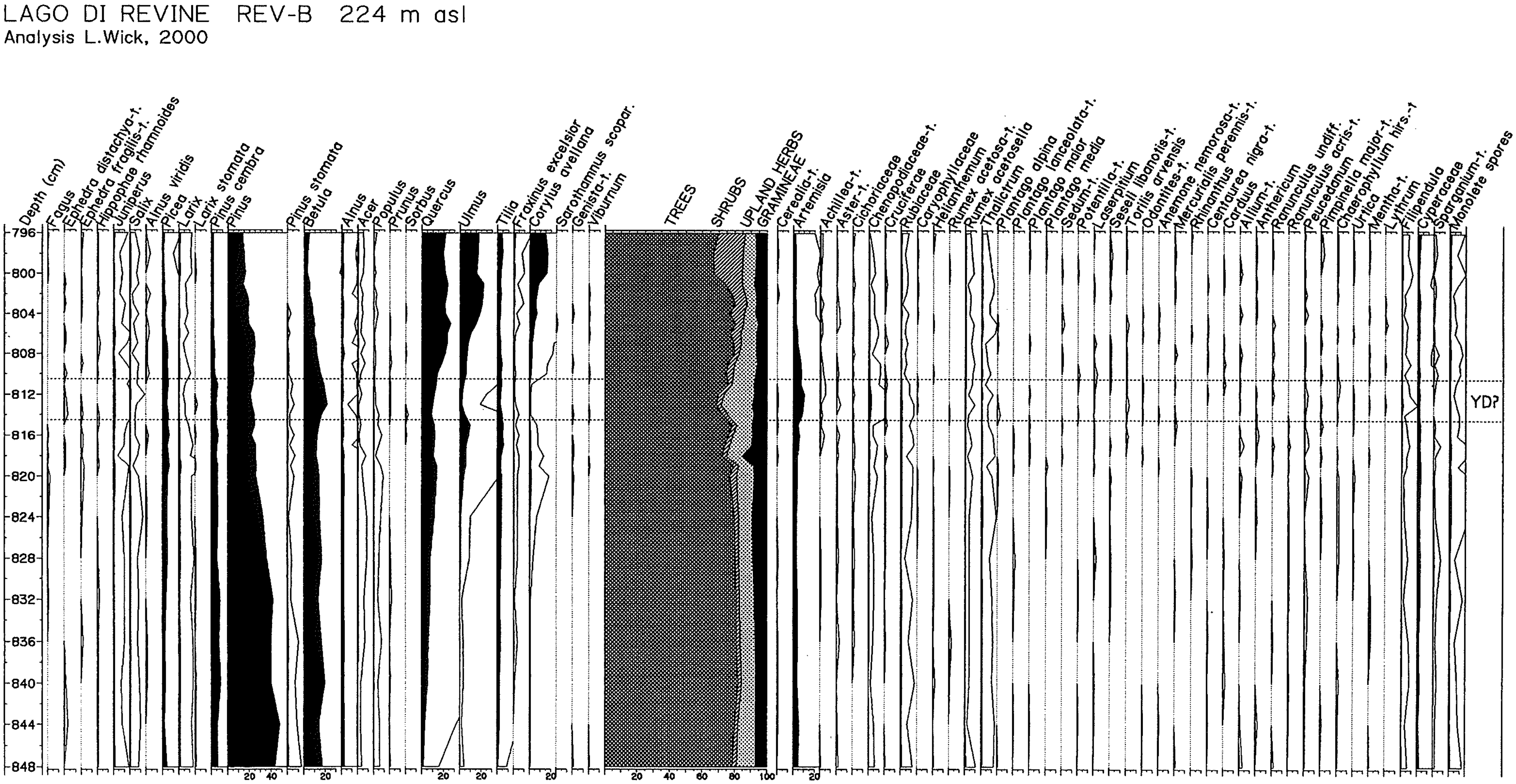
H: Hippophaë rhamnoides

E: Ephedra t. fragilis

Pollen percentage diagram of Lago di Revine, core D (northern part of the lake, 708 cm water depth). The section is covered by a sand layer of 8 cm thickness. Below 826 cm sediment depth there is morainic material. The sequence might include the period of *Larix* occurrence at Fornaci di Revine (Casadoro et al., 1976). Radiocarbon datings are not yet available.



Pollen percentage diagram of Lago di Revine, core B (southern part of the lake, 690 cm water depth). The section is following on top of the sand layer covering section REV-D and shows the Lata-Glacial expansion of mesophilous trees and the beginning of the Holocene. It was not possible to penetrate the sand layer at this place. The sediment consists of calcareous gyttja with silt.



Late-glacial and late Holocene vegetation history of the subalpine lake Obersee (2016m, East-Tyrol)

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Introduction

The interpretation of pollen diagrams from high altitudes frequently causes difficulties since the pollen spectra not only reflects the vegetation of the surrounding but also vegetation changes in lower and more distant areas. The differentiation between local pollen and pollen transported from distant areas is often hardly possible, among others the local pollen production is low (BORTENSCHLAGER, 1992; JOCHIMSEN, 1986).

Nevertheless, pollen profiles gained from bogs and lakes situated at high altitudes record changes in the vegetation more accurate then profiles from lower elevation because the plant cover at extreme environments responds very sensitive to climate variability. Sediments obtained from bogs above and close to the present timberline were analysed several times (BORTENSCHLAGER, 1984; 2000), but it was found that at these sites sediment accumulation did not start before Holocene.

Therefore in the Eastern Alps lakes at the timberline, which cover most part of the vegetation development since the beginning of the Late-glacial, were rarely obtained (cf. OEGGL & WAHLMÜLLER, 1994a,b).

Geography and Geology

The lake Obersee is situated in the southern region of the central Alps within crystalline bedrock (BÖGL & SCHMIDT, 1976, SENARCHLENS-GRANCY, 1960) at 2.016m a.s.l. in the Defereggen-valley (Hohe Tauern) in East-Tyrol (Austria) near the border to Italy (Fig. 1).

Climate

According to WALTER-LIETH (1960) the climate is relative continental in character (Table 1; 2) and is located in the climate-zone IX(X), which is characterised as follows: high-alpine zone with arctic climate-character, short frost-free period and moderate precipitation (Defereggen-Alps).

Table 1: Seasonal and annual average of precipitation in mm (FLIRI, 1975)

Station	Altitude (m)	winter	spring	summer	autumn	year
Rain	1600	140	190	417	236	984
Antholz	1236	104	194	406	218	921
St. Jakob/D.	1410	142	204	461	263	1060
St. Magdalena	1398	105	177	397	206	884

Table 2: Monthly and annual average of temperature in °C (1931-1960) according to FLIRI (1975).

Station	Altitude (m)	J	F	M	A	M	J	J	A	S	O	N	D	year
St Jakob/D.	1410	-6,0	-3.5	0.3	4.4	8.2	11.7	13.6	13.1	10.6	5.5	-0.2	-4.6	4.4
Rain	1600	-4.7	-2.9	0.0	3.7	7.8	11.3	13.4	12.9	10.3	5.4	0.2	-3.4	4.5

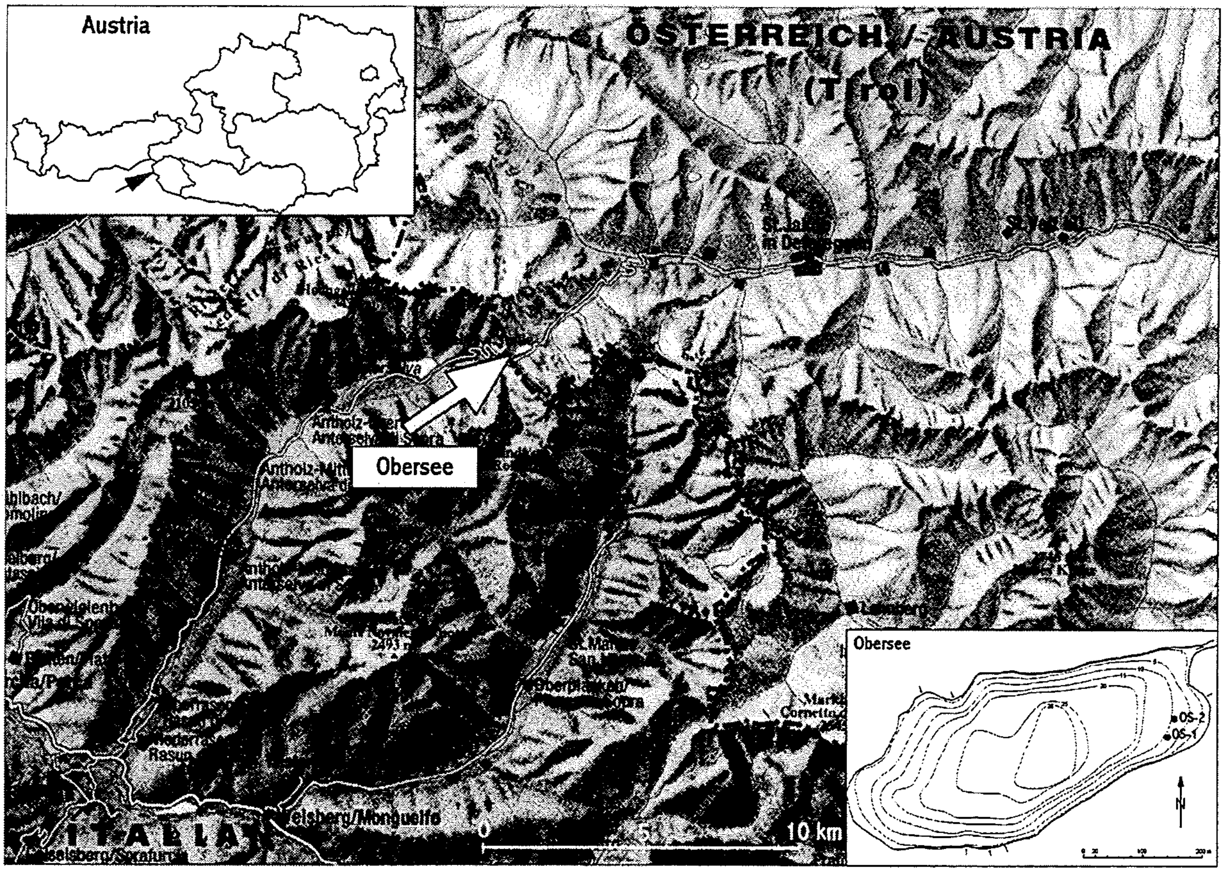

Fig 1: Location of the study area and location of cores OS1 and OS2

Lake and catchment parameters

Several small inflows from different locations exist, but only one outflow, the „Staller Almbach", in the north-east (Fig. 1).

Table 3: Lake and catchment parameters (according to STEINER, 1987)

elevation (m)	2.016	length (m)	624
Longitude	12°12`20``E	mean depth (m)	15,1
Latitude	46°53`30``N	width (m)	286
lake area (ha)	12,9	volume (m^3)	1,946.200
max. depth (m)	26,7	catchment area (ha)	approx. 210

Vegetation

In areas of acidic rock the forest limit is formed by *Pinus cembra, Picea abies* and *Larix decidua* (ELLENBERG, 1995). The forest limit in the Defereggen-valley lies at an altitude of 2250 m a.s.l (Fig. 2). At higher altitudes, a dwarf-shrub heath vegetation is followed by alpine grassland.

The area of the lake Obersee is dominated by an open vegetation caused by human impact. The north- and west side of the lake is surrounded by a Pinetum cembrae, where the understorey is dominated by *Juniperus nana*. The vegetation in the southern and eastern part of the lake is a mosaic formed by Rhododendretum ferruginei, Vaccinietum myrtilli and uliginosi, Callunetum, Nardetum und Loiseleurietum.

m (a.s.l.)	Altitudinal zones	SW (East Tyrol, Deferegger-valley)	SO (Oberkärnten)	N (Salzburg)
2250		Timberline		
2200		*Cembran pine*		
2000	high-subalpine	*Cembran pine (Larch, Spruce)*	Timberline *Cembran pine (Larch, Spruce)*	Timberline
1800			*Spruce (Larch, Cembran pine)*	*Spruce (Larch, Cembran pine)*
1600	low-subalpine	*Spruce (Larch, Cembran pine)*		
1400	high-	*Spruce*	*Spruce (Fir)*	*Spruce (Fir)*
1200	montane			
1000	low-		*Spruce (Fir,Beech)*	
800				

Fig. 2.: Potential natural altitudinal zonation in the south-west (SW), south-east (SO) and north (N) of the "Hohen Tauern" (according to KRAL, 1985).

Sampling

In winter 1994 two long sediment cores (OS1, OS2) were made using a GEONOR-corer. The cores were taken from the undisturbed water in the south-east part of the lake where the ground is relatively flat (Fig. 1).

Sediment

Table 3 gives a brief description of the sediments. In the pollen diagram the lithology is presented with symbols according to TROELS-SMITH (1955). The pollen analysis of the two cores (OS1 not shown) show that in both series part of the sediment is missing.

Tab 3: The sediments of core Obersee 2 (OS2)

depth	sediment	colour
865-1035 cm	Diatom-gyttja, sandy layers	brown
1035-1037.5 cm	Diatom-gyttja, sandy,silty	brown
	Limes acutus	
1037.5-1082.5 cm	Clay-gyttja, sandy	grey
1082.5-1107.5 cm	Clay-gyttja, sandy	dark-grey (organic)
1107.5-1110 cm	Clay-gyttja, sandy	grey
1110-1117.5 cm	Clay-gyttja, sandy	dark-grey (organic)
1117.5-1120 cm	Clay-gyttja, sandy	grey
1120-1122.5 cm	Clay-gyttja, sandy	grey
1122.5 cm	Sand, Clay-gyttja	grey
1122.5-1147.5 cm	Clay-gyttja, sandy	grey
1147.5 cm	Sand, Clay-gyttja	grey
1147.5-1167.5 cm	Clay-gyttja, sandy	grey
1167.5 cm	Sand, Clay-gyttja	grey
1167.5-1185 cm	Clay-gyttja, sandy	grey
1185-1190 cm	Gravel, sand, silt	grey

The centric diatom-taxa *Cyclotella pseudostelligera* (HUST.), *Aulacoseira italica* (EHR.) SIMONSEN and *Cycl. distinguenda* var. *unipunctata* (HUST.) H⊕KANSON and CARTER are prevailing in the Holocene diatomgyttja.

LATE-GLACIAL VEGETATION DEVELOPMENT

From lake Obersee no radiocarbon-dates are available until now. Therefore the ^{14}C-dates shown in the pollen diagram were placed by pollen stratigraphical correlation with other diagrams from East- and South Tyrol, predominantly from similar altitudes (OEGGL & WAHLMÜLLER, 1994; SEIWALD, 1980; KRAL, 1985). Chronozonation follows WELTEN (1982).

Local PAZ-OS1: *PINUS-JUNIPERUS*-GRAMINEAE-*ARTEMISIA* ZONE

Development of pioneer vegetation and of alpine meadows (about 12700±200 - 12000? BP)

Coarse erosional input is documented in the lowest part by gravel and sandy clay (1190-1185 cm), which is almost free of pollen.

Pinus pollen (*Pinus cembra, Pinus* sp.) from distant areas and lower altitudes increases suddenly from zero to 80-95%. In the depth of 1182.5 cm the clay-gyttja contains pollen spectra which are an indication of pioneer vegetation dominating on raw soils. The pollen diagram shows that between 1182.5-1165 cm herbaceous plants like *Saxifraga oppositifolia*-Typ, *Helianthemum*, Rubiaceae, Caryophyllaceae, Ranunculaceae, Rosaceae, Cichoriaceae, *Senecio*-Typ, *Achillea*-Typ and Scrophulariaceae colonise the area.

These entomophilous pollen types are not widely dispersed (OEGGL, 1994; WELTEN, 1982) and therefore indicate local vegetation. In contrast pollen of Gramineae, Cyperaceae, *Rumex*-type, Umbelliferae, *Plantago, Plantago major*-type and spores of Pteridophyta can be of local or regional/extraregional origin. This applies also to the heliophile taxa *Artemisia*, Chenopodiaceae and *Thalictrum*, which dominate in open and cold steppe vegetation.

The low pollen concentration, high sand content in the sediment and the occurrence of *Gypsophila repens* indicate sparse vegetation cover and erosion (OEGGL, 1992). Above 1160 cm the absolute values of herbs increase which show that the vegetation cover around the lake became denser.

Pollen of *Betula* (<5%) comes probably from more distant localities though the occurrence of *Betula nana* at the study site can not be excluded. The continuous occurrence of *Juniperus* (up to about 4%) might indicate a primary colonisation in the area. *Salix* (*Salix herbacea*) is possibly related to snow-bed vegetation.

Local PAZ-OS-1a: *PINUS-ALNUS*-GRAMINEAE-*ARTEMISIA*-ZONE

Development of pioneer vegetation and alpine meadows (about 12000? BP)

The distinct increase of NAP in this zone might be due to climate depression.

Pinus (*Pinus cembra* and *Pinus sp.*) reaches the late-glacial minimum with 63% of the pollen sum. This minimum value is caused by a decrease of *Pinus* sp. and also the AP concentration markedly decreases in this zone. The pollen concentration of herbaceous plants shows similar tendency but it is not that distinct. This suggests that the pioneer vegetation cover was impaired by the climate depression but the effect on the *Pinus*-forests at lower altitudes was more serious. Probably the forest limit was lowered or the canopy cover decreased. The effects of this regressive phase seem to concern not only *Pinus* but also *Juniperus*.

The lowest *Pinus* value is combined with strikingly high values of *Alnus viridis* (8%) and *Dryopteris* (10%).

Local PAZ-OS-2: *PINUS*-GRAMINEAE-ZONE and
Local PAZ-OS-2a: *PINUS-ARTEMISIA*-ZONE
Development of alpine meadows (about 11700±170 – 10770±165 BP)

Both zones belonging to the Alleröd-biozone have a high proportion of *Pinus* (85-95%) in common. The difference between the two zones is that the older one shows a decrease in *Betula* and *Artemisia*, an absence of shrub pollen and a low species diversity. The *Rumex*-type, *Saxifraga oppositifolia*-type, Apiaceae and Rosaceae are missing. The pollen concentrations of the herbaceous plants however rise strongly in both zones and the sandy proportions in the sediment decreases in relation to the sediments from the Bölling-biozone, which refers to an increasing cover of the vegetation.

The increase of the cool steppe elements *Artemisa* and *Ephedra fragilis*-type in the second half of the Alleröd-biozone (lPAZ-OS-2a) points to temporarily unfavourable conditions.

Within the younger part of the lPAZ-OS-2a the productivity of the lake rises due to more favourable climate conditions. For the first time *Pediastrum* and *Daphnia* sp. occur in the sediment.

The occurrence of large charcoal particles (to 200 µm) with pinoid pits (occupying almost the entire cross-field) however suggests that the *Pinus* forest limit is near the lake Obersee (2016 m). These particles are frequent toward the end of the Alleröd-biozone (1090-1097.5; 1082.5).

The continuous curve of charcoals > 100 µm in the Alleröd-biozone sediments points to a continuous fire activity and thus rather dry, continental conditions. The climate might have become somewhat wetter in the second half of the Alleröd, since a decrease in the curve of charcoals > 50 µm and a rise of *Betula* is recognisable.

lPAZ-OS-3: GRAMINEAE-*ARTEMISIA-PINUS* ZONE
Opening of the meadows - pioneer phase (about 10770±165 – 10030±170 BP)

In the lake Obersee the cold phase of the Younger Dryas, which caused a decrease of the forest limit, is two-tailed, whereby the two halves are separated by a short, but climatic more favourable phase (*Pinus* increase).

The values of Gramineae, *Artemisia*, *Thalictrum*, Chenopodiaceae, Caryophyllaceae, *Senecio* type, Cichoriaceae and *Ephedra* increase again. The increasing sand proportions in the sediment suggest an open vegetation cover. Also the occurrence of *Gypsophila repens* and *Saxifraga oppositifolia*-type point in that direction.

The older part is characterised by higher values of Gramineae, Cichoriaceae and *Achillea*-type, while in the younger part the values of *Artemisia*, Chenopodiaceae, *Ephedra* and *Juniperus* are higher and Gramineae decrease. Combined with the absence of charcoals > 100 µm in the older part of the Dryas III more wet conditions are indicated, whereas drier conditions are suggested to have occurred in the younger part of the Dryas III.

In the late-glacial the highest charcoal concentrations of the class >100 µm are present above and below the *Pinus* increase, which separate the Younger Dryas. The *Pinus* increase is combined with a decrease of the fire activity (charcoal decrease) and thus possibly fall into a wetter phase.

LATE-HOLOCENE VEGETATION DEVELOPMENT

lPAZ-OS-4: *PICEA-PINUS-ABIES-FAGUS* ZONE
Open forest of *Picea, Pinus cembra* and *Larix*

lPAZ-OS-5: *PICEA-PINUS* ZONE
Opening of the forest, meadows and pastures, open *Alnus viridis*, Ericaceae and *Juniperus* scrubs

lPAZ-OS-6: *PINUS-PICEA-JUNIPERUS* ZONE
Meadows and pastures, open *Alnus viridis*, Ericaceae and *Juniperus* scrubs

Since at the time when sedimentation starts again in the middle Subboreal, cultural and pasture indicators (Cerealia, *Plantago lanceolata*) appear, human and climatic effects on the vegetation are difficult to separate. Around the lake Obersee an open spruce-cembran pine forest with larch occurred and *Alnus viridis* and *Pinus mugo* colonise suitable locations.

In the middle part of the lPAZ-OS-4 a rise of *Alnus viridis*, Gramineae and herbs is recognisable. At the same time single pollen grains of *Plantago lanceolata*, *Plantago major*-type, Cannabaceae, *Urtica* and Cerealia occur. This points to a human intervention in the vegetation during this time (Bronze/Iron Age). According to PATZELT (1972) at approx. 2200-2800 ^{14}C yr BP a climatic depression occurs also, that climatic and human impact on the vegetation are difficult to distinguish in detail.

At the end of the zone an extension of the forest to higher regions and simultaneously a strong decrease in herbs is detectable which probably is caused by climate improvement.

Anthropogenic intervention takes place in this climatically favourable Iron-age phase and causes a retreat of the forest. The increase of the charcoal curves and the decrease of *Picea*, *Pinus cembra* and *Pinus* sp. (*Pinus mugo*) is clearly recognisable since the middle Iron-Age. This tendency is preserved until today.

The pollen diagram suggests that the strongest anthropogenic influence at the lake Obersee takes place in the Middle Ages. This is shown by the increase of NAP, *Plantago lanceolata*, *Rumex*-type and *Cerealia* at the boundary lPAZ-OS-5 (*Picea-Pinus* zone) and lPAZ-OS-6 (*Pinus-Picea-Juniperus* zone).

The investigation of the diatom composition from the medieval sediments show that the nutrient content (inferred total phosphorus) in the lake Obersee was higher in the Middle Ages than today (data not shown). This may be connected with an intensive medieval use (forest clearing, pasture, burning) of the area by human activities (WUNSAM & SCHMIDT, 1995).

Discussion

The pollen precipitation at the lake Obersee is distinctly marked by pollen of regional origin (10 Tauber pollentraps in the surrounding of the lake, data not shown).

A large proportion of the pollen in the sediment might probably be of extralocal or regional origin, since pollen traps which were situated also in higher areas (up to 2350 m) and far away from forest stands (> 500 m), are characterised by high *Pinus* and *Picea* influx values. Due to the topography of the study area this might be caused by air masses of predominantly south-west origin.

Pollen analysis from lake Obersee suggests that the exact position of the timberline is difficult to detect by means of pollen analytical methods only, but the relative shifts of the timberline are well recognisable. This applies particularly for the Late-glacial.

The intended macro fossil analyses will give valuable information and complete the pollen analytic investigations.

Bölling

Above the basal gravel- and sandrich layer *Pinus* values abruptly increase to approx. 85%. This indicates that the base of the profile (1182.5 cm and younger sediments) originates from a period , where the *Pinus* forests in the valleys spread or already have spread. Pollen stratigraphical comparison with profile Sommersüß (870m, distance 40km), where the *Pinus* expansion was radiocarbon dated, suggests a maximum age for the Obersee-base of approx. 12.700±200 14C yr BP (SEIWALD, 1980).

The profile Sommersüß indicates that around 12.700±200 ^{14}C yr BP *Pinus* rises to 70-80% and exceeds *Juniperus* and *Hippophae*.

Possibly the *Juniperus- Hippophae* peaks in the profile Sommersüß correspond to the *Juniperus- Hippophae* peaks in 1177.5-1172.5 cm of the lake Obersee; they are the highest values in the profile Obersee. Accordingly the ^{14}C-date of 12.700±200 BP would have to be arranged after these peaks at approx. 1170-1172.5 cm in the Obersee profile.

Therefore it is suggested that the lake Obersee became ice-free approximately during the *Juniperus-Hippophae* shrub phase (cf. Hobschensee (2017 m a. s. l.); WELTEN, 1982). The ^{14}C-date of 12.700±200 BP, however, lies in a ^{14}C-plateau and therefore an exact temporal resolution is not possible.

AMMANN and LOTTER (1989) redefined the Oldest Dryas/Bölling-Biozone boundary at ca. 12.700 ^{14}C yr BP. In the Swiss lowland the onset of the forested Late-glacial is marked by a sharp peak in *Juniperus* percentages (regional *Juniperus-Hippophae* PAZ) that lasted from 12.700-12.600 to 12.500-12.400 yr BP.

Aegelsee fluctuation

The regressive phase which appears in the lPAZ-OS-1a and which leads to a decrease of the forest limit, probably corresponds to the Aegelsee fluctuation in Switzerland and the Older Dryas pollen zone of southern Sweden (BJÖRCK & MÖLLER, 1987). The Aegelsee fluctuation is dated by peat and terrestrial macro fossil at approx. 12.300-12.000 ^{14}C yr BP (LOTTER et al., 1992)

The rise of green alder during this climatic depression can be explained by the fact that green alder is adapted to long snow cover and short vegetation periods. Therefore *Alnus viridis* can compete successfully with the remaining tree species at the upper forest limit (SPEAR, 1989). Retreat of trees create suitable locations for green alder, so the formation of a green alder-zone at and above the forest limit is made possible by a climatic depression (BORTENSCHLAGER, 1977, 1984; MAYLE et al., 1993). On the other hand green alder is considered a survivor species because it sprouts from basal or underground parts following fire and repeated fires near treeline can even result in green alder thickets (HANSON, 1953; WEIN and MAC LEAN, 1983). Concerning the interpretation of moisture conditions the charcoal curves can be consulted. They show a continuous rise, which suggests rather dry conditions, so that the climatic conditions probably were cold and dry.

Younger Dryas

In profiles from higher altitudes in Switzerland the Dryas III is also divided into two parts. KÜTTEL (1974); WEGMÜLLER & LOTTER (1990); WELTEN (1972) and MARKGRAF (1969) assume that the first, Poaceae rich part of the Younger Dryas is wetter than the second one.

This is confirmed by results of lake Obersee. According to KERSCHNER (1987) at the start of the Younger Dryas high precipitation must have occurred to permit an extension of alpine glaciers. Later on, however, precipitation must have decreased because the glacial advance diminished.

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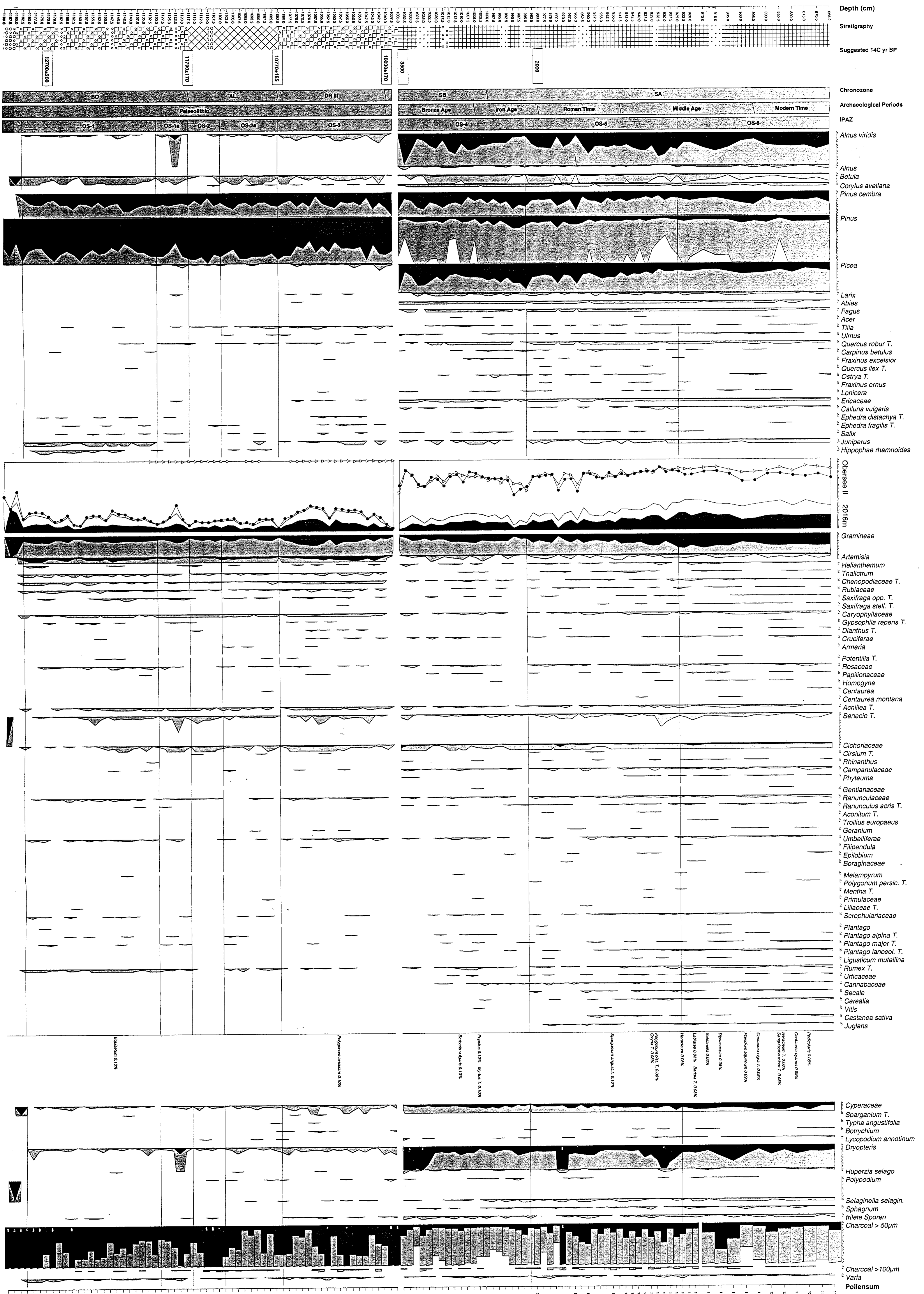
Depth (cm)
Stratigraphy
Suggested 14C yr BP
12700±200
11790±170
10770±165
10030±170
3500
2000
Chronozone
BO
AL
DR III
SB
SA
Archaeological Periods
Paleolithic
Bronze Age
Iron Age
Roman Time
Middle Age
Modern Time
IPAZ
OS-1
OS-1a
OS-2
OS-2a
OS-3
OS-4
OS-5
OS-6
Alnus viridis
Alnus
Betula
Corylus avellana
Pinus cembra
Pinus
Picea
Larix
Abies
Fagus
Acer
Tilia
Ulmus
Quercus robur T.
Carpinus betulus
Fraxinus excelsior
Quercus ilex T.
Ostrya T.
Fraxinus ornus
Lonicera
Ericaceae
Calluna vulgaris
Ephedra distachya T.
Ephedra fragilis T.
Salix
Juniperus
Hippophae rhamnoides
Obersee II 2016m
Gramineae
Artemisia
Helianthemum
Thalictrum
Chenopodiaceae T.
Rubiaceae
Saxifraga opp. T.
Saxifraga stell. T.
Caryophyllaceae
Gypsophila repens T.
Dianthus T.
Cruciferae
Armeria
Potentilla T.
Rosaceae
Papilionaceae
Homogyne
Centaurea
Centaurea montana
Achillea T.
Senecio T.
Cichoriaceae
Cirsium T.
Rhinanthus
Campanulaceae
Phyteuma
Gentianaceae
Ranunculaceae
Ranunculus acris T.
Aconitum T.
Trollius europaeus
Geranium
Umbelliferae
Filipendula
Epilobium
Boraginaceae
Melampyrum
Polygonum persic. T.
Mentha T.
Primulaceae
Liliaceae T.
Scrophulariaceae
Plantago
Plantago alpina T.
Plantago major T.
Plantago lanceol. T.
Ligusticum mutellina
Rumex T.
Urticaceae
Cannabaceae
Secale
Cerealia
Vitis
Castanea sativa
Juglans
Equisetum 0.10%
Polygonum aviculare 0.10%
Berberis vulgaris 0.10%
Populus 0.10% Myrtus T. 0.10%
Sparganium angust. T. 0.10%
Polygonum bist. T. 0.08% Oxyria T. 0.08%
Heracleum 0.08%
Labiatae 0.08% Bartsia T. 0.08%
Soldanella 0.08%
Dipsacaceae 0.08%
Pteridium aquilinum 0.09%
Centaurea nigra T. 0.08%
Heracleum T. 0.08% Sanguisorba minor T. 0.08%
Centaurea cyanus 0.09%
Pedicularis 0.08%
Cyperaceae
Sparganium T.
Typha angustifolia
Botrychium
Lycopodium annotinum
Dryopteris
Huperzia selago
Polypodium
Selaginella selagin.
Sphagnum
trilete Sporen
Charcoal > 50µm
Charcoal >100µm
Varia
Pollensum

Timberline development and human impact on the Hirschbichl (Eastern Tyrol)

Klaus OEGGL & Notburga WAHLMÜLLER

Introduction:

The timberline is a significant vegetation limit in mountain areas. Its physiognomy is determined by several factors: topography, macroclimate, site-conditions, seed production, snow-cover dynamics, forest fires and human impact (Stern 1983). A major factor in the development of the timberline is the macroclimate, respectively the shortening of the vegetation period with advancing altitude (Larcher 1963; Tranquillini 1979). There exist different hypotheses about the nature of the alpine timber-line under natural conditions without human perturbation. One opinion postulates a transition zone. This timber-line ecotone varies from dense forests to a more and more open structured woodland up to the tree-line, where single individuals of trees could still exist. An other view is that forests always reach their upper climatic limit in a dense stand. Above this sharp vegetation limit the growth of individual groups of trees is possible (Stern 1983). The comparison of timber-line situations in mountain ranges without human impact provide evidences, that several varieties of these two hypotheses are possible. An sharp straight-lined limit, where the timber-line coincides with the tree-line, occurs only in mountains with favourable homogenous soil conditions. Already minor disturbances, e.g. avalanches, landslides, etc., are sufficient for opening the straight-lined limit. In most of the cases mosaic structures of dense forests, crippled trees and alpine grasslands are noticeable. The opening up of dense forests into single individual stands is known from highlands with limited water relations (mediterranean, arid areas). Even within the Alps all of these formations of the timber-line mentioned above are observable (Klötzli 1991).

Above the timber-line evergreen needle-leaved or cold-deciduous shrublands, tall-forb formations, dwarf scrub and alpine mats expand according to relief, soil and microclimate. The last mentioned alpine mats as so-called "Urwiesen" are important areas for grazing. Even before human interference in alpine regions floods, avalanches and game are able to put enough nutrients into the root area to support stands with the character of natural pastures (tall-forb rich Trisetetum). In principle, no new plant communities were created with the occurrence of prehistoric man in the alpine highlands. Some already existing and some new selection factors, like irrigation, pasture, fertilisation, mowing, etc., become more effective. This causes a large-scale expansion of existing nutrient-rich plant communities in alpine regions, which is in contrast with to valley bottom regions where new plant communities were created. Only the basic species combination becomes modified by the stronger effective selection factors (Klötzli 1991). Unambiguous plant indicator species for human impact in alpine zones are therefore difficult to establish. The Table 1 presents an overview of alpine plant species, which react positively to anthropogenic selection factors (Oeggl 1994).

Site Description

The "Plank Lacke", a small tarn on the Hirschbichl in Osttirol, presented an exceptional chance to investigate a lake site not affected by problems, such as the frequent disturbance of the sedimentation by avalanches or rockfalls. The tarn lies on a minor, rounded hilltop surrounded by mountain slopes on all sides (Fig. 1). The tarn covers an area of roughly 50 m diameter and is now almost entirely overgrown, with an open-water area of only circa 10 m diameter.

Table 1. Alpine plant species, which react positively to different anthropogenic selection factors, and their possible record in pollen diagrams: ○ = under-represented, ● = over-represented in the local pollen rain (Oeggl 1994).

Taxon	Pasture	Fertilisation	Irrigation	Pollen-type
Arnica, Achillea moschata, Achillea nana, Adenostyles, Antennaria, Carlina, Cirsium, Gnaphalium, Homogyne, Senecio alpinus, S. doronicum, S. uniflorus, S. incanus	○			Achillea-type, Adenostyles-type, Carlina, Cirsium, Cirsium-type, Homogyne-type, Homogyne, Senecio-type, Asteraceae
Aconitum	○			Aconitum-type, Ranunculaceae
Alchemilla, A. alpina, A. subcrenata, A. vulgaris, A. hybrida	○	○	○	Alchemilla-type, Rosaceae
Allium, Crocus, Gagea, Lloydia	○			Allium-type, Crocus, serotina, Paradisia, Tofieldia, Paris-type Tofieldia, Lloydia serotina, Paradisia liliastrum, Liliaceae-type
Anemone	○			Anemone nemorosa- type, Ranunculaceae
Arctostaphylos, Erica,	○			Arctostaphylos,
Artemisia	○			Artemisia
Arnica montana, Antennaria, Chrysanthemum leucathemum,	○		○	Asteraceae
many Pteridophytes	○			Botrychium, monolete spores, Pteridophyta
Calluna vulgaris	○			Calluna, Ericaceae
Campanulaceae, Campanula rhomboidalis, Phyteuma orbiculare	○		○	Campanulaceae, Campanula
Cerastium alpinum, C. caespitosum, Stellaria nemoreum	○	○		Caryophyllaceae
Chenopodium, Chenopodium bonus-henricus	●	●		Chenopodiaceae-type
Compositae, Hieracium, Leontodon hispidus, Taraxacum officinale, T. major	○		○	Cichoriaceae, Asteraceae
manny Cruciferae	○	○		Cruciferae
Cyperaceae	○			Cyperaceae
Empetrum	○			Empetrum-type
Gentiana	○			Gentianella campstris- type, Gentianaceae
Geranium sylvaticum,			○	Geranium
Trisetum flavescens, Dactylis glomerata, Agrostis tenuis, Phleum alpinum, Poa alpina, Poa pratensis, Nardus stricta, Festuca alpestris	●	●	●	Gramineae
Juniperus communis	○			Juniperus
Mentha longifolia		○		Lamiaceae
Veratrum, Colchicum	○	○		Liliaceae-type
Papillionaceae, Oxytropis montana, Trifolium badium, Trifolium pratense, Trifolium repens	○		○	Oxytropis-type, Trifolium, Papillionaceae
Pinguicula	○			Pinguicula

Table 1. continued

Taxon	Pasture	Fertilisation	Irrigation	Pollen-type
Plantago-Arten, Plantago media	○		○	Plantago, Plantago major-Typ
Polygala	○			Polygala
Potentilla	○			Potentilla-type, Rosaceae
Primula elatior, P. farinosa, P. integrifolia, Primula viscosa, Soldanella	○	○		Primula farinosa-type, Primula hirsuta-type, Soldanella Primulaceae
Ranunculaceae	○			Ranunculaceae
Rhododendron	○			Rhododendron(?);Vaccinium-type
Rumex, R. acetosa, R. alpinus,R. arifolius	○	○	○	Rumex; Rumex acetosa-Typ
Saxifraga	○			Saxifragaceae
Bartsia, Euphrasia, Pedicularis, Rhinanthus, Veronica chamaedrys	○	○		Bartsia-type, Euphrasia, Pedicularis, Rhinanthus, Scrophulariaceae
Sedum	○			Sedum
Sempervivum	○			Sempervivum
Thesium	○			Thesium
Daphne	○			Thymeleaceae
Eryngium, Heracleum sphondylium, Pimpinella saxifraga, Umbelliferae (Ligusticum mutellina!),	○	○	○	Eryngium-type, Pimpinella major-type, Chaerophyllum-type, Heracleum-Typ, Ligusticum-type, Ligusticum mutellina, Umbelliferae
Urtica dioica		●		Urtica, Urticaceae
Rhododendron, Loiseleuria, Vaccinium	○			Vaccinium-type, Ericaceae
Valeriana	○			Valeriana, Valerianaceae

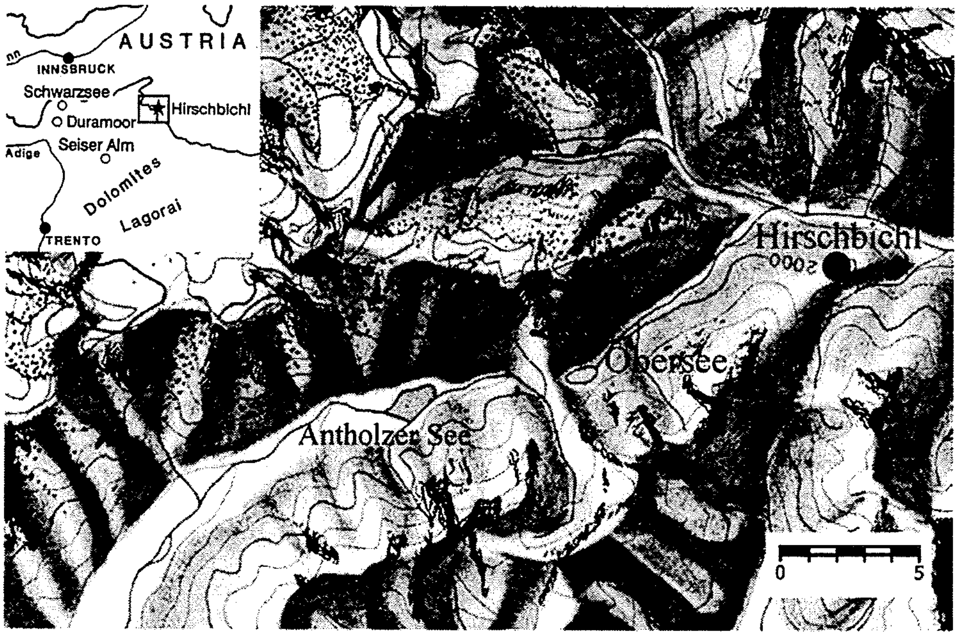

Figure 1. Location of the Mesolithic seasonal dwelling site on the Hirschbichl at 2150 m above sea-level on the border between the Eastern-Tyrol and Northern Italy.

The present tree-limit is formed by a Larici-Pinetum cembrae community and lies at the same altitude as the investigated site. The wider vicinity of the 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 extrasylvaticum community, which is replaced by a Loiseleurietum on wind-exposed ridges. At the northern end the mire vegetation of the "Verlandungs" zone is composed of *Trichophorum caespitosum, Carex magellanicum, Carex rostrata, Carex pauciflora, Eriphorum vaginatum, Drepanocladus* sp., *Calliergon stramineum* and *Sphagnum* spp.. In the southern part there are scattered *Sphagnum*-hummocks, with *Carex magellanica* and *Carex rostrata*. The open-water zone is occupied by floating *Sparganium minimum*, with *Carex rostrata* and *Menyanthes trifoliata* on the margins.

A seasonal settlement site is located in the surroundings of the tarn and hemmed in by the steep mountain slopes around. In consequence the archaeological 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. The excavations carried out so far indicate a particular accumulation of artefacts from the Older Mesolithic period (Stadler, 1992). The seasonal hunting camp on the Hirschbichl forms one of the most northerly of the sites belonging to the local Mesolithic subculture.

The Vegetation Development during the Early Holocene

The sediments laid down in the tarn on the Hirschbichl provide evidence for the development of the local vegetation from the Alleröd until the end of the Subatlanticum. The base of the clay gyttja is dated to 11,420 ± 90 BP. The succession starts with a *Pinus-Artemisia* zone (lpaz 1). For the most part the AP of lpaz 1 comprises pollen grains of *Pinus diploxylon*-type derived from the regional vegetation. Pollen of *Pinus cembra* and *Juniperus* document their regional presence. The dominant components of the NAP sum include the Gramineae and plants of open habitats, such as *Artemisia*, Chenopodiaceae and *Thalictrum*. Typical representatives of the late-glacial flora are the two *Ephedra*-species, *E. distachya* and *E. altissima*-type. The presence of these apocratic floral elements prompts the conclusion that the area in the immediate vicinity of the tarn was still treeless, although the tree-line cannot have been far away due to the high pollen influx of *Pinus diploxylon*-type.

The above conclusions are confirmed by the macrofossil remains. The basal clay gyttja sediment (*Salix herbacea-Dryas octopetala* zone: lmaz 1) contains mainly remains of widely distributed arctic-alpines and dwarf shrubs: *Arabis alpina, Dianthus* cf. *glacialis, Dryas octopetala, Gypsophila repens, Saxifraga moschata, S. oppositifolia* and *Silene* cf. *acaulis*. These indicate the presence of pioneer communities of scree formations and alpine mats. Snowbed communities are represented by remains of *Salix herbacea, Cephalozia ambigua* and *Polytrichum sexangulare*. The plant macrofossils in this layer confirm the palynological conclusion, that the area around the Hirschbichl was still treeless at the beginning of the Preboreal Chronozone. The Younger Dryas is only reflected in the marked increase in *Artemisa* and high Gramineae values in the second half of the *Pinus-Artemisia* zone. Additionally the higher content of mineral components in the sediment let us conclude that the vegetation cover was still open.

In the middle of the Preboreal Chronozone a coniferous woodland became established on the Hirschbichl. This is documented by the *Pinus-Juniperus* zone (lpaz 2). Pollen values for *Pinus diploxylon*-type decline to ca. 60%, but this still remains the dominant pollen. *Pinus cembra, Alnus viridis, Betula „alba“* pollen increases a little and *Larix* pollen first appears. As well as the increase in the pollen influx values for AP, compared to those recorded during the *Pinus-Artemisia* zone (lpaz 1), the finds of needles of *Larix, Pinus* sp. and *P. cembra* provide evidence of the local presence of these tree species on the Hirschbichl itself from the mid-Preboreal onwards. Remains of the pioneer plants of open habitats in the alpine zone and of those of the snowbed communities (*Polytrichum sexangulare, Cephalozia ambigua*) disappear from the record at the same time.

The rise of the tree-line is an expression of a marked climatic amelioration which is also manifested by the change in sediment type from clay gyttja to fine detritus gyttja. At the same time, the *Pinus-Juniperus* zone commences (lpaz2). This ecological change, that *Larix-Pinus* woodlands became established on the Hirschbichl itself at an altitude of 2100 m, has been radiocarbon dated to 9370±170 BP (VRI-1137). By the close of the Preboreal Chronozone, the *Larix-Pinus* woodlands had reached the 2300 m level on the inner-alpine mountain slopes of the Eastern Alps (Bortenschlager, 1984).

One may assume, therefore, that in the Hirschbichl area the woodlands had colonized the slopes up to an altitude of at least 2200 m. This woodland was composed of *Larix decidua* and *Pinus cembra*, probably with *Pinus mugo* as well. *Alnus viridis* had colonised the wetter habitats at and above the tree-line. The forest floor vegetation in the *Larix-Pinus* woodlands already included members of the ericaceous dwarf-shrub community (*Rhododendron* sp., *Vaccinium* sp.), which are characteristic species of the Lariceto-Pinetum cembrae community.

The woodland itself had an open structure, since species of open habitats were still widespread. In particular during the older section of the *Pinus-Juniperus* zone (lpaz 2) light-demanding species such as *Artemisia, Betula,* Caryophyllaceae, Ericaceae, *Helianthemum, Juniperus* and *Thalictrum* could still thrive in the immediate vicinity of the tarn. Even later on pollen types of plants of the tall-forb formations are frequent, e. g. Umbelliferae, Cichoriaceae, Rosaceae, *Rumex* sp., *Senecio*-type.

Picea immigrated into the area at the end of the *Pinus-Juniperus* zone (lpaz 2), as shown by the slow but gradual increase in *Picea* pollen values and by the presence of sporadic needles in these sediment samples. Species of open habitats on the other hand, such as *Artemisia,* Chenopodiaceae and *Thalictrum* decline in frequency, thus indicating that the woodland was becoming more of a closed forest. Ericaceae now formed an increasing component of the ground flora.

Picea became a component of the forests at the altitude of the investigated site during the Boreal Chronozone (9110 ± 90 BP, the beginning of lpaz 3: *Pinus-Juniperus-Alnus* zone) and continued to spread altitudinally. This expansion of *Picea* is reflected in the marked increase in its pollen influx and in the increase in the frequency of its needles among the macrofossils. The AP sum is still dominated by pollen of *Pinus diploxylon*-type and, although *Pinus cembra* and *Larix* still attain percentage values, their pollen curves have markedly declined. This decline is similarly reflected in the macrofossil diagram, whereas finds of *Picea* increase markedly. Successively with the spread of *Picea* the Ericaceae pollen values rise, which is proven by the occurrence of *Rhododendron* and *Vaccinium* seeds. This in connection with the decline of the apocrats (*Artemisia,* Chenopodiaceae, *Helianthemum*) indicates a higher humus accumulation and acidification of the soil, that results in a change in the low-growing flora.

At the upper limit of the *Pinus-Picea-Corylus* zone (lpaz 4) the pollen values for *Picea* exceed those for *Pinus diploxylon*-type. This *Picea* dominance is confirmed by the results of the macrofossil analyses (lmaz 5). Spruce forests expand in the vicinity of the tarn at the beginning of the Atlantic Chronozone and displace the *Larix-Pinus cembra* forest to higher altitudes. At the end of this lpaz 4 *Picea* reaches its maximum altitudinal extension.

During the *Picea-Pinus* zone (lpaz 5) the forest composition at high altitudes remained unchanged until the beginning of the *Picea-Pinus-Fagus zone* (lpaz 6). The spread of *Fagus* in the lower valley bottoms is recognized in the pollen diagram by distinct percentage values and marks the beginning of the Subboreal Chronozone. In the local forests of the subalpine zone the values of *Picea* start to decline whereas *Pinus* increases indicating a timberline depression. At the end of the Subboreal *Pinus* und *Picea* attain the same percentage values.

In the *Pinus-Picea* zone (lpaz 7) the values of *Pinus* and *Picea* remain unchanged, whereas *Pinus cembra, Juniperus* and *Larix* increase. Additionally among the NAP a higher diversity is recognisable, as well as an increase of the Gramineae, indicating a decrease of the timberline. From the beginning of the Subatlantic an open *Pinus cembra-Larix* forest thrives at the altitude of the tarn.

Vegetational Changes During The Early Holocene

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 had also at the latest in the late Preboreal Chronozone regressed to their present-day extents and at no time in between 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 parameters by the late Preboreal (Patzelt and Bortenschlager 1973). Since by that time the tree-limit had risen above the altitude of the Hirschbichl. At the beginning of the Preboreal reforestation starts with a *Betula-Juniperus* phase, which is superseded by a *Betula alba-Pinus cembra-Larix* forest. *Alnus viridis* is already present at the site. In the undercover of the forest there are already thriving the characteristic representatives of the Larici-cembretum (*Rhododenron, Vaccinium*). Besides Gramineae taxa of tall forbs (e.g. Umbelliferae, Cichoriaceae, Thalictrum) are common and indicate open forest communities. In these open forests *Picea* immigrates in the middle of the Preboreal. At the beginning of the Boreal latest *Picea* has arrived at the altitude of the site. Now that tree competes with *Pinus cembra* and *Pinus mugo,* of which the PAR decline from now on. Understanding succession as a population process PAR enable an other insight in the vegetation development at that times. The PAR of *Picea* shows a constant rise from 9500 until 8500 BP whereas the pollen influx of *Pinus* decreases. The values for *Alnus viridis* remain unchanged on the same level. This means that *Picea* occupies of the stands of *Pinus,* especially *Pinus mugo.*

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* from the late Preboreal onwards. However they all first achieved their maximum distributions only during the early Atlantic Chronozone. The relative falls in *Pinus diploxylon*-type pollen values, in the middle of the *Pinus-Juniperus* zone (lpaz 2) and again at the start of the *Pinus-Picea-Corylus* zone (lpaz 3) are only accompanied by relatively minor increases in the NAP curve. Since these declines in the *Pinus* values at 310 and 287,5 cm occur abruptly, they must have been caused by some kind of sudden, short-term disturbance. At both these levels in the macrofossil diagram there are increases in the frequency of charcoal fragments. In particular carbonised needles and wood of *Pinus cembra,* carbonised wood fragments of *Pinus* sp., of *Larix/Picea*-type and also of Ericaceae (*Vaccinium* sp.) were identified. The size of the charcoal fragments concerned (mostly in the >2mm range) and the species involved indicate the occurrence of local fires in the subalpine region.

The detailed palynological record of this event is as follows: at 310 cm depth both the pollen diagram and the pollen influx diagram show a marked decrease in the curve of *Pinus diploxylon*-type. In consequence the values of *Alnus viridis, Pinus cembra, Larix, Artemisia, Alnus* sp., *Alnus viridis,* Umbelliferae, *Betula,* Chenopodiaceae, Gramineae and *Juniperus* all rise. Pollen types of representatives of the tall forb-formations (*Epilobium, Geranium, Rumex*) and of the alpine mat vegetation (Gentianaceae, *Botrychium, Selaginella selaginoides*) are frequent. Sporadic pollen finds of hemerophilous species (Urticaceae) also occur. Afterwards, at 305 cm depth, the values for the *Pinus diploxylon*-type rise once more and those of the light-demanding species mentioned above decline. Taken together this is a reflection of an opening-up of the woodland in the immediate vicinity of the tarn, followed by a secondary succession that starts with *Alnus viridis,* which is in its turn superseded by a *Betula-Larix-Pinus* woodland and finally a *Larix-Pinus* woodland.

A similar vegetation change, also accompanied by the presence of charcoal fragments, is identifiable at 287.5 cm depth. In this case the decreases in tree pollen are in the values for *Pinus diploxylon*-type and *Pinus cembra.* In consequence of the deforestation, pollen derived from the long distance transport of pollen are better manifested, e.g. *Corylus.*

The question now is, were these fires caused naturally or by man? Jacobi et al. (1976) have argued that periodic forest fires within any particular area are highly probably man-induced.

Zoller (1960) found a comparable situation in pollen diagrams from two mires in the subalpine region of the Western Alps. During the early Holocene a lot of horizons containing charcoal fragments were noted. Coincident with these charcoal layers there were maximum values for herb pollens: viz. Umbelliferae, *Artemisia,* Brassicaceae, Campanulaceae, Caryophyllaceae, Chenopodiaceae, Cichoriaceae, *Epilobium angustifolium,* Fabaceae, *Humulus/Cannabis*-type, *Plantago alpina*, Ranunculaceae, Rosaceae, *Thalictrum, Urtica* and *Vitis*. The first of these charcoal horizons yielded a 14C-date of 9560 + 150 BP. That this date falls in the Mesolithic period, together with the fact that no previous indications of fires were recorded, suggests strongly that human impact was involved. Solitary finds of pollen of plants, that grow in the alluvial forests (*Humulus/Cannabis*-type, *Vitis*), may have been associated with Mesolithic hunters (Zoller 1960). However, this explanation disregards the change in the sources of pollen that occur when an area around a sedimentation basin becomes deforestated. In addition one must remember that long-distance derived pollen will be deposited on the snow cover within the catchment area of such a locality and will be washed down during the snow melt. In alpine regions pollen of plants growing in the colline and montane zones is deposited during early spring and summer, whilst there is still a snow cover on the catchment area. These types of pollen are not present in the Hirschbichl diagrams because of the drainage area of the tarn is only as extensive as the lake surface itself. In pollen diagrams from localities, in which the catchment area is much more extensive than the lake surface, the record of pollen types derived from the colline and montane zones is usually more consistent (Fig. 2).

If fire was a method used by the Mesolithic hunters and gatherers to influence the subalpine environment, periodic burning would have been necessary to maintain an open structure of the woodlands. The investigations on the Hirschbichl show that burning occurred at such long intervals, that complete vegetation successions from open areas to a mature forests once more could take place after each disturbance by fire. This makes it unlikely, that the fires were caused by man.

It seems much more likely that, as has been found to be the case in the Lagorai mountain group (Kofler 1992), such localised forest fires represent natural disturbances in the *Larix-Pinus* forests. Charcoal fragments occur in the Hirschbichl sediments throughout the Preboreal and Boreal Chronozones, but decline during the Atlantic. Only twice within a five-hundred-year period was the fire intensity sufficient to deforest the area adjacent to the tarn. Most of the charcoal fragments were probably derived from fires in the understorey of the *Larix-Pinus* woodlands.

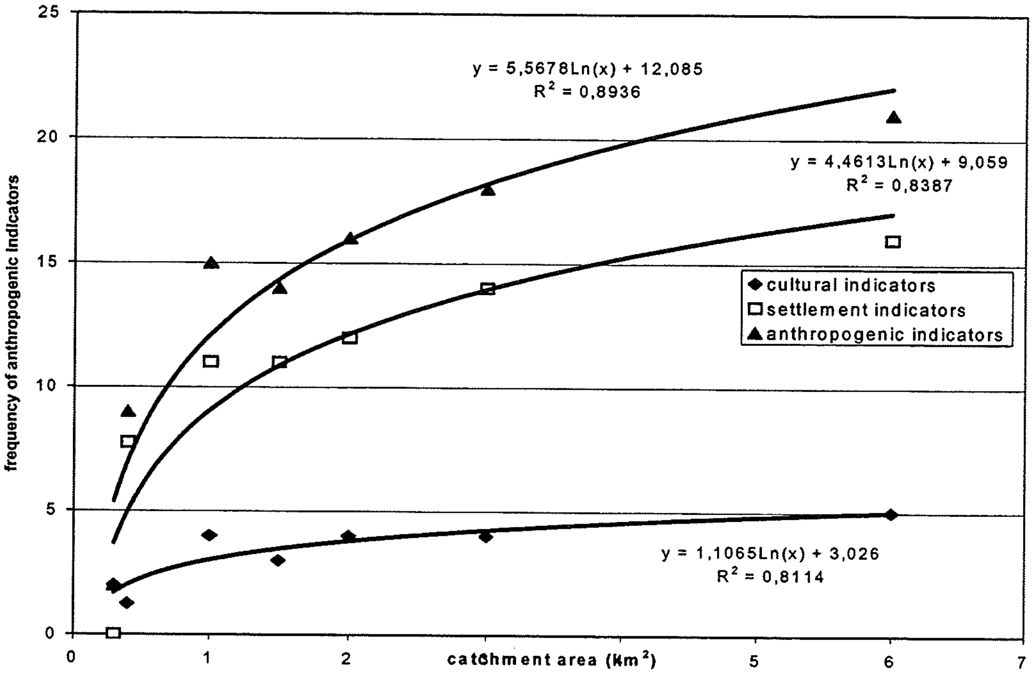

Fig. 2: Frequency of long-distance transported anthropogenic indicator pollen in relation to the catchment area of the sediment deposit (according to Oeggl & Wahlmüller 1994).

Fire as a disruptive factor in the forests at these altitudes in the Alps has been an under-rated factor for a long time now, because no naturally-caused forest fires at the tree-limit have been reported during the recent historic period. However, forest fires are frequent in primeval natural forests because of the accumulation of dead wood and surface litter (Dengler, 1935). Nevertheless, in the early Holocene, fire has probably contributed materially to the maintenance of the open structure of the subalpine forests, such that patches of alpine mat vegetation and of tall-forb formations were able to find a foothold between the trees. Only after the marked expansion of *Picea* in the forests at these altitudes during the Atlantic Chronozone, did the canopy become closed enough to exclude these ground-cover communities.

Conclusions

During the early Holocene fires probably commonly occurred in the subalpine *Larix-Pinus cembra* woodlands. The periodicity of such fires provides no evidence of human impact in these regions at that time. On the other hand, the fires contributed to the maintenance of a high bio-diversity in this ecotone. The subalpine region therefore provided favourable grazing habitats for the herbivorous mammals, that roamed the alpine region and which were the quarry of the Mesolithic hunters.

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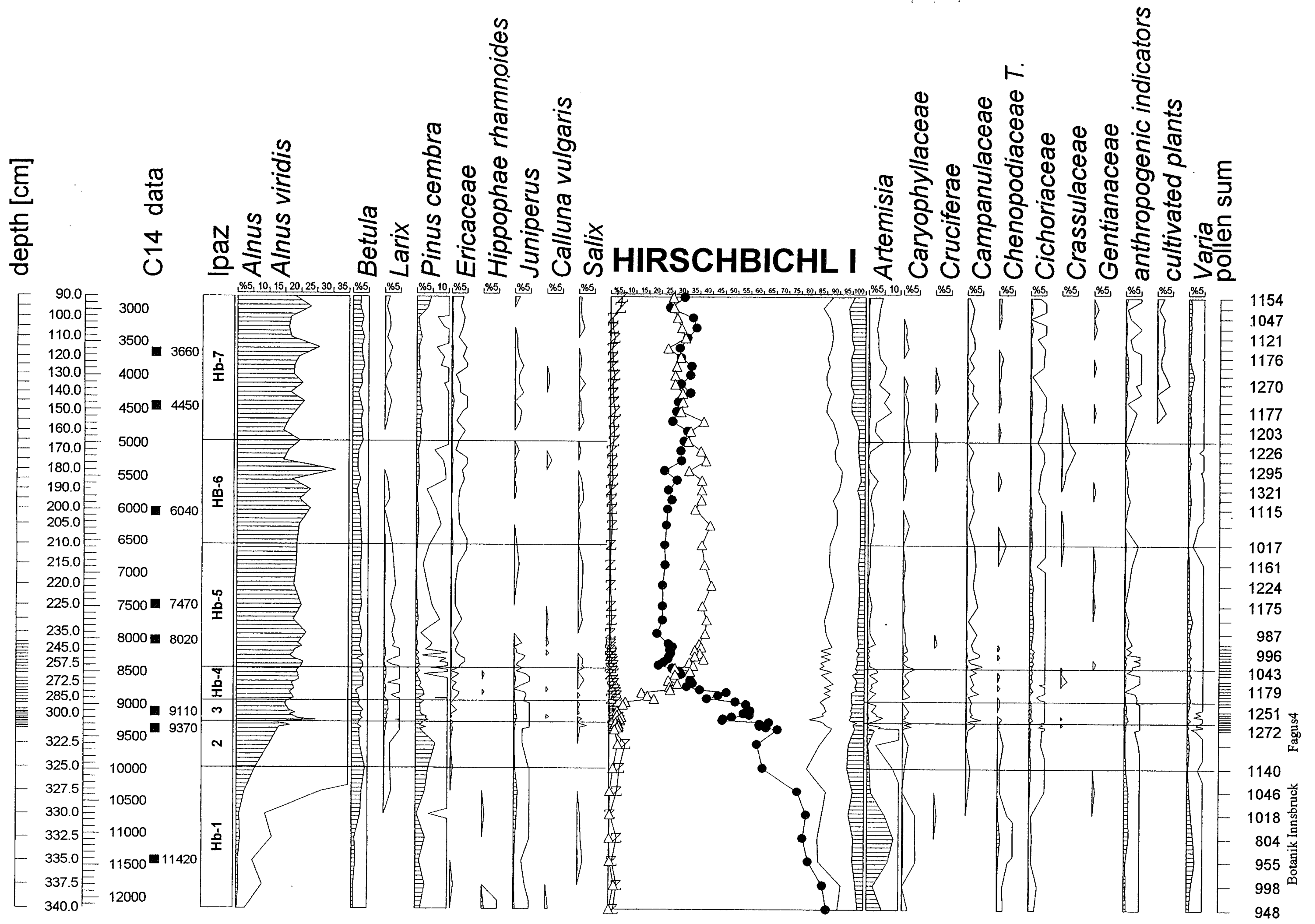
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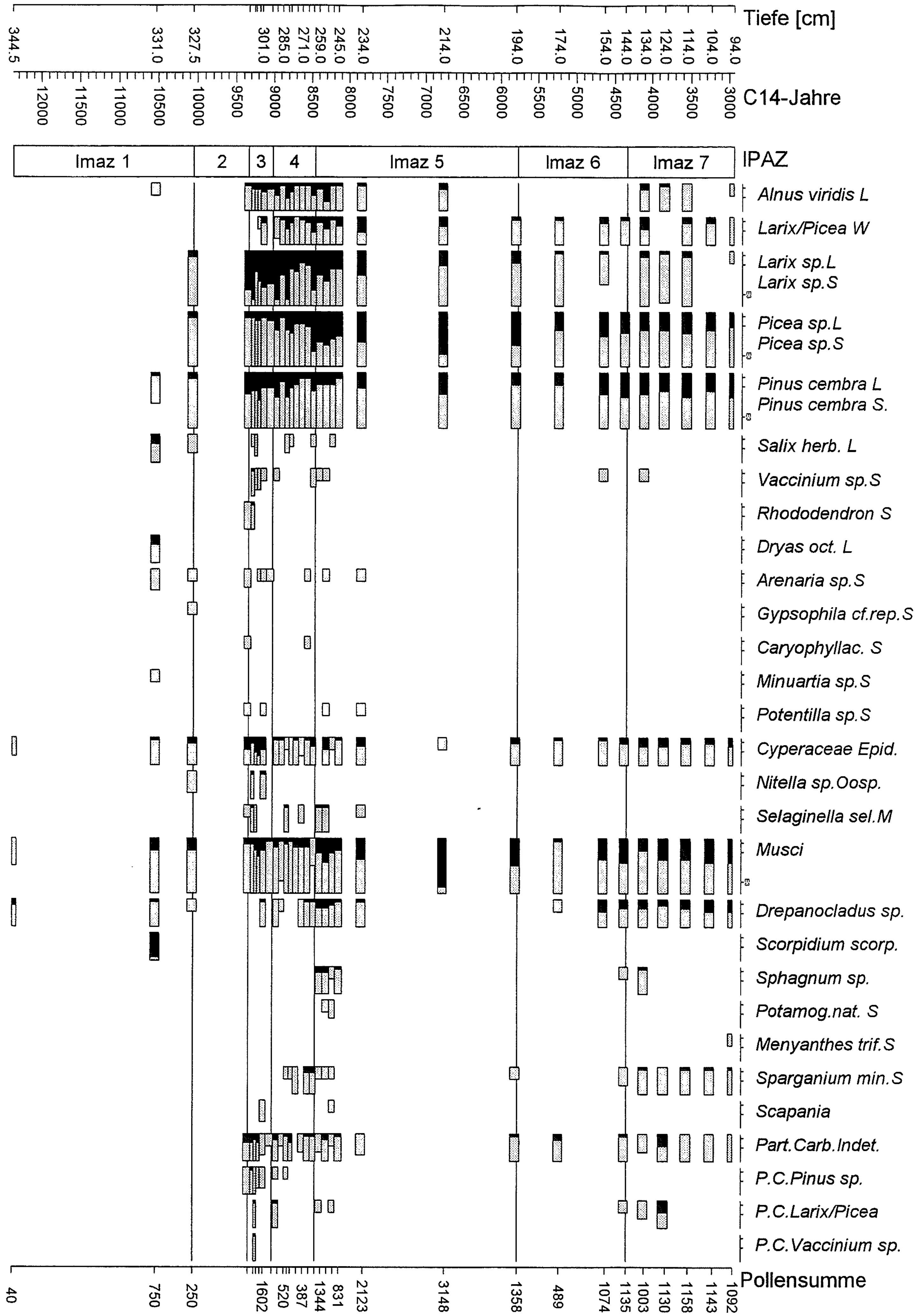

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Late-glacial and Holocene vegetation development of the Überetsch (Südtirol)

Karin Kompatscher & Klaus Oeggl

INTRODUCTION

The terrace of the Überetsch is located south-west of Bozen and is surrounded by the steep shelving dolomite rocks of the Mendel in the West and the Mitterberg (quarz porphyry) in the East, where the rocks slope to the recent Etsch valley. The Überetsch itself represents a former interglacial (Riss-Würm) valley bottom of the Etsch valley and extends 14 km from Sigmundskron in the North to Auer in the South. The maximum altitude of the former valley bottom is 652 m.

The modern landscape of the Überetsch was made by advancing glaciers and the Etsch river 50.000 yrs ago, when fluviatile gravel up to 400 m thick was deposited on the terrace. The major components of the gravel are crystalline rocks, but there is also sandstone, quartz porphyry, and in minor quantities, limestone. During the Würm-maximum the terrace was covered by a 1500 m thick glacier. The deposits of the ground moraine are only a few meters thick and cover the gravel beds.

The Great Montiggler lake is embedded in one of the longitudinal basins of the Mitterberg (Fig. 1). The basin of the lake was formed by the Würm glacier and is characterised by a steep sloping shoreline and a broad, flat basement. The maximum lake extension is 750 m from north-east to south-west direction, and the maximum depth of the lake is 11,5 m in the north-eastern part. The Small Montiggler Lake is located within the hydrological catchment area. It drains into the Great Lake during spring. The Great Montiggler Lake is fed by rainfall, snow, melting water and ground water. A surface outflow exists in the south-west end of the lake. There a wetland adjoins the lake. It is dominated by *Phragmites australis*. The most common hydrophytes are *Nymphaea alba, Myriophyllum spicatum, Acorus calamus, Ceratophyllum demersum, Carex elata, Carex diandra, Carex lasiocarpa, Drosera rotundifolia, Rhynchospora alba, Schoenoplectus lacustris, Equisetum fluviatile, Hydrocharis morsus-ranae, Iris pseudacorus, Menyanthes trifoliata, Polygonum amphibium, Potamogeton* div. spec., *Thelypteris palustris, Typha latifolia.*

The forests around the lake consist of pine (*Pinus sylvestris*) with varying admixtures of broad-leaves like *Castanea sativa, Quercus pubescens, Quercus petrea, Fraxinus ornus, Ostrya carpinifolia, Populus tremula, Betula alba and Tilia playtyphyllos* as well as the conifer *Larix decidua.* On wet ground there thrive formations with *Fagus sylvatica, Picea abies* and *Abies alba.*

Today in the wider vicinity of the lake, the vegetation is characterised by vine yards and orchards. Remains of the submediterranian Orneto-Ostryetum are found in the submontane zone of the Mendel and on the slopes of the Mitterberg, there is a Vaccinio-Pinetum sylvestris rich in *Castanea sativa* and *Populus tremula.* Above on the limestone of the montane zone a Abieti-Fagetum and pine forests grow. On the mountain summits krummholz with *Pinus mugo* occurs.

Archaeology:

The Überetsch is one of the most interesting archaeological areas of the Southtyrol. Human traces are detected from the Mesolithic period onwards. The Neolithic is represented only by burials. The appropriate settlement has yet to be discovered. The only settlement known on the southern part of the Mitterberg derives from the Eneolithic. A strong settlement activity is recognisable for the Bonze Age, in particular for the middle Bronze Age period. During the late Bronze Age human activity seems to have reduced, because only seven sites are known within the area.

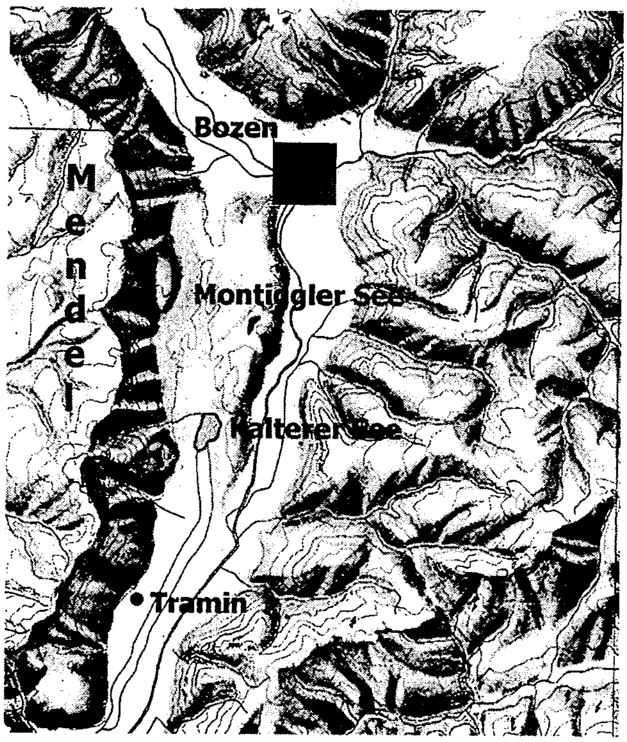

Figure 1. Location of the Lake Montiggler.

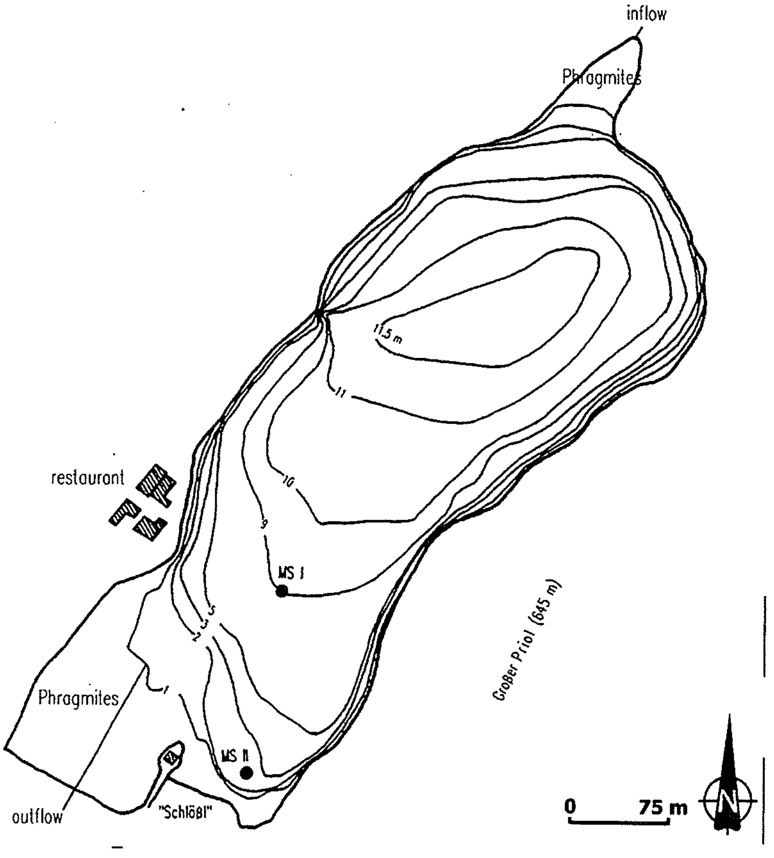

Figure 2. Bathymetric map of the Lake Montiggl

The Iron Age is represented by many traces. One of the most famous finds of iron tools (axes, caulking-chisel, hammer, hoes, pickaxes, knives, sickles, etc.) from the entire Alps comes from this area. During the early Iron Age (4th century BC) several settlements were abandoned because of the Celtic migrations.

In 15 BC Drusus conquered the Überetsch and several Roman farmhouses were established in the 1st century AD on the terrace of the Überetsch.

Vegetation history:

The earliest Late-glacial vegetation development is not included in the sediment profile from the centre of the Lake Montiggl. Reforestation (*Pinus-Betula-Hippophae-Artemisia*-lpaz) has already taken place when the sedimentation started at the coring point. *Pinus* is dominating whereas *Betula* shows only 6%. Although the AP reach 91%, the pine forests were quite open. Apocrats (*Artemisia*, Chenopodiaceae, *Thalictrum*) and the light demanding shrubs *Hippophae* and *Juniperus* are still thriving in the forests. Pollen from warmth demanding species (Quercetum mixtum) is missing.

The Younger Dryas is documented in an NAP maximum at the beginning of *the Pinus-Betula-Artemisia*-lpaz. This climatic deterioration is also recognisable within the sediment composition. Now more minerogenic particles are admixed in the fine detritus gyttja. Within the forests the participation of *Betula* grows, although *Pinus* is still the dominating tree. In the second half of the younger Dryas the trees of the Quercetum mixtum (*Quercus, Ulmus, Tilia, Fraxinus*) are immigrating in the investigation area.

With the spread of the warmth-demanding species (*Corylus, Quercus robur*-type, *Ulmus, Tilia*) the Holocene starts. This is documented in a *Pinus-Betula-Quercus-Picea*-lpaz, which lasts from the Preboreal until the early Boreal. The dominating forest community is still the *Pinus-Betula* forest, but at the beginning of this lpaz the Quercetum mixtum species immigrated and expanded in the investigation area. There is no confirmation of an earlier occurrence of these species, as was claimed by Schmidt (1975) according to the record of *Quercus* and *Fraxinus* pollen in the Alleröd of another sequence from the lake. Other newcomers in this lpaz are *Carpinus betulus* and *Picea*.

At the end of this lpaz in 1172 – 1182 cm depth, a higher sand accumulation in the fine detritus gyttja is taken as a sign of higher erosion within the catchment area. This event is contemporary with the Venediger Schwankung (Patzelt & Bortenschlager 1973), which can also be recognised in high altitudinal profiles from the Villanderer Alm (Seiwald 1980).

At the beginning of the *Pinus-Alnus-Quercus*-lpaz, which includes the Boreal, Atlantic and Subatlantic Chronozone *Pinus* forests still dominated beside the Quercetum mixtum, but also *Picea* expanded, and *Abies* immigrated. A little later (ca. 7100 BP interpolated) *Fagus* thrived at the site, which is proven by macroremains (wood). If this 14C-date from 1170 cm depth is correct and not affected by hard-water effect, then *Abies* would have occurred 1000 years earlier in the Überetsch than in the adjacent areas (Beug 1964, Bertoldi 1968, Kofler 1992). On the other hand an early occurrence of *Fagus* in the area is shown by 14C-data from the nearby located Tschögglberg (6825+ 230 BP, Wahlmüller 1990), as well as in peat profiles from the Villanderer Alm (Seiwald 1980). Nevertheless, both *Abies* and *Fagus* established an Abieti-Fagetum, which colonised mainly the montane zone of the Mendel limestone slopes in the west, whereas the porphyry summits in the east were covered by *Quercus* and *Pinus* forests.

Anthropogenic impact in the wider vicinity of the lake is recorded by single finds of *Plantago lanceolata* pollen from 6000 BP. Neolithic farming is documented by anthropogenic indicators (*Artemisia*, chenopods, *Plantago lanceolata*-type, *Rumex, Urtica*) and cultural indicators (*Cerealia*-type) for the first time at 4600 BP in the lake deposits.

The second part of the Subboreal is reflected by a *Pinus-Quercus-Corylus-Juniperus* lpaz. This lpaz is characterised by several anthropogenic vegetation changes. From the beginning of this pollen zone the charcoal particles rise indicating a greater frequency of fires within the catchment. Consequently the Gramineae and herbs increase and single finds of cultural indicators (Cerealia) are recorded. Human impact increases at 4000 BP. A marked decline in the *Pinus*-curve contemporary with a charcoal peak reflects the stronger human interference on the local vegetation. Maxima in *Betula, Corylus, Juniperus* as well as in the Gramineae, Chenopodiaceae, *Rumex, Plantago lanceolata* and Umbelliferae indicate open forests, which were used for pasture. In consequence *Ostrya carpinifolia* and *Fraxinus ornus* expand in the disturbed forests, whereas *Tilia* almost disappears. This settlement phase ends at the end of the Neolithic and *Pinus* forests re-established again.

At the beginning of the Bronze Age another clearing is recognised in the decrease of *Pinus* again. Now the severe impact on the vegetation is reflected in a change of the tree composition. The Pinus forests are burned and Quercus expands.

According to the human interference from the Neolithic onwards a new forest type is created: the manna-ash-hophornbeam forest (Orno-Ostryetum). Both species thrived in the *Quercus* forests of the area since the middle of the Atlantic, but their expansion started with the Neolithic human interference. Beug (1964, 1965) and Kral (1982) explain this change of the downy oak forests to hophornbeam woodlands as a consequence of coppicing. This forest management benefited *Ostrya* and *Fraxinus ornus*, because, firstly, both these species regenerate faster than *Quercus*, and secondly, they show a higher fire resistance. Nevertheless, the ecological demands and distribution of both species show that they prefer shady humid northwest exposed sites. This lets us suggest that beside the anthropogenic interference also a climatic impact (increase in humidity) was responsible for the expansion of these forests.

During the *Quercus-Fagus-Betula* lpaz human impact became more intensive. At the beginning of this lpaz *Quercus* exceeded the amount of *Pinus* pollen, and *Ostrya* showed a maximum. The *Pinus* forests are reduced whereas the deciduous forests dominated by *Quercus* expanded.

Large clearings are recorded by a decrease of the *Quercus* curve at the beginning of the Iron Age, and they last until the Roman period. New cultivated plants appear, e.g. *Castanea sativa, Juglans* and *Secale.*

During the Roman period the oak forests expanded again, but at the beginning of the Middle Ages they are drastically reduced (*Quercus-Pinus-Corylus-Juniperus* lpaz). Also *Ulmus, Fraxinus excelsior* and *Carpinus betulus* are affected. These former forest stands were also changed into fertile land.

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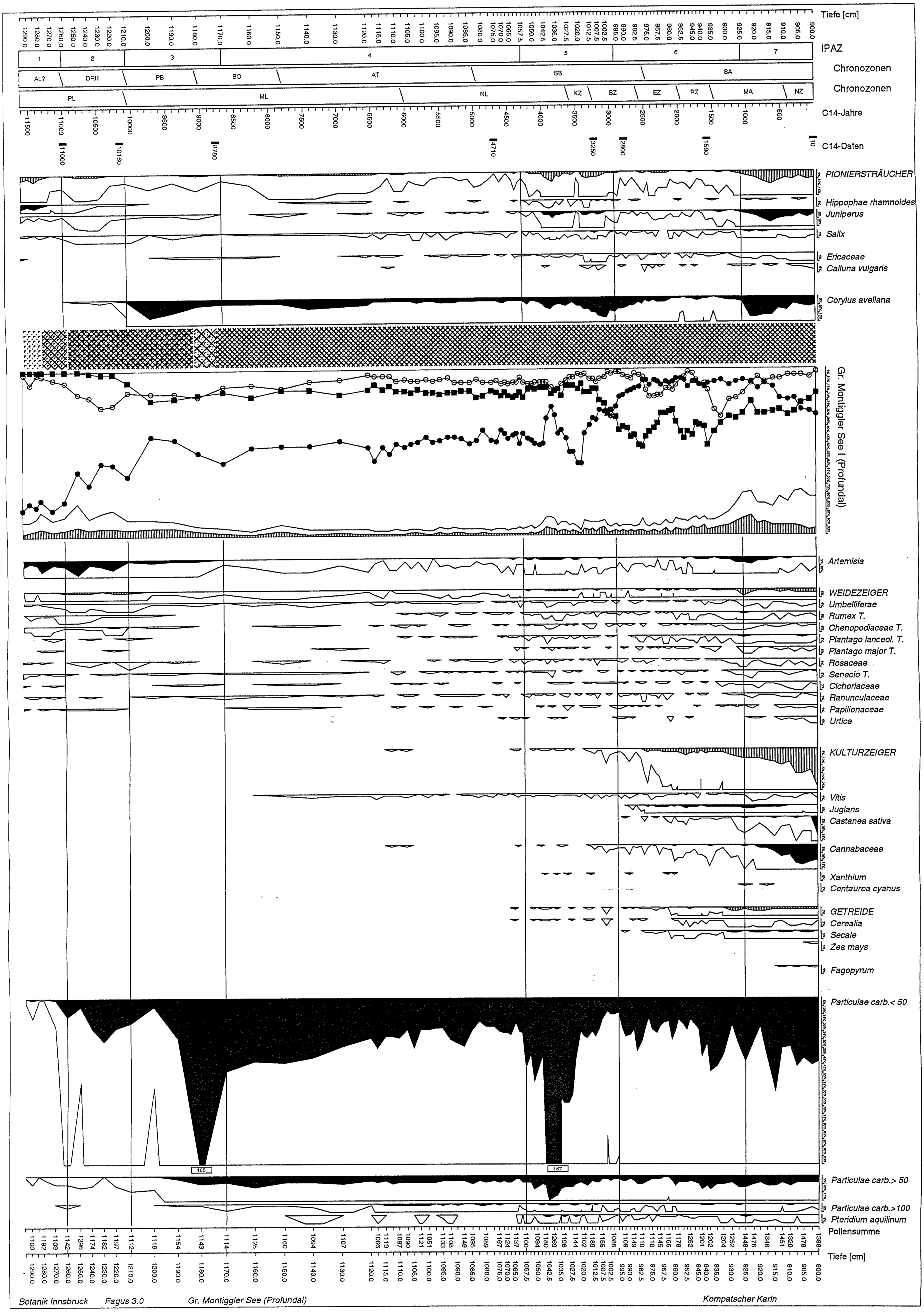

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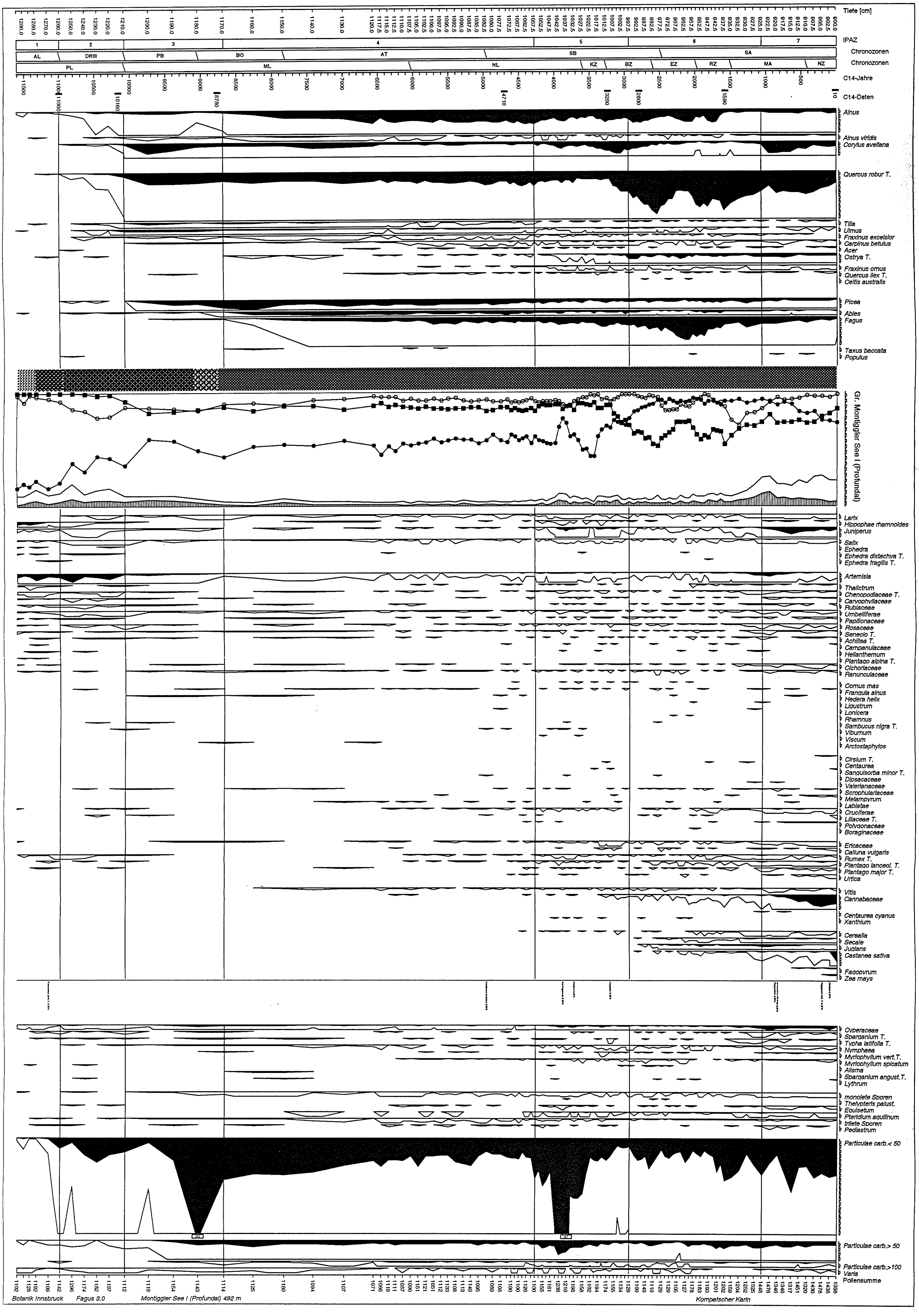
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Tilia
Ulmus
Fraxinus excelsior
Carpinus betulus
Acer
Ostrya T.
Fraxinus ornus
Quercus ilex T.
Celtis australis
Picea
Abies
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Taxus baccata
Populus
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Hippophae rhamnoides
Juniperus
Salix
Ephedra
Ephedra distachya T.
Ephedra fragilis T.
Artemisia
Thalictrum
Chenopodiaceae T.
Caryophyllaceae
Rubiaceae
Umbelliferae
Papilionaceae
Rosaceae
Senecio T.
Achillea T.
Campanulaceae
Helianthemum
Plantago alpina T.
Cichoriaceae
Ranunculaceae
Cornus mas
Frangula alnus
Hedera helix
Ligustrum
Lonicera
Rhamnus
Sambucus nigra T.
Viburnum
Viscum
Arctostaphylos
Cirsium T.
Centaurea
Sanguisorba minor T.
Dipsacaceae
Valerianaceae
Scrophulariaceae
Melampyrum
Labiatae
Cruciferae
Liliaceae T.
Polygonaceae
Boraginaceae
Ericaceae
Calluna vulgaris
Rumex T.
Plantago lanceol. T.
Plantago major T.
Urtica
Vitis
Cannabaceae
Centaurea cyanus
Xanthium
Cerealia
Secale
Juglans
Castanea sativa
Fagopyrum
Zea mays
Cyperaceae
Sparganium T.
Typha latifolia T.
Nymphaea
Myriophyllum vert. T.
Myriophyllum spicatum
Alisma
Sparganium angust. T.
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Equisetum
Pteridium aquilinum
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The Bronze Age storage assemblages of Ganglegg at Schluderns (Vinschgau, North Italy)

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Study site

The Bronze Age settlement Ganglegg is located at Schluderns in an altitude of 1142 m (Fig. 1). Climatic and geographic factors have made the Vinschgau suitable as a prehistoric farming and settlement area. The relief of the Vinschgau caused a long insolation period similar to the upper Italian lowlands (Oberitalianische Tiefebene). The average number of sunny hours per year is 2400 and this area is one of the most intense insolated area of the Alps (excluded the Southeast part of the French West Alps). Annual precipitation measured in the surroundings of shallow the study site is about 500 mm per year. The greatest part of the annual precipitation is falling in the summer half-year. Below an annual precipitation of 750 mm an irrigation-system is necessary to allow an intensive grassland farming. So already the prehistoric man introduced the irrigation channels called "Wale" in Vinschgau. The "Wale" are still known from the Celtic time (Iron Age).

Mean annual temperature is around 9 – 10 °C. A closed snow cover occurs not every year (FLIRI, 1975). In the inner Alps semiarid grasslands are typical in lower parts and they have a definite "pasture character", especially where they are growing on soils (ELLENBERG 1988).

Material and Methods

The Bronze Age settlement under investigation was not waterlogged, and so as the result of these preservation conditions, only charred and a few mineralised awns were found. The material was taken from a Bronze Age storehouse. This building contained a unique structure: plinths of stone were set up along the house wall in a distance of 40 cm. On this masonry followed a wall of wood which created a deposit for storing cereal and pulses. A fire destroyed the house and the charred material spread on the floor (GAMPER & STEINER 1999). In addition, also samples were taken from the outdoor area. But these samples contained only few fragments of cereals and charcoals. The charred plant remains of the soil samples were rescued by flotation technique. Before the process of flotation was carried out, the weight and volume of the samples were recorded. The sieves had following size of the mesh: 2, 0.5 and 0.25 mm.

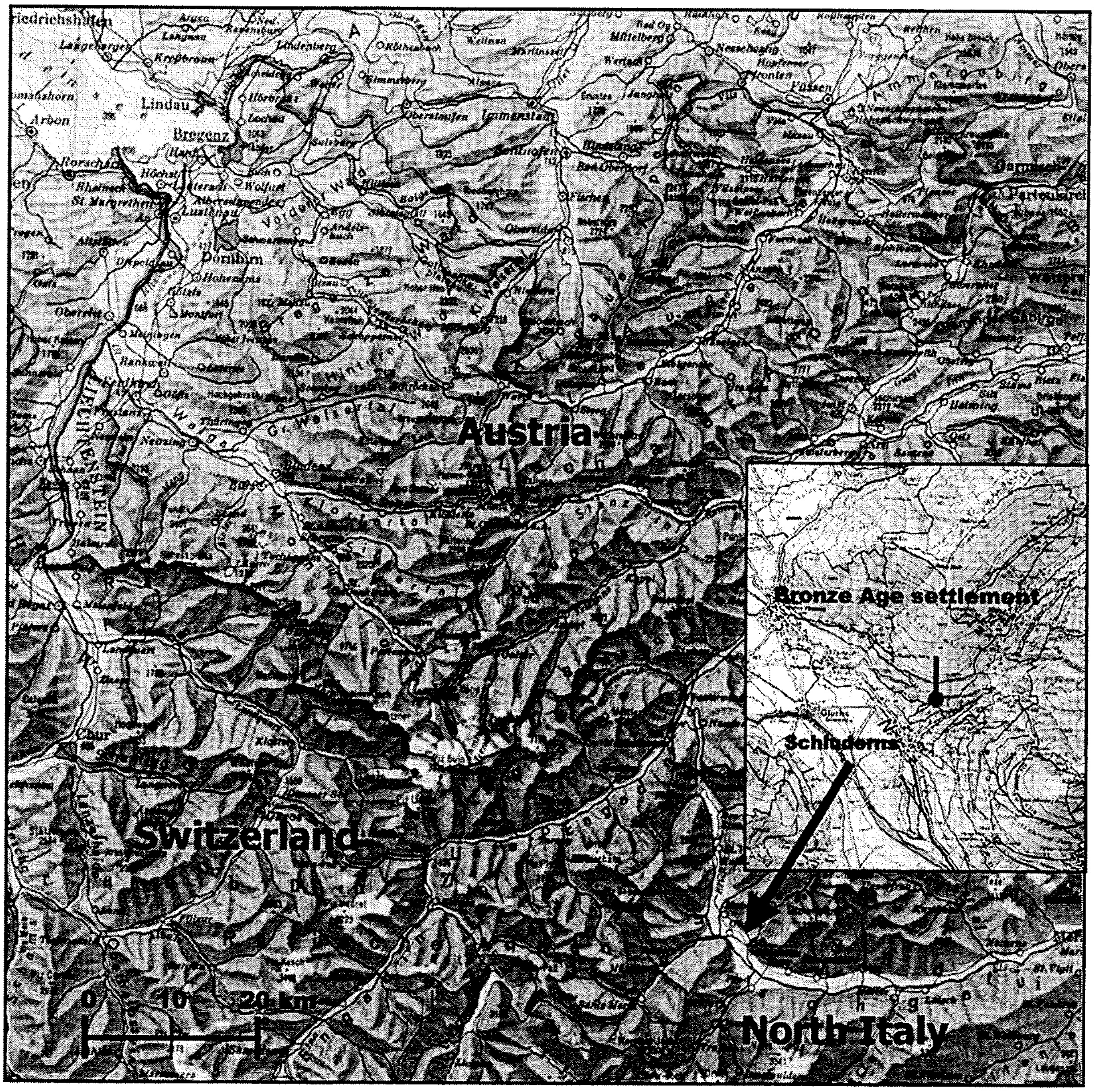

Fig. 1. Map showing the location of the Bronze Age settlement "Wallburg" Ganglegg

Results and Discussion

In the discussion of storage assemblages should also be included the weight of grains and pulses because of the different seed production among the species. So the archaeobotanical research established legume *Vicia faba* (horsebean) as the main crop in Ganglegg. Beside this legume the major species of cereals were *Hordeum vulgare* var. *nudum* (naked barley) and *Panicum miliaceum* (broomcorn millet) and in small quantities *Hordeum vulgare* (hulled barley) and *Triticum dicoccum* (emmer) (table 1 and Fig. 2).

Horsebeans dominated in the half of samples from the layer 4 and also in one sample of layer 5 (Fig. 2). *Vicia faba* grows well in both warm, summer-dry Mediterranean environments and in the more northern temperate parts of Europe and Asia. Archaeological remains of *Vicia faba* ranging from the Neolithic period to Roman times were all within the range of var. *minor*. The measurements of the seeds of Ganglegg were referred to var. *minor*. Larger quantities of frequently somewhat bigger seed appeared in final Neolithic/Bronze Age settlements (3rd millennium BC) in the west Mediterranean basin, and in the contemporary Bronze Age sites in south and central Europe. HOPF (1983) investigated storage finds of horsebean at the site Scuol-Munt Baselgia (Graubünden, Switzerland).

Table 1. Cultivated plant remains of late Bronze Age layers (1400 – 1200 BC) at Ganglegg/Schluderns (North Italy) (n = number of remains, w= weight in g)

Layer	**5**		**4**		**TOTAL**	
Number of samples	4		20		**24**	
Total volume (l)/weight (kg)	3.5	4.0	19.7	33.9	**23.2**	**37.9**
	n	w	n	w	**n**	**w**
Cereal grains						
Hordeum vulgare (hulled barley)	296	3.2	1232	16.4	**1528**	**19.6**
Hordeum vulgare var. *nudum* (naked barley)	13240	141.3	5071	66.1	**18311**	**207.4**
Triticum dicoccum (emmer)	1147	15.4	1762	27.7	**2909**	**43.1**
Triticum monococcum (einkorn)	3	0.1	12	0.2	**15**	**0.3**
Triticum spelta (spelt)	4	0.1	17	0.3	**21**	**0.4**
Hordeum vulgare (hulled barley)/ *Triticum dicoccum* (emmer)	2475	32.0	831	11.0	**3306**	**43.0**
Triticum sp. (wheat)	0	0	2	0.1	**2**	**0,1**
Avena sp. (oat)	0	0	7	0.2	**7**	**0,2**
Panicum miliaceum (broomcorn millet)	86964	88.1	56807	76.0	**143771**	**164.1**
Cerealia, indet.	0	0	932	12.5	**932**	**12.5**
Pulses						
Pisum sativum (field peas)	47	1.5	2396	61.8	**2443**	**63.3**
Vicia faba (horsebean)	647	52.0	8104	614.4	**8751**	**666.4**
TOTAL	**104823**	**333.7**	**77173**	**886.7**	**181996**	**1220.4**

At the site Ganglegg grains of both naked and hulled barley were frequently represented. Barley withstands drier conditions, poorer soils, and some salinity. Because of these qualities, it has been the principal grain in numerous areas and an important element of the human diet. Hulled barley evidences were predominated in North Italy, North Tyrol and Switzerland (Graubünden). However, very few naked barley grains were recorded in Sot□iastel (SWIDRAK & OEGGL, 1997), Riparo Gaban (NISBET, 1984) and Padnal/Savognin (RAGETH, 1986). During the Bronze Age, from ca 1800 to 700 BC, a shift from naked to hulled barley can be noticed, whereas the glume wheats einkorn and emmer were still very common. Cereals, especially *Triticum dicoccum* but also *Hordeum vulgare*, prevail; pulses are slightly better represented than in the Neolithic. In traditional farming communities naked barley were frequently favoured for the preparation of food, while hulled forms were preferred for brewing beer and for animal feed. The naked grain trait is controlled by a single recessive gene. Kernels of naked barley could be frequently recognised by their shrivelled skin and by the furrow that stayed narrow also near the apex. The preservation of the carbonised barley grains was rather poor. Most of them showed deformations caused by puffing. Because of the poor condition of the grains it was very difficult to distinguished between grains of *Hordeum vulgare* var. *nudum* and *Triticum dicoccum*.

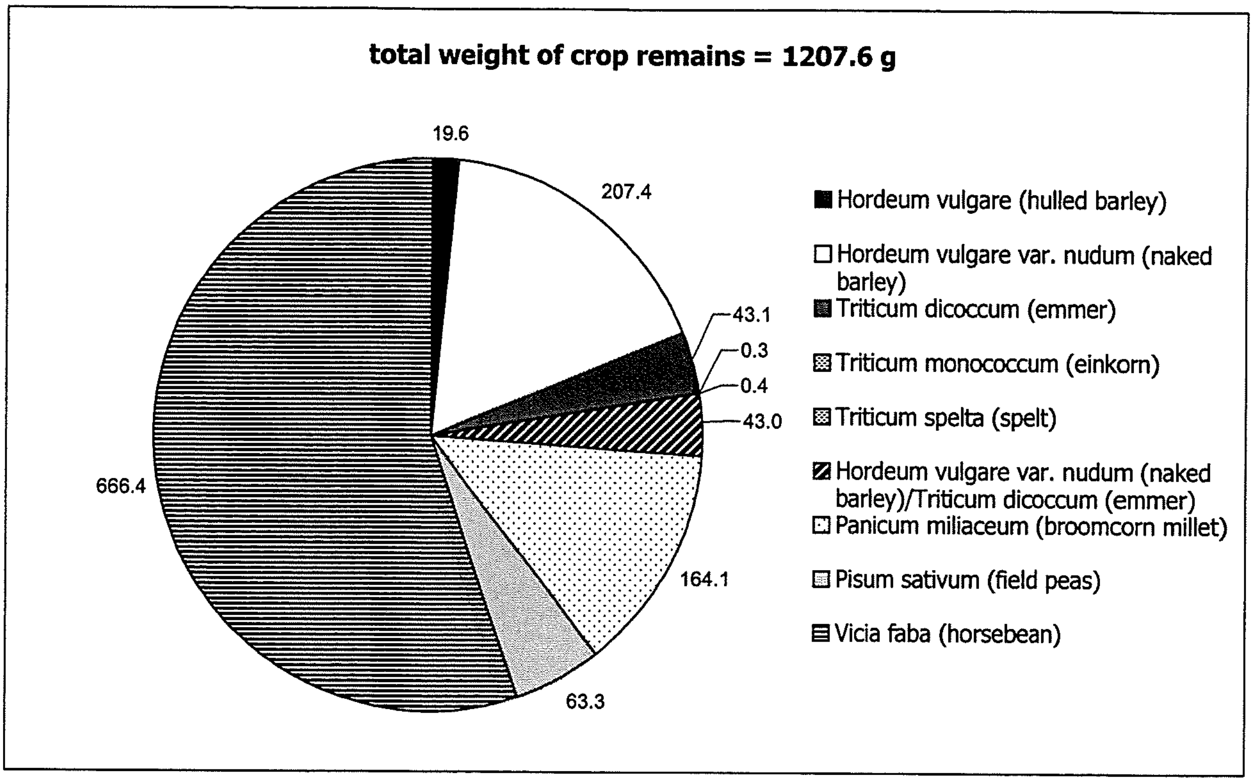

Fig. 2. Composition of the Bronze-Age samples (layer 4+5)

An enormous amount of Broomcorn millet were discovered in one sample of layer 5 and in one of layer 4 (Table 1 and Fig. 2). *Panicum miliaceum* ranked among the hardiest cereals. It is a warm season plant which stands up well to intense heat, poor soils, and severe droughts, completing its life cycle in a very short time and succeeding in areas with short rainy seasons. In Northern Italy, the millet appeared in early Bronze Age (1700 – 1500 BC) settlements.

The minor presence of einkorn and spelt could be interpreted as a small admixture of main crops. Also the number of oat grains was very small and the naked caryopses could not be identified to the species. Most of the oat grains mentioned since the Early Neolithic must be regarded as weedy admixtures.

Two samples from the layer 4 were dominated by *Pisum sativum* and in one of these samples field peas were mixed with hulled barley. Peas are associated with the spread of Neolithic agriculture into Europe and here they are closely associated with the wheat and barley production. Finally, throughout Europe the Bronze Age finds of peas (as well as of other pulses) are fewer and sparser compared to the Neolithic finds. The earliest peas from Eastern Europe and Switzerland come from either late Neolithic or Bronze Age sites. Richer deposits of pulses, including lentil and broad bean, occur again in the European settlements of later periods.

By rotation or mixing legume crops with cereals the cultivator is able to maintain higher levels of soil fertility. Another virtue is that the seed of pulses are exceptionally rich in storage proteins. Thus they complement each other as food elements and contribute to a balanced human diet. In traditional agricultural communities pulses served – and still serve – as a main meat substitute (ZOHARY & HOPF 1993).

Crop weeds were poorly represented and the frequency distribution of grains (f. e. naked barley Fig. 3) could also be a result of a crop cleaning process. Seeds of weeds as *Chenopodium album*, *Fallopia convolvulus*, *Galium spurium* and *Polygonum aviculare* showed cropping by cutting high up. BEHRE (1983) and WILLERDING (1988) had argued that the comparatively low numbers of seeds of arable weeds at Neolithic and Bronze Age sites suggest that the cereals were cut under the ears during these periods. Finds of seeds from tall-growing or climbing arable weeds, and low values for short-stemmed species, are also cited in support of this hypothesis. The practice of cutting high up, or perhaps even hand plucking the ears, is explained as due to the retention of the "Mesolithic man the collector" behaviour pattern. Cereals in the Iron Age were probably cut close to the ground, using iron sickles that varied somewhat in shape throughout the whole period. The habit of cutting close to the ground may have been introduced in the Pre-Roman Iron Age.

The ecological behaviour of the plants by indicator values expressed by ELLENBERG et al. (1991) representing 9-12 degrees of behaviour according to the environmental factors of light, temperature, continentality, moisture, acidity and nitrogen supply. These ecological indicator values of crop weeds gave more information about the arable fields. Most of the species preferred soils which were rich in available nitrogen and have an average dampness – absent from both wet ground and places which may dry out.

Table 2. Threshing products from the Bronze Age layers

	Layer 5	Layer 4	TOTAL
Hordeum vulgare, rachis segments	8	0	**8**
Hordeum vulgare, spikelet forks+ glume bases	8	30	**38**
Hordeum vulgare, awn fragments	48	75	**123**
Triticum dicoccum, rachis segments	4	0	**4**
Triticum dicoccum, spikelet forks + glume bases	315	778	**1093**
Triticum dicoccum, awn fragments	976	216	**1192**
Triticum spelta, spikelet forks + glume bases	0	12	**12**
Triticum dicoccum/spelta, spikelet forks + glume bases	0	38	**38**
Triticum sp., rachis segments	0	1	**1**
Triticum sp., spikelet forks + glume bases	67	179	**246**
TOTAL	**1426**	**1329**	**2755**

In the grain find rachis segments, spikelet forks, glume bases and awn fragments were in some samples frequently, but not predominant. So, the cereals were probably threshed outside the house, because the threshing remains were underrepresented in the samples. The products of threshing belonged to *Hordeum vulgare*, *Triticum dicoccum* and small quantities *Triticum spelta*.

The use of sieving and the size of the mesh can be determined quite easily by looking at the diameters of the weed seeds and cereal grains in the sample. From the frequency distribution of width (Fig. 3) can be concluded that the size of the mesh amounted to 1.7 – 1.9 mm. However, it would probably be impossible to determine whether the sieving had been preceded by pouring, winnowing or flinging. Because of the grain size and few finds of crop seeds the cleaning by flinging could be possible. This process involved a continuous selection of obtaining the best seed corn.

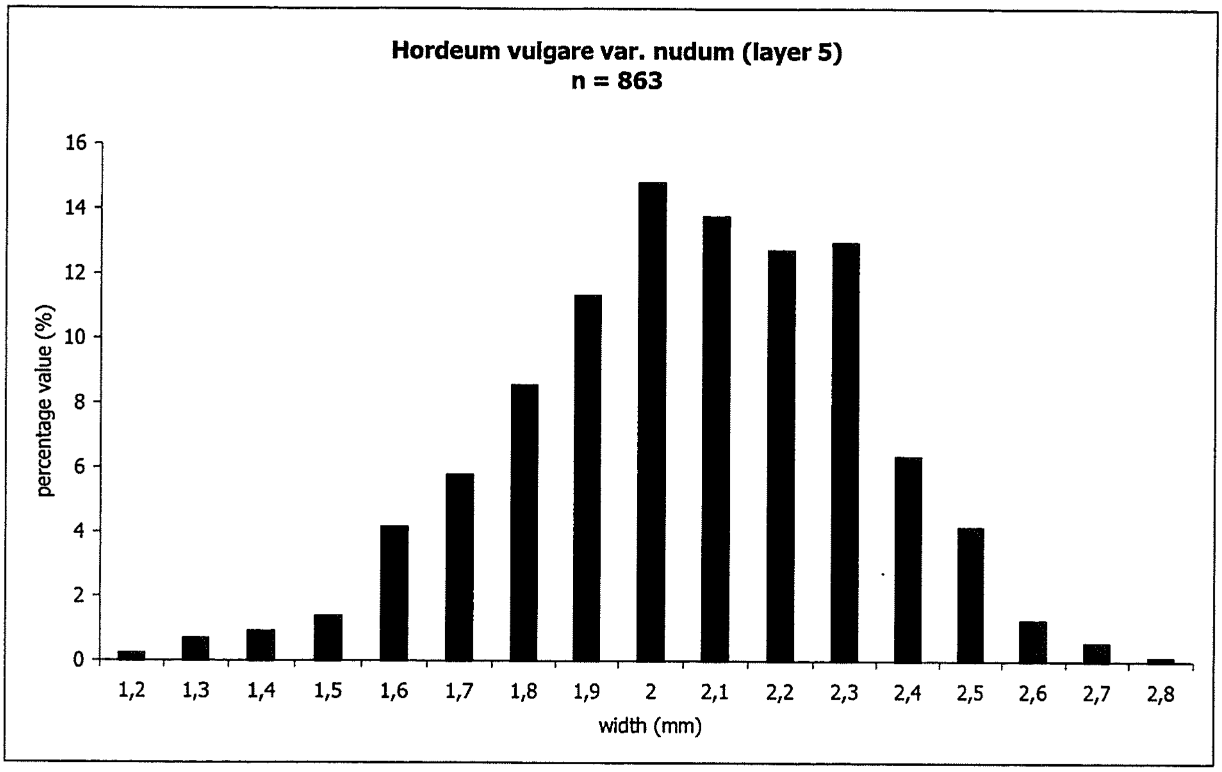

Fig. 3. Frequency width-distribution of *Hordeum vulgare* var. *nudum*-grains

The distribution and composition of the samples from the Bronze Age layer 4 showed a distinctive storing (Fig. 4). Two samples (2 and 6) near the post hole should be excluded in the interpretation of storing because they recovered very few carbonised crop remains. Sample 6 represented a range of crop weeds and wild plants which provided some of the most important sources of information about the conditions of the arable fields of the past. Mineralised awn fragments were found in sample 6. The less "dusted" crop samples were stored in a threshed and cleaned state.

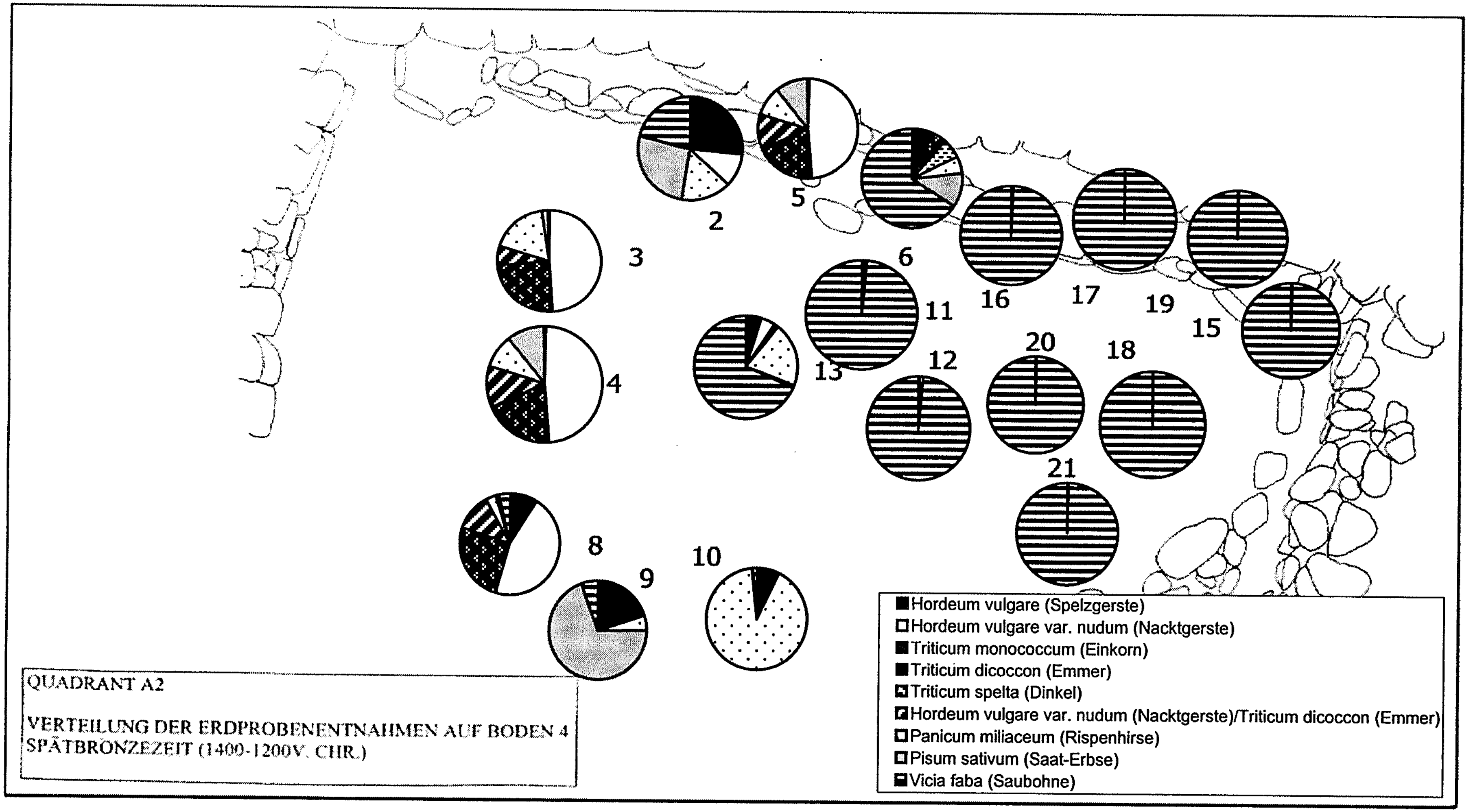

Fig. 4. Distribution of samples on the layer 4, late Bronze Age (1400 – 1200 BC), in the house (QA2)

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