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NEW DATA FROM NORTHERN APENNINES (ITALY) POLLEN SEQUENCES SPANNING THE LAST 30,000 YRS

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ABSTRACT: Bertoldi R., Chelli A., Roma R. & Tellini C., *New data from Northern Apennines (Italy) pollen sequences spanning the last 30,000 yrs*. (IT ISSN 0394-3356, 2007).
Palynological analyses and radiocarbon dates were performed on lacustrine sequences from the two sites of Berceto (820 m a.s.l.) and Lagdei (1,254 m a.s.l.) in Parma Province (Northern Italy). This work allowed us to obtain new data and constrains about vegetational and climatic history of the Northern Apennines from Upper Pleistocene to Lower Holocene.
The Berceto core provided a long pollen sequence from the Pleniglacial to the Lateglacial. In it the oscillations of the percentage of Picea and of the concentration values of AP, allow us to highlight a succession of stadials and interstadials. The correlation among three climatic amelioration periods found in the Berceto pollen sequence and the interstadials Tursac, Laugerie and Lauscaux was discussed.
The Lagdei lacustrine sequence, already studied by one of us in the 1980, was newly cored and analyzed in its portion tributable to the Lateglacial and Postglacial. The results from pollen analyses and radiocarbon dates allowed us to establish that Bertoldi interpretation, questioned by Lowe, was correct and to reconstruct the vegetation characters at the Lateglacial/Postglacial boundary for the Northern Apennines.

RIASSUNTO: Bertoldi R., Chelli A., Roma R. & Tellini C., Nuovi dati da sequenze polliniche degli ultimi 30.000 anni nell'Appennino settentrionale (Italia)*. (IT ISSN 0394-3356, 2007).*
Sono state condotte analisi palinologiche, corredate da datazioni assolute 14C, in due depositi lacustri dell'Appennino Parmense nell'ambito di più vaste ricerche glaciologiche-geomorfologiche in questo settore dell'Appennino settentrionale.
Scopo di questo lavoro è la ricostruzione della storia vegetazionale e climatica dell'Appennino settentrionale nell'intervallo Pleistocene superiore – Olocene inferiore che finora appare ancora ampiamente lacunosa. Infatti mentre sono numerosi gli studi pollinici in piccole conche palustro-lacustri di età olocenica, soltanto due profili pollinici (Lagdei e Prato Spilla) svelano episodi di età tardoglaciale. Nessun dato pollinico e/o cronologico è invece disponibile finora per il Pleniglaciale.
La successione lacustre del deposito di Berceto (820 m s.l.m.) ha fornito una lunga sequenza pollinica appartenente al Pleniglaciale ed in parte al Tardoglaciale. Questa successione vegetazionale è troncata alla sommità da una grossa lacuna sedimentaria che delimita alcuni eventi riferibili al Postglaciale inferiore. La sequenza pollinica pleniglaciale permette di intravedere episodi stadiali e interstadiali, sulla base delle oscillazioni dei valori percentuali di Picea e dei valori delle concentrazioni AP. Le fasi stadiali sono caratterizzate da formazioni steppiche con Pinus, mentre quelle interstadiali da formazioni aperte a Pinus con presenza di Picea. Tentativamente le tre fasi di miglioramento climatico del Pleniglaciale sono correlate (messe in relazione) con gli interstadiali di Tursac, Laugerie e Lauscaux. Il limite Pleniglaciale/Tardoglaciale sembra chiaramente espresso ed appare un po' più antico di 14.480 ± 50 14C BP. La sequenza tardoglaciale di Berceto è troncata al livello di m 6,20 datato 11.150 ± 70 14C BP.
Il deposito lacustre di Lagdei, Alta Val Parma (1254 m s.l.m.), già studiato nel 1980 da uno di noi, ma allora non corredato da datazioni assolute, è stato nuovamente sondato e studiato nella sua porzione tardoglaciale e postglaciale (Lagdei-II) con il supporto di datazioni radiometriche. Scopo principale era quello di individuare nella sequenza il limite Tardoglaciale /Postglaciale e quindi di ordinare nel tempo gli eventi vegetazionali del Tardoglaciale, che erano stati contestati e reinterpretati da Lowe. I risultati pollinici e cronologici della sequenza di Lagdei-II confermano in pieno l'originaria interpretazione della sequenza pollinica fatta da Bertoldi nel 1980. In particolare è stato stabilito definitivamente il limite Tardoglaciale/Postglaciale al limite tra le z.p. C e D, limite che coincide con il passaggio fra sedimenti inorganici ed organici e che risulta collocato 15/20 cm sotto al livello datato 9.900 ± 80 14C BP. E' stato così possibile seguire nel tempo l'evoluzione vegetazionale stadiale/interstadiale durante l'intero Tardoglaciale nell'Appennino settentrionale.

Keywords: Pleniglacial, Lateglacial, palynology, palaeoclimate, Italy.

Parole chiave: : Pleniglaciale, Tardoglaciale, palinologia, paleoclima, Italia.

1. INTRODUCTION

The sector of the Northern Apennines (Northern Italy) among Liguria, Emilia and Tuscany is between 45° 05'N and 43° 30'N and between 8° 39'E and 12° 22'E. It reaches the maximum altitude in correspondence of Mt. Cimone (2,165 m) (Fig. 1).

Severe geomorphological processes acted in the Northern Apennines in the late Quaternary, during which at least two glacial episodes occurred (Losacco, 1949; Federici, 1977). Glacial landforms (i.e.: cirques, troughs, moraines) and deposits (i.e.: till and lacustrine sequences) are well represented in several areas, such as in the Parma and Enza valleys, at elevations ranging from 750 to 1,800 m a.s.l.

Many palustrine and lacustrine deposits in this area were extensively studied by means of pollen analyses, in order to reconstruct the vegetational history and environmental changes which occurred. Unfortunately, only occasionally the pollen analyses were supported by radiocarbon datings (Chiarugi, 1936; Ferrarini, 1962; Braggio Morucchio *et al.*, 1978;

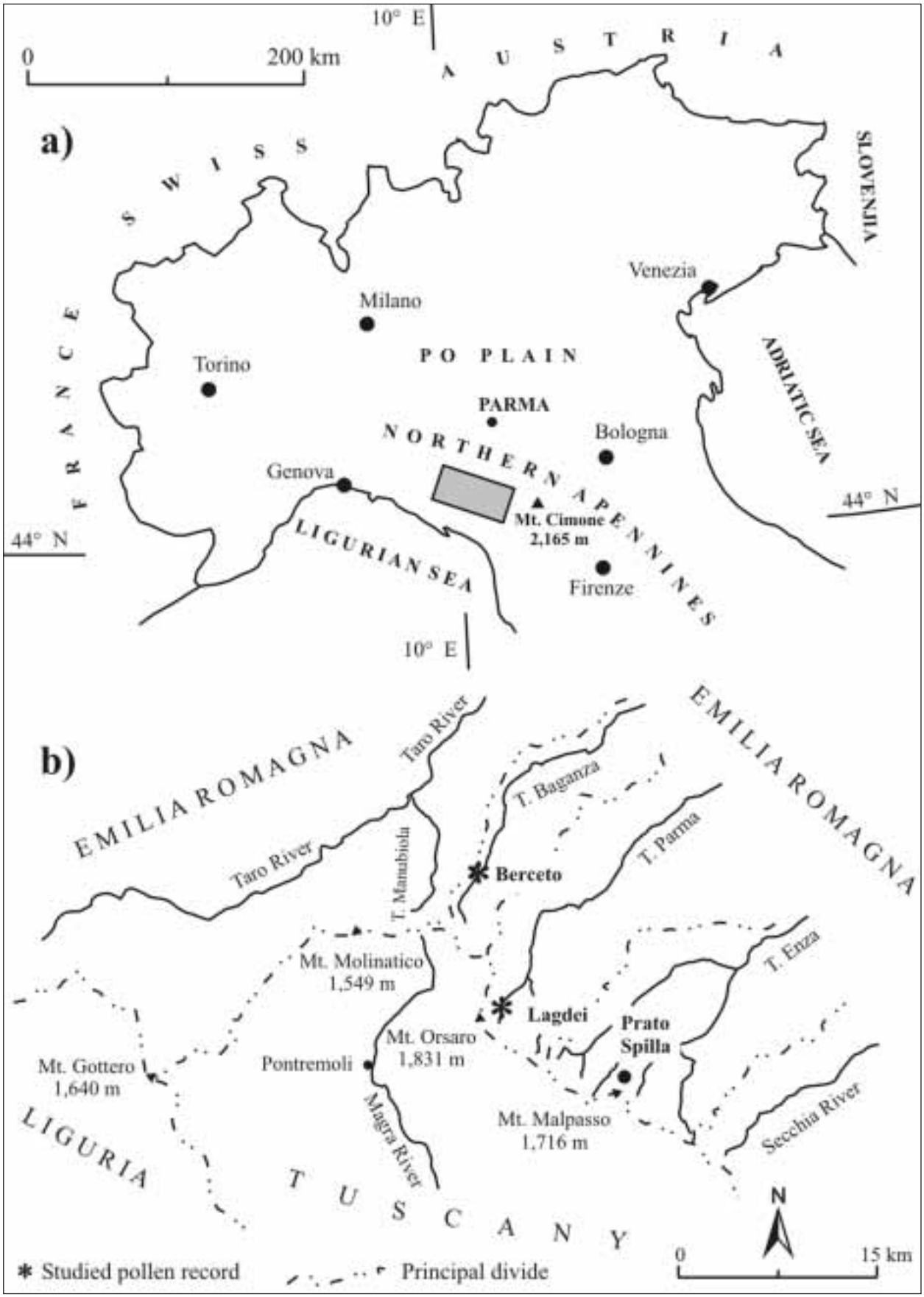

Figure 1 - Geographic sketch map of the area (a) and of the sites considered in the text (b).
Inquadramento geografico dell'area (a) e delle località considerate nel testo (b).

BERTOLDI, 1980; GENTILE *et al*., 1988; CRUISE, 1990; LOWE, 1992; LOWE & WATSON 1993; MONTANARI *et al*., 1994; WATSON, 1996), and only for two sequences,(1) at Lagdei, in the Parma Valley (BERTOLDI, 1980) and (2) at Prato Spilla, in the Enza Valley (LOWE, 1992) (Fig.1) was demonstrated a Lateglacial age (no more than 13,000 ^{14}C yr BP) for the deepest parts of the deposits. In reality, at Lagdei a pollen record was detected that can be confidently referred to early Upper Pleistocene (BERTOLDI, 1980), but the lack of radiocarbon datings did not allow its sure chronological attribution. At present, no pollen sequences and/or radiocarbon datings are available in this area for the Pleniglacial.

Therefore, one of the problems in the palaeoenvironmental studies in the Northern Apennines, is the lack of palaeoclimatic records corresponding to the time interval from the Last Glacial Maximum to Lateglacial, a crucial time for the environmental changes.

In this paper we present the results of pollen analyses and radiocarbon datings performed on a lacustrine sequence found in correspondence to the Berceto village (Parma Province), located not far from the site of Lagdei, containing the LGM and the transition to the Lateglacial. Moreover, we present a new pollen diagram from the sequence of the Lagdei site, this time supported by radiocarbon datings.

On the whole, the pollen data and radiocarbon dates from the two sequences allow us to illustrate, for the first time, the vegetational and floristic features of the Pleniglacial in the Northern Apennines and to investigate the boundary Pleniglacial/Lateglacial. Moreover, more detailed issues are provided on the vegetational and climatic events that took place during the Lateglacial-early Postglacial time.

2. THE STUDIED SITES

2.1 The Berceto site

The Berceto village lies at 820 m a.s.l., close to the divide between the Baganza Torrent and Manubiola Torrent, the latter a tributary of the Taro River (Fig. 1).

The geological setting of the Berceto area, where three different Ligurian tectonic units outcrop (SERVIZIO GEOL. IT., 2002), is characterized by a south-verging recumbent anticline that develops within sandstones (*Arenarie di Scabiazza Formation*). The rocks underlying the sandstones are mainly shaly rocks (*Argille a palombini di Monte Rizzone* Formation and the so-called *Complesso ofiolitico*) (BERTOLDI *et al.*, 2004).

Berceto is at the top of a westward-trending slope that experienced many landslide events of different types and sizes. A shallow hollow, lengthened NNE-SSW and with an extension of about 30x103 m^2, is in the area between the village and the divide. It is the morphological expression of the trench linked to a rotational landslide that involves the large part of the top of the Berceto slope.

2.2 Lithostratigraphy of the Berceto core

The lacustrine sequence found in Berceto is 25 meters long and represents about 50% of the total length of a core (Fig. 2) collected from a borehole drilled in the centre of the trench due to the landslide.

Lithostratigraphic analyses were performed on the deposit. In particular, optical microscopy on polished thin-sections yielded information on the sediments fabric and structure; petrographic and mineralogical investigations were also accomplished by means of SEM analyses. Here we present the main highlights on the Berceto sequence and the more exhaustive description is available in BERTOLDI *et al*. (2004).

The sequence represents the infill of the landslide trench and, from the bottom to the top, the sequence was subdivided into 6 lithological units.

The borehole encountered the bedrock at the depth of 48.00 m, represented by *Argille a palombini di Monte Rizzone*, while from 48.00 to 31.00 m (unit 6, Fig. 2) a breccia made up of clasts with silty matrix appeared.

The first unit of the lacustrine sequence extends from 31.00 to 17.00 m depth (unit 5, Fig. 2). Generally, it is composed by light grey silty graded laminae, from 1 to 3 mm thick, and submillimetric dark clayey organic laminae. In detail, the graded laminae are fining upward and show a grey-yellowish lower portion gradually changing pale grey. Sometimes, whitish (pale) very thin laminae are put together with the clayey dark organic ones. The pale laminae contain dolomite and mixed layers of clay minerals (illite/smectite). The laminae are folded and affected by shear surfaces.

The clastic graded laminae are short repeated sedimentary events. They may represent either flows which occurred from the banks of the lake or the sediment influx from its catchment area. In reality, the lake did not have a tributary but the main source for the water was, likely, the surface runoff that occurred in its surrounding area. The dark and pale laminae were produced by precipitation and flocculation of clay-rich material, during periods characterized by the lack of coarse clastic inputs.

Between 17.00 and 9.20 m depth (unit 4, Fig. 2) a grey-yellowish silt exists that contains levels with pale and dark laminae, deformed in a ductile way and, locally, very fine sands with scattered plant scraps and wood fragments appear. The pale and dark laminae are vague, even if they are still visible.

From 9.20 to 6.10 m depth (unit 3, Fig. 2), a massive package occurs of light grey fine silty sand. There are intraclasts that vary in colour from light- to dark grey and, locally (especially between 9.20 m and 9.12 m depth), thin levels with plant remains. Within this unit the deformation is high, the formerly laminated structures are almost completely destroyed and the material is rather homogeneous.

In general, as stated by BERTOLDI *et al.* (2004), the whole lacustrine sequence shows, from the bottom to the top, a rising deformation linked to small shackings, as testified by the coherence of the sequence, due to the landslide movements. The features of different units show that the landslide events occurred after the deposition of the unit 5 and they were recorded by each unit in different ways, probably regarding their depth below the bottom of the ancient lake. In the units 4 and 3 the events occurred just after their deposition, when they were still very close to the bottom of the lake and to the water, whereas the unit 5 was affected by folding and shearing when it was already covered by overlying sediments and far from the water.

The unit 2 (Fig. 2) from 6.10 to 4.30 m depth,

represents the definitive infill of the Berceto lacustrine basin. The unit starts with a thin layer of sand, gradually replaced upwards by a thick layer of poorly preserved peat, as emphasized by the content of sporomorph that is dominated by oxidized and broken specimens. The bad conservation of peat suggests that it underwent events of pervasive reworking.

From 4.30 m depth to 0 m (unit 1, Fig. 2) a chaotic breccia made up of poligenic clasts (limestones, sandstones, ophiolithes, etc.) of different sizes and a silty-clay matrix exists.

2.3 The Lagdei site: features and previous works

The Lagdei site is located in the high Parma Valley at about 1,254 m a.s.l., 12 km south of Berceto (Fig. 1).

Around the Lagdei site, a mainly arenaceous succession (*Macigno* Formation, Tuscan Nappe) that is made up of thick to very thick turbiditic units, is widely exposed. From a geomorphological point of view, relict glacial landforms and deposits prevail.

The evolution of the confluent Parma Valley glacier, after its maximum in correspondence of the LGM (Equilibrium Line Altitude-ELA 1,260 m a.s.l. and glacier front at 730 m a.s.l.), was the topic of an article written by Federici & Tellini (1983). They recognized at least three stages during the retreat of the glacier. The ELA of the first stage reached about 1,370 m a.s.l., with an increase of about 110 metres as regards the LGM. In correspondence of the second stage (ELA 1,530 m a.s.l.) the Parma valley was characterized by three distinct glaciers, each one confined within one of the three main deep valleys representing the high Parma Torrent basin. At that time, the overdeepened hollow of Lagdei was free from the ice and the sediment deposition started.

During the third stage, the ELA exceeded the medium altitude of the divide of the Northern Apennines and only very small glaciers were within the cirques or snowfields which existed on the slopes with a northern aspect.

Federici & Tellini (1983) correlated, by means of the increases of the Equilibrium Line Altitude (ELA), the glacial stages of the Parma valley with the classic ones of the Alps and they put the third stage in correspondence to the Younger Dryas.

Nowadays, a marsh in the middle of the Lagdei site exists and it represents the closure of the deposit that filled the overdeepened glacial hollow.

Pollen analyses on the Lagdei sequence began in the early 1980s, when a 12.60 m borehole was handdrilled in the centre of the deposit and analyzed for its pollen contents (Bertoldi, 1980).

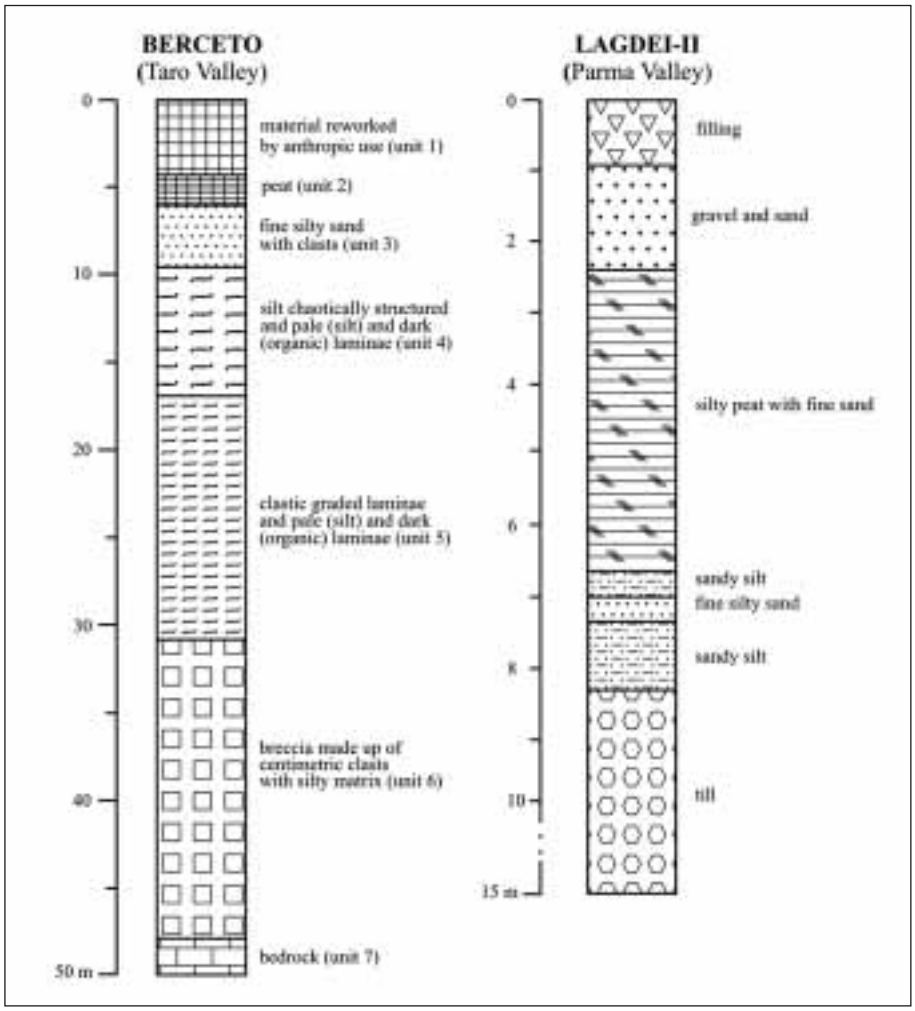

Figure 2 - Lithological features of Berceto and Lagdei-II boreholes.
Litostratigrafia dei carotaggi di Berceto e di Lagdei-II.

The pollen record indicates that the upper segment (i.e., from the top of the core down to 8.80 m depth) represents the Holocene. A good correlation was found between this interval and the coeval pollen records previously identified in the Northern Apennines (Chiarugi, 1936; Ferrarini, 1962; Braggio Morucchio *et al*., 1978).

Also the middle part of the core (between 9.85 and 8.80 m depth) provided a well preserved pollen record. Because of the lack of radiocarbon datings, the chronostratigraphic interpretation of this interval was achieved by comparison with the better age-constrained vegetational sequences from the southern Alps (Zoller, 1960; Beug, 1964; Sercelj, 1966; Bertoldi, 1968; Beaulieu De & Jorda, 1977; Behre, 1967; Schneider, 1978), which suggested that the middle part of the Lagdei sequence is Lateglacial in age. This finding was especially important, because for the first time a complete pollen record straddling the Lateglacial was found in the Northern Apennines. In the basal portion of the core (from 12.60 to 10.00 m depth), further vegetational events were recognized, but their age still remains unk-

nown.

A new core ("Lagdei-II" core hereafter) was recovered in 1994 with the specific purpose of collecting material suitable for radiocarbon datings, thus providing better age control for the Lagdei pollen record.

The Lagdei-II borehole was drilled at the southern margin of the Lagdei lacustrine area. A continuous and undisturbed core, approx. 15.00 m long, was recovered and can be subdivided into 7 lithostratigraphic units (Fig. 2) that are synthetically described.

From the top to the bottom of the sequence, after 0.90 m of reworked filling there are:

- The unit between 0.90 and 2.40 m depth: an alluvial fan deposit characterized by gravels with silty-sandy matrix.
- The unit between 2.40 and 6.70 m depth: represented by a well-preserved peat layer that contains a fine sandy inorganic fraction.
- From 6.70 to 7.00 m depth: grey to greenish sandy silt.
- The unit between 7.00 and 7.30 m depth: made of medium to coarse silty sand, that ranges in color from grey to greenish.
- From 7.30 to 8.30 m depth: yellowish sandy silt with layers made of silty sand.
- The unit from 8.30 m to the bottom of the core: a diamict made of clasts of variable size and a sandy-silty matrix. This unit is interpreted as a lodgement till left from the glacial tongue on the bottom of the overdeepened hollow.

3. MATERIALS AND METHODS

In order to perform pollen analysis, we collected 65 samples from the Berceto core, in the interval between 4.30 and 30.00 m, and 70 samples from the Lagdei core, in the interval between 2.50 and 8.50 m.

Peaty samples were prepared according to the techniques described by FAEGRI & IVERSEN and acetolysis (Erdtman's) procedures. Sediment samples with prevailing inorganic content were treated according to standard laboratory protocols (ZHENG, 1986, modified): 10 grams of dried sediments, washing with HCl, soaking in HF, Lüber tecnique, boiling in diluited 10% KOH, followed by enrichment procedure, in particular gravitative separation using $ZnCl_2$ (density 2,004 g/cm^3) and sonication.

During the first step of chemical treatment, a tablet containing a determined number of Lycopodium spores was added to each sample in order to estimate the pollen concentration (STOCKMARR, 1971). An average of 400 pollen grains per sample were counted.

The pollen flora is represented in analytical pollen diagrams (Figs. 3-5). The pollen curves show the role and development of single taxa, both of the arboreal (AP) and herbaceous plants (NAP).

Interpretation of the vegetational development is based on summary pollen diagrams, in which percentage curves either of selected pollen taxa (such as *Betula, Picea, Abies, Fagus*) or pollen groups are shown. Specifically, these are:

- Pinus-group: mainly *Pinus* + other pioneering taxa, such as *Juniperus* and *Hippophae*;
- Quercetum: mainly *Quercus*, secondly *Corylus*, *Ulmus, Tilia, being Acer, Carpinus, Ostrya* and *Ilex* sporadic;
- other AP: principally *Alnus, Salix*, cf. *Populus*;
- Artemisia-group: mainly *Artemisia* + *Ephedra;*
- other NAP: in decreasing order of abundance, these are Asteraceae, Poaceae, Caryophyllaceae, Chenopodiaceae, Cistaceae (*Helianthemum* included), Ranunculaceae (*Thalictrum* included), Brassicaceae, Polygonaceae, Fabaceae, Plantaginaceae and other sporadic herbaceous taxa. Hygro-hydrophytes are also included in this group, because their presence is persistently low and discontinuous.

On the right side of the pollen diagrams, the AP concentration curve is represented.

4. RESULTS

4.1 Berceto sequence

Pollen flora

Taxonomic details are shown in the analytical pollen percentage diagram (Fig. 3). The AP are ever prevalent. In detail, in the middle-lower portion of the diagram Pine (mainly *Pinus sylvestris*-type and traces of P. *mugo*-type) clearly prevails accompanied by low values of *Picea, Juniperus, Hippophae*, while broad-leaved trees (as *Quercus, Betula, Ulmus, Tilia, Carpinus, Corylus*, etc.) are sporadic. These last taxa with *Abies* become significant only in the final spectra of the profile.

The NAP are represented continuously by *Ephedra* (*E. distachya*-type and *E. fragilis*-type), *Artemisia* and other Asteraceae, Chenopodiaceae, Poaceae. Open curves show Ranunculaceae with *Thalictrum*, Brassicaceae, Fabaceae, Polygonaceae, Plantaginaceae, Rubiaceae, Rosaceae, and traces of other NAP, as Dipsacaceae, Ericaceae, Gentianaceae, etc. The Hygro-Hydrophyta (Cyperaceae, Sparganiaceae, Typhaceae, Nymphaeaceae, *Myriophyllum*) are very scarce.

Biostratigraphy

The Berceto summary pollen sequence (Fig. 4) can be subdivided into three major segments.

The basal segment is rather long, from 30.00 to 12.50 m depth, and characterized by a rather homogeneous pollen flora. Specifically, Pinus-group is dominant (percentages 80%-90% of the pollen sum) with relatively abundant *Picea*, other AP occur sporadically, while the NAP groups are largely subdued.

Further subdivisions of these segments in local pollen assemblage zones (paz) can be established based on the oscillations either of *Picea* percentages or AP concentrations. Indeed, paz BER-2, BER-4, BER-6 and BER-8 show relative high percentages of *Picea* and appreciable AP concentrations (in excess of 5,000 grains/g); in contrast, paz BER-1, BER-3, BER- 5 and BER-7 are characterized by negligible values of *Picea* and low AP concentrations (around 2,500 grains/g).

The middle segment of the sequence, between 12.50 and 6.20 m depth, is characterized by two successive events of major increases in the NAP complex, which simultaneously result in the two abrupt decreases in the Pinus-group.

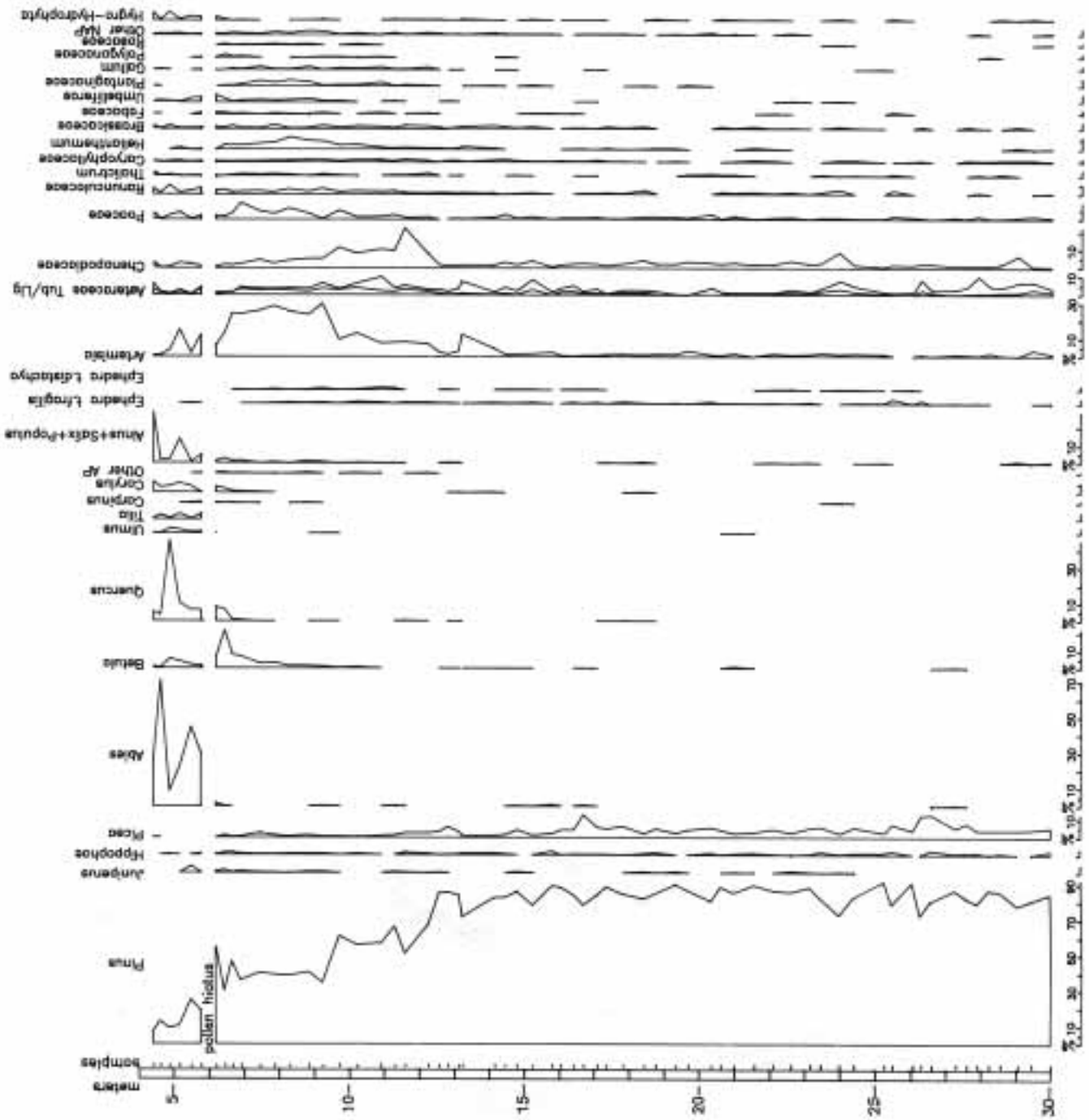

Figure 3 - Analytical pollen percentage diagram of Berceto. Percentages refer to the pollen sum (AP+NAP).

Diagramma pollinico analitico di Berceto. Le percentuali si riferiscono al conteggio totale dei pollini (AP+NAP).

Specifically, basal paz BER-9 is characterized by high percentages of the Pinus-group (about 60% of the pollen sum), a decrease of the *Picea* curve and very low AP concentrations (about 2,500 grains/g). The overlying paz BER-10 is characterized by a further decrease in the Pinus-group, which falls at about 40% of the total pollen, a rise of herbs (especially *Artemisia*) and the continuous presence of *Betula*, which reaches 20% of the total sum in the uppermost pollen spectra. At first, the Quercetum elements (essentially *Quercus* and *Corylus* grains) are scattered and dispersed. However, they increase and become continuous in the upper spectra of this pollen zone. *Picea* shows a gradual decrease and *Abies* is sporadic. AP concentrations are significant, since they vary from 7,500 to a maximum of 15,000 grains/g in the upper part of paz BER-10.

The transition to the upper segment of the sequence, from 6.20 to 4.30 m of depth (paz BER-11), is marked by a sharp sedimentary gap, which results in a dramatic change in the overall vegetational state in respect to the lower paz BER-10. Indeed, a cyclical turnover between Abies and Quercetum is observed, along with the decrease of other arboreal and non-arboreal taxa, apart from the other AP-group (*Alnus, Salix, Populus*). AP concentrations raise up to the maximum value detected throughout the succession (about 190,000 grains/g).

Chronostratigraphy and vegetational-climatic features

Interpretation of the Berceto succession can be attained by integrating floristic and biostratigraphic data with radiocarbon ages.

Globally, the Berceto pollen sequence yielded an overall "modern" arboreal flora, which closely resembles the present-day woodlands of Northern Italy. Therefore, it is strongly suggested, based on pollen evidence, that the Berceto succession was laid during Upper Pleistocene and Holocene times.

The lower segment of the pollen diagram (Fig. 4) shows four pollen zones paz BER-2, BER-4, BER-6 and BER-8 characterized by boreal-like Pinus forests with Picea alternating with four paz BER-1, BER-3, BER-5 and BER-7 characterized by steppe/forest-like of Pinus.

The radiocarbon ages from bulk sediment recovered at 22.50 and 11.65 meters depth (Table 1) allow us to arrange chronologically the pollen zones sequence. The paz BER-1 and BER-2 are probably older than 30,000 year BP. The time interval between paz BER-3 and BER-8 corresponds very well to the last würmian Pleniglacial (Orombelli & Ravazzi, 1996).

The vegetation pattern suggests that in the mountain belt of Northern Apennines, drastic changes took place in the regional availability of effective moisture. Specifically, the significant abundances of *Picea* amidst the open Pine woodlands is indicative of continental and moderately humid climates, which can be regarded as "interstadial" intervals. By contrast, the dominance of steppe/forest communities with *Pinus* stands suggests harsher climatic conditions, thus fully consistent with "stadial" intervals.

The middle segment of the succession encompasses the Lateglacial, although documentation is interrupted abruptly by a sedimentary gap immediately above 11,150±70 ^{14}C yr BP, i.e. at 6.20 m depth.

Paz BER-9 represents a stadial interval, being characterized by the abrupt increase of herbs (NAP) in an open woodland with Pine. In contrast, the following paz BER-10 documents a more forested phase, evidenced by two distinct increases of the AP pollen concentration, with dominant *Pinus* and, secondly, *Betula*. The pollen features of BER-10 suggest that a transient reforestation event of the Apennine slopes took place, principally in response to a significant increase in average temperatures. Still, the overall sporadic occurrence of water-demanding trees suggests that effective moisture remained low, although in the uppermost spectra a slight increase in temperate elements is observed.

In the uppermost segment of the sequence, i.e.: paz BER-11, *Abies* and Quercetum are dominant. This interval is in stark contrast with the previous ones, being characterized by vegetational features that are fully consistent with a postglacial phase.

4.2 Lagdei site

Pollen flora

The AP findings, as *Pinus, Abies, Quercus, Tilia, Ulmus, Corylus, Alnus* + *Salix* + *Populus,* show widely variable curves. Low and discontinuous values of *Juniperus, Hippophae, Picea, Betula, Acer, Fraxinus, Fagus, Taxus* (cf.) and other AP (traces of *Carpinus, Ostrya, Castanea, Juglans, Ilex, Hedera ,Viscum, Cornus*, etc) occur (Fig. 5). The NAP flora is qualitatively and quantitatively rich. The most important taxa are *Artemisia* and other Asteraceae and Poaceae. Chenopodiaceae, Ranunculaceae with *Thalictrum*, Helianthemum, Ericaceae, Plantaginaceae, Polygonaceae, Caryophyllaceae, Brassicaceae, Umbelliferae, Rosaceae show discontinuous curves. Other NAP, such as Dipsacaceae, Fabaceae, Campanulaceae, Rubiaceae show only sporadic values and the Hygro-Hydrophyta (Cyperaceae, Sparganiaceae, Typhaceae, Hydrocharitaceae) are scarce. Findings of *Ephedra* were found only in the lower spectra.

Table 1 - Results of ^{14}C datings from Berceto core (Beta Analytic Inc, Miami, Florida, U.S.A.) (from Bertoldi *et al*. 2004).

Risultati delle datazioni radiocarbonio dei campioni di Berceto (Beta Analytic Inc, Miami, Florida, U.S.A.) (da Bertoldi et al. *2004).*

Dating code	Sample depth (m)	Conventional ^{14}C age (^{14}C yr BP)	Calibrated ^{14}C age (cal yr BP)
Beta 178882	6.20	11,50±70	13,390-13,240/13,240-12,900
Beta 181866	11.65	14,80±50	17,705-17,00
Beta 181867	22.50	19,620±290	----------

Biostratigraphy and chronostratigraphy

In the continuous and undisturbed Lagdei-II lacustrine succession, pollen data demonstrate that the interval between 2.40 and 8.30 m depth documents the Lateglacial and the early Postglacial.

Very good agreement exists

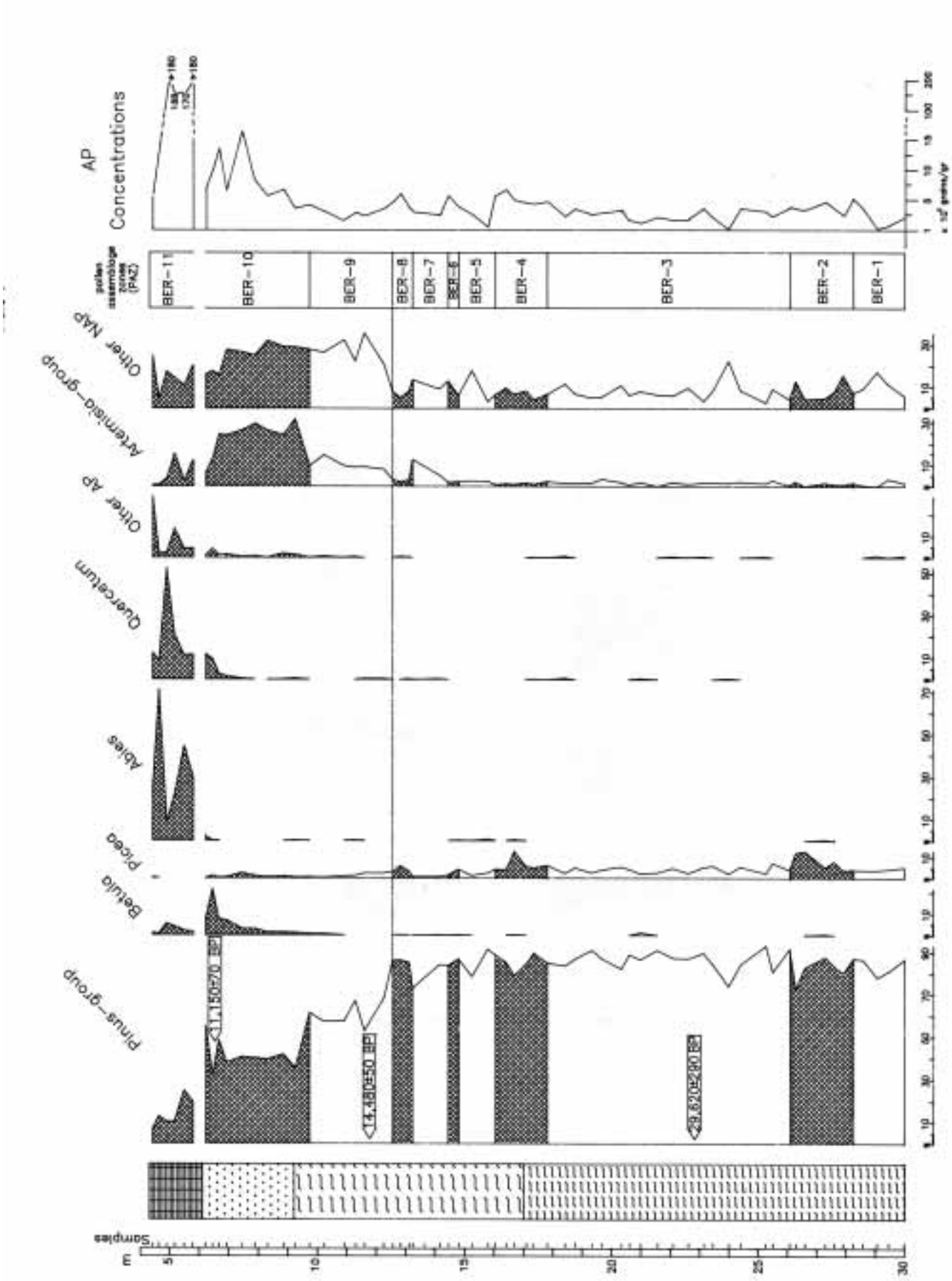

Figure 4 - Summary pollen percentage diagram of Berceto with selected single taxa (Betula, Picea, Abies) and pollen groupings. The percentages are calculated with respect to the total pollen sum. On the left of the diagram are represented the stratigraphic column, the radiocarbon datings and, on the extreme right, the AP concentration curve.

Il diagramma pollinico riassuntivo di Berceto mostra singoli taxa selezionati (Betula, Picea, Abies) e raggruppamenti pollinici. Le percentuali sono calcolate rispetto alla somma totale dei pollini. Sulla sinistra del diagramma sono rappresentate: la colonna stratigrafica e le datazioni radiocarbonio; all'estremità destra è riportata la curva di concentrazione AP.

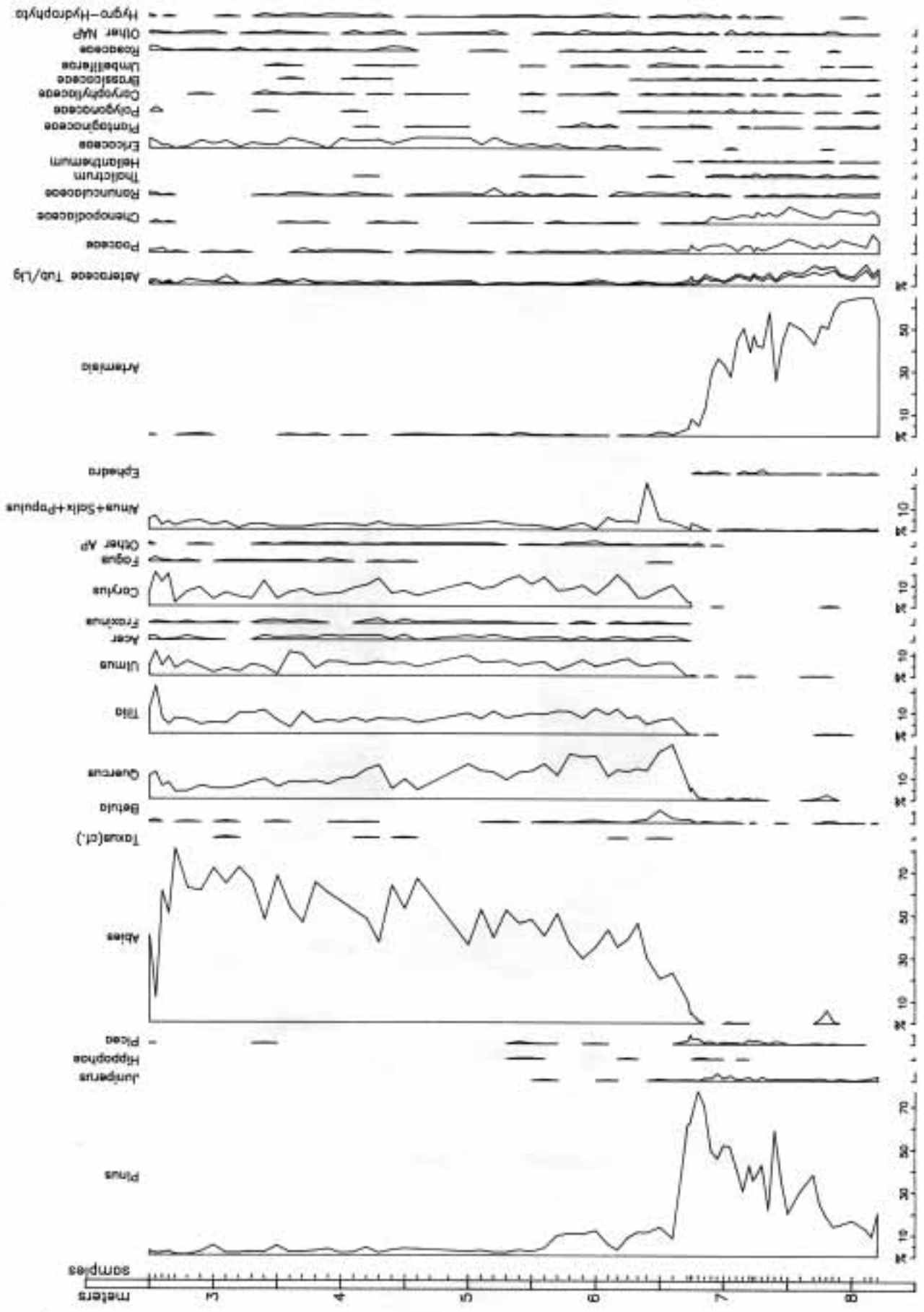

Figure 5 - Analytical pollen percentage diagram of Lagdei-II. Percentages refer to the pollen sum (AP+NAP).
Diagramma pollinico analitico di Lagdei-II. Le percentuali si riferiscono al conteggio totale dei pollini (AP+NAP).

both in tempo and modes of the dynamics of the floristic taxa found in this sequence with respect to the previous one reported in Bertoldi (1980).

The criteria employed for subdividing the Lagdei-II pollen record (Fig. 6) into 6 pollen assemblage zones, namely paz LGD-A to paz LGD-F, are the same as Bertoldi (1980) here integrated with the AP concentration datum. As a result, it was at first demonstrated that the former subdivision proposed is in excellent correspondence with the zonation established in the Lagdei-II pollen record, where 4 age control points based on radiocarbon dating are also available (Table 2).

Table 2 - Results ^{14}C datings of Lagdei-II core (^{14}C Radiocarbon dating Laboratory, Dept. of Earth Sciences, University of Rome, Italy).

Risultati delle datazioni radiocarbonio dei campioni di Lagdei-II (Radiocarbon dating Laboratory, Dipartimento di Scienze della Terra, Università La Sapienza-Roma, Italia).

Dating code	Sample depth (m)	Conventional ^{14}C age (^{14}C yr BP)	Calibrated ^{14}C age (cal yr BP)
Roma-875	2,43-2.53	6,840±60	7,670-7,570
Roma-876	4.50-4.60	8,190±70	9,250-8,990
Roma-877	6.00-6.10	9,620±70	10,950-10,500
Roma-878	6.50-6.60	9900±80	11,200-10,990

A major result is represented by the firm recognition of the Lateglacial/ Postglacial boundary, which occurs at 6.75 m depth in close correspondence to a manifest change both in vegetation and in sedimentation. Age of the boundary is approximated by the radiocarbon age of 9,900±80 ^{14}C yr BP derived from a peaty sample at 6.50÷6.60 m depth. The transition to the Postglacial is continuous and well documented by the stratigraphic sequence and pollen record, being correlative to the sharp transition from paz LGD-C to paz LGD-D. This is in agreement with the data derived from the core drilled in the centre of Lagei hollow in 1980.

Besides this, the radiocarbon age 9,620±70 ^{14}C yr BP at 6.00÷6.10 m depth supports the attribution of the paz LGD-D to the basal Holocene.

The other radiocarbon datings (8,190±70 ^{14}C yr BP at 4.50÷4.60 m and 6,840±60 14C yr BP at 2.43÷2.53 m of depth) allow us to attribute the paz LGD-E and LGD-F to the early-middle Holocene (Table 2; Fig. 6).

Paz LGD-A, LGD-B and LGD-C belong to the Lateglacial. However, radiocarbon ages are not available in this segment and therefore, chronology of paz LGD-A, LGD-B and LGD-C is based on the occurrence of prominent vegetational features.

Paz LGD-A is consistent with the Oldest Dryas, being characterized by minimal AP concentrations (<1,000 grains/g) that document a steppe-like landscape with sparse *Pinus* stands.

Paz LGD-B represents a closing *Pinus* forest with scattered occurrences of other trees such as *Betula, Picea, Quercus, Alnus* and *Salix*. The peculiar pollen assemblage and the increasing AP concentration (from 1,000 to 20,000 grains/g) are in full agreement with the well-known interstadials of the Lateglacial. Specifically, the two-folded distribution pattern of the AP concentration curve suggests that paz LGD-B encompasses the Bölling - Alleröd interstadial complex.

Paz LGD-C is characterized by a culmination of the Pinus-group curve, along with a decrease of herbs (especially the Artemisia-group) and a sharp fall of the AP concentration. This interval is logically correlative to the Younger Dryas stadial oscillation.

The beginning of the Preboreal (i.e., the base of the Holocene) is especially well documented. A last dramatic fall is observed of the Pinus-group (base of paz LGD-D), which is gradually replaced by *Abies* and temperate deciduous trees. From this point upwards, all herbaceous taxa are persistently subdued.

5. DISCUSSION

5.1 Pleniglacial

Both vegetational data and radiocarbon ages indicate that the interval from BER-3 to BER-8 of the Berceto pollen sequence (Fig. 4) belongs to the last Pleniglacial, which spans from ca. 30,000 to 15,000 yr BP, including the Last Glacial Maximum (LGM) (see e.g. Zagwijn & Paepe, 1968; Mangerud *et al.*, 1974; Woillard & Mook, 1982; Behre, 1989; Allen *et al*., 1999; Beaulieu De & Reille, 1992; Antonioli & Vai [eds.], 2004; Bini *et al*., 2004; Orombelli *et al*., 2005).

The chronostratigraphic interpretation of the Berceto sequence is based on the oscillations of the *Picea* percentage values. Indeed, spruce survived during the Pleniglacial in the Northern Apennines in relict area that represented its most southern refuges in Europe (Ravazzi, 2002). Only during the Lateglacial began a phase of contraction of the spruce range with its extinction at the beginning of the Holocene, except two small areas where the spruce survived (Chiarugi, 1936; Bertoldi, 1980; Ravazzi, 2002; Ravazzi *et al.*, 2006). As a consequence, moderate peaks of the percentage pollen curve of *Picea* are climatically significant. The co-variance of the AP concentration curve confirms the significance of the *Picea* culminations.

Specifically, paz BER-4, BER-6 and BER-8 document short-lived events of climatic amelioration (i.e., interstadials) that are older than 14,480±50 ^{14}C yr BP and thus are likely to develop during last Pleniglacial times. Based on these chronological ties, it is strongly suggested that paz BER-4, BER-6 and BER-8 correlate confidently with the well documented interstadials Tursac, Laugerie and Lascaux that were first recognized and dated in pollen sequences from southern France by Leroi-Gourhan (1965, 1968, 1980) and confirmed afterwards by Laville (1988) and Weissmueller (1997).

In the light of a long-distance correlation, the Berceto pollen emergences are especially worthy of note and provide further evidence that latitudinal control on the vegetation in Europe was especially strong during Pleniglacial times. So far, indeed, documentation of Tursac, Laugerie and Lascaux interstadials is virtually missing in central Europe and north-eastern France (Hammen Van Der *et al*., 1967; Zagwijn & Paepe, 1968; Frenzel, 1968; Woillard, 1978; Behre, 1989) and largely

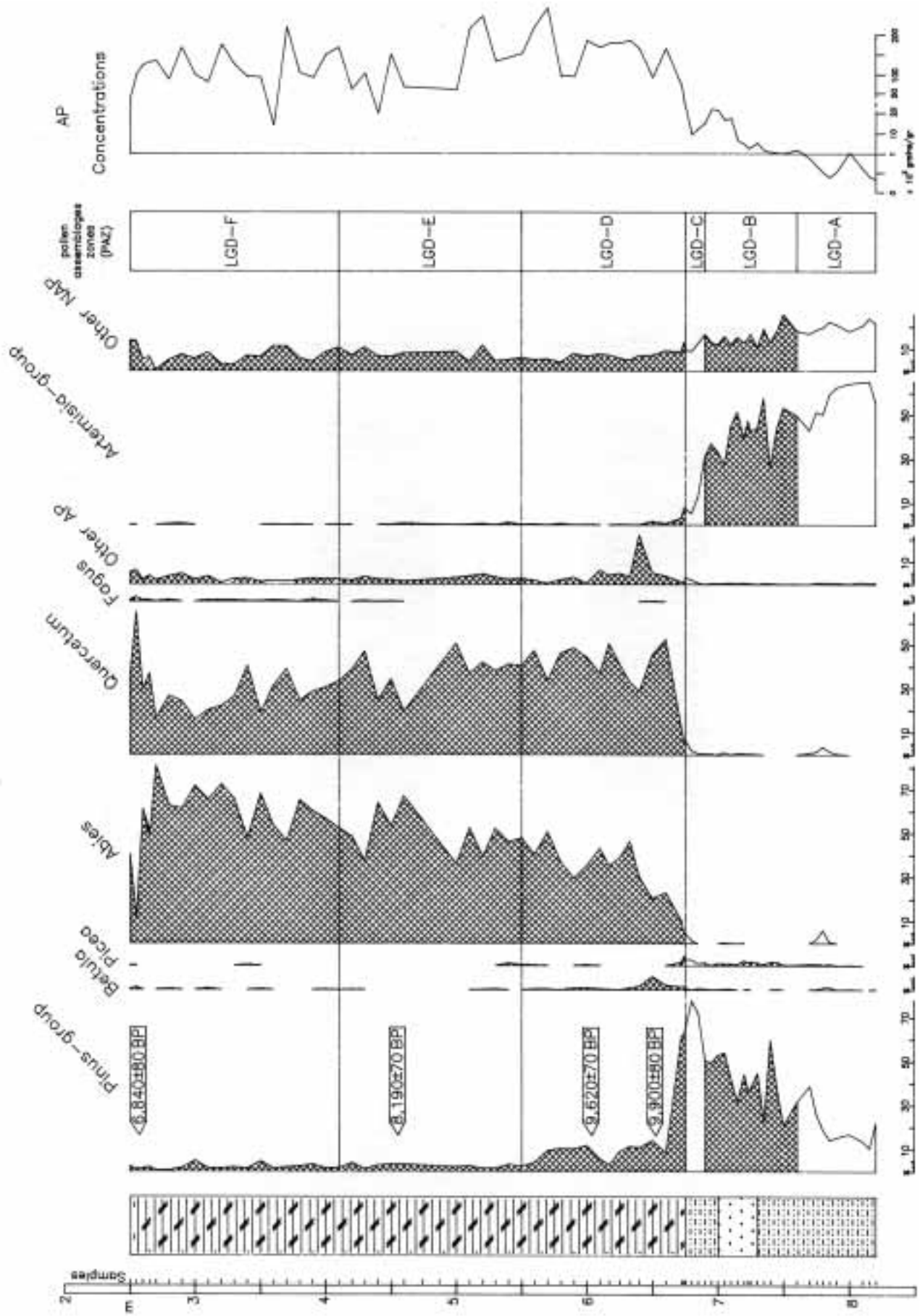

Figure 6 - Summary pollen percentage diagram of Lagdei-II with selected single taxa (Betula, Picea, Abies, Fagus) and pollen groupings. The percentages are calculated with respect to the total pollen sum. On the left of the diagram are represented the stratigraphic column, the radiocarbon datings and, on the extreme right, the AP concentration curve.

Il diagramma pollinico riassuntivo di Lagdei-II mostra singoli taxa selezionati (Betula, Picea, Abies, Fagus) e raggruppamenti pollinici. Le percentuali sono calcolate rispetto alla somma totale dei pollini. Sulla sinistra del diagramma sono rappresentate: la colonna stratigrafica e le datazioni radiocarbonio; all'estremità destra è riportata la curva di concentrazione AP.

incomplete in the eastern Mediterranean region (Wijmstra, 1969; Bottema, 1979). In central-southern Italy, where a fairly complete record of the last Pleniglacial is provided by a number of pollen sequences (Watts, 1985; Follieri *et al*., 1988, 1989; Lowe *et al*.,1996; Allen *et al*., 1999) Tursac, Laugerie and Lascaux events were not identified, although prominent peaks of AP curves at about 20,000 yr BP were recognized in several crater lakes in the Lazio region (Follieri *et al*., 1998; Magri, 1999). Furthermore, integrated analyses based on a wide range of climatic proxies (geomorphology, geochemistry, magnetic susceptibility, foraminifers) unravelled the occurrence of short-term events of climatic amelioration that are younger than 24,000 yr BP (Antonioli & Vai [eds.], 2004; Carboni *et al*., 2005).

However, in the sedimentary succession of the Venice lagoon (Northern Italy: Müllenders *et al.*, 1996; Serandrei *et al*., 2005) Tursac and Laugerie interstadials were recognized and age-calibrated at 22,270 and 19,060-19,260 yrs BP respectively; a detailed discussion from one of us is available in Serandrei *et al*. (2005). Interestingly, such interstadials were not detected by means of pollen analyses in the sedimentary cores recovered from the neighbouring Po and Veneto floodplains (Amorosi *et al*., 1999, 2004; Miola *et al*., 2003; Bondesan *et al*., 2003).

The Lascaux interstadial, which is also correlative to the Philippi interstadial (Tenaghi Philippon, Greece: Wijmstra, 1969), occurs between 17,800 and 16,500 yr BP (Leroi-Gourhan, 1965, 1968, 1980). This event was not documented in Italian pollen records so far, although high-resolution studies have been performed on coeval sedimentary cores from the Adriatic Sea (Zonneveld, 1996).

Indeed, the Lascaux interstadial is not represented in the Venice sedimentary succession because of a major stratigraphical gap that occurs in the upper part of the Venice core (Bortolami *et al*., 1977).

In the lowermost part of the Berceto core, a stadial (paz BER-1) and an interstadial (paz BER-2) have been recognized that are older than 29,620±290 ^{14}C yr BP. Chronology of paz BER-2 is fully consistent with the Arcy interstadial, which yielded an age of about 31,000 yr BP (Leroi-Gouhran, 1968). Likely, this event corresponds to the onset of the Denekamp Interstadial, recognized in central and western Europe (Hammen Van Der *et al*., 1967; Zagwijn & Paepe, 1968; Zagwijn, 1974; Mangerud *et al*., 1974; Woillard & Mook, 1982; Behre, 1989; Beaulieu De *et al*., 1994). Warming climatic oscillations referable to the same age but named differently were recognized, thanks to pollen data, both in crater lakes of central Italy (Follieri *et al*., 1998; Magri, 1999) and in other European regions (Gullentops, 1954; Lumely De, 1965; Wijmstra, 1969). In our opinion the paz BER-1 and BER-2 can be collocated at the end of the middle Pleniglacial, as shown in Table 3, where the likely correlation between the pollen zones of Berceto and the Central-Southern European climatostratigraphy for the late Upper Pleistocene is shown.

5.2 Lateglacial

Pollen data and radiocarbon age constraints recovered from the Berceto and Lagdei-II records permit the reconstruction of the vegetation history in the mountain slopes of the Northern Apennines, both at low and high altitude, during the Lateglacial period.

Specifically, the transition from paz BER-8 to paz BER-9 in the Berceto sequence (Fig. 4), characterized by the abrupt rise of NAP and the concomitant decrease of the Pinus-group, documents a peculiar vegetational pattern that is also observed at the Pleniglacial/Lateglacial boundary in southern Europe. The Pleniglacial/Lateglacial boundary yielded an age of ca. 15,000-16,000 yr BP in many pollen sequences from central-western Europe and from the Adriatic region as well (Hammen van der, 1957; Zoller, 1960; Hammen van der *et al*., 1967; Behre, 1967; Grüger, 1975; Beaulieu de & Reille, 1984a, 1984b; Beaulieu de *et al*., 1985; Reille & Beaulieu de, 1988; Beulieu de & Reille, 1992; Rossignol-Strick *et al*., 1992; Andrieu *et al*., 1993; Beualieu de *et al*., 1994), in good agreement with the Berceto record. Indeed, the age datum of 14,480±50 ^{14}C yr BP observed at 11.65 m depth in the Berceto core suggests that the base of paz BER-9 (at 12.57 m depth) is slightly older than 15,000 yr BP, thus possibly representing the Pleniglacial/Lateglacial boundary. This horizon was not identified in the Lagdei-II succession, where the boundary is likely to occur beneath the bottom of the recovered core.

In the Lagdei-II pollen sequence (Fig. 6), the Lateglacial/Postglacial boundary, as mentioned above, was pinned down at about 6.75 m depth (transition from paz LGD-C to paz LGD-D), in correspondence with the latest sharp decline of *Pinus*, *Artemisia* and other herbs, which occurs in concomitance with the immigration and the prominent increase of *Abies* and warm-temperate trees. A radiocarbon dating performed at 6.50-6.60 m depth yielded an age of 9,900±80 ^{14}C yr BP, slightly younger than the age 10,300 yr BP conventionally established for the Pleistocene/Holocene boundary throughout Europe, as testified by the abrupt change in different proxies (e.g. see in: Zagwijn & Paepe, 1968; Zoller, 1960; Mangerud, 1982; Welten, 1982; Burga, 1987; Pons & Reille, 1988; Dansgaard *et al*., 1989; Reille, 1993; Beaulieu de *et al*., 1994; Lang, 1994; Bottema, 1995; Lowe *et al*., 1996; Friedrich *et al*., 1999). Recently, the International Commission on Stratigraphy (Gibbard, 2004) proposed to shift the boundary Pleistocene/Holocene at 10,000 yr ^{14}C BP (11,550 ± 50 yr cal BP).

With respect to the boundaries mentioned above, it is suggested that paz BER-9 and BER-10 of the Berceto sequence, as well as the lower part of the Lagdei-II sequence (i.e., paz LGD-A, LGD-B and LGD-C), represent the Lateglacial. We attempted (Table 4) a correlation between the pollen assemblage zones in the study sections and the chronozones as proposed and calibrated by Mangerud *et al*. (1974).

The AP concentration curve, which testifies the degree of arboreal coverage during the considered time interval, demonstrates that a significant correlation exists between major forestation events at Berceto and Lagdei.

In particular, a steppe-woodland with *Pinus* extended in the mountain slopes of the Northern Apennines during the Oldest Dryas. The observed lesser discrepancies in AP concentrations may still depend on the different altitudes of the studied sites.

On the contrary, a sharp increasing trend of AP concentrations is documented in the upper lateglacial

chronozones, which are correlated to the Bölling-Alleröd interstadial complex.

In the Berceto record, the percentages of the Quercetum (essentially *Quercus* and *Corylus*), at the beginning overall sporadic, become continuous and important starting from the end of the Alleröd interstadial. However, the stratigraphic record is interrupted abruptly at 11,150±70 ^{14}C yr BP, in relation to a major coring hiatus that hampered the preservation of the final Lateglacial-early Postglacial interval.

On the other hand, the interval straddling the Bölling-Alleröd chronozones is continuous in the Lagdei-II succession, being characterized by the dominance of *Pinus* with *Betula* and the virtual dearth of temperate deciduous trees. Paz LGD-C, similar indeed to paz LGD-B in terms of vegetation, corresponds to

Table 3 - Local pollen assemblage zones, vegetational and climatic succession of the Berceto core tentatively related to the main chronologic and climatostratigraphic units used in Central-Southern Europe for the late Upper Pleistocene.

Tentativo di correlazione tra zone polliniche, successione vegetazionale e climatica di Berceto con le unità cronologiche e climatostratigrafiche dell'Europa centro-meridionale del tardo Pleistocene superiore.

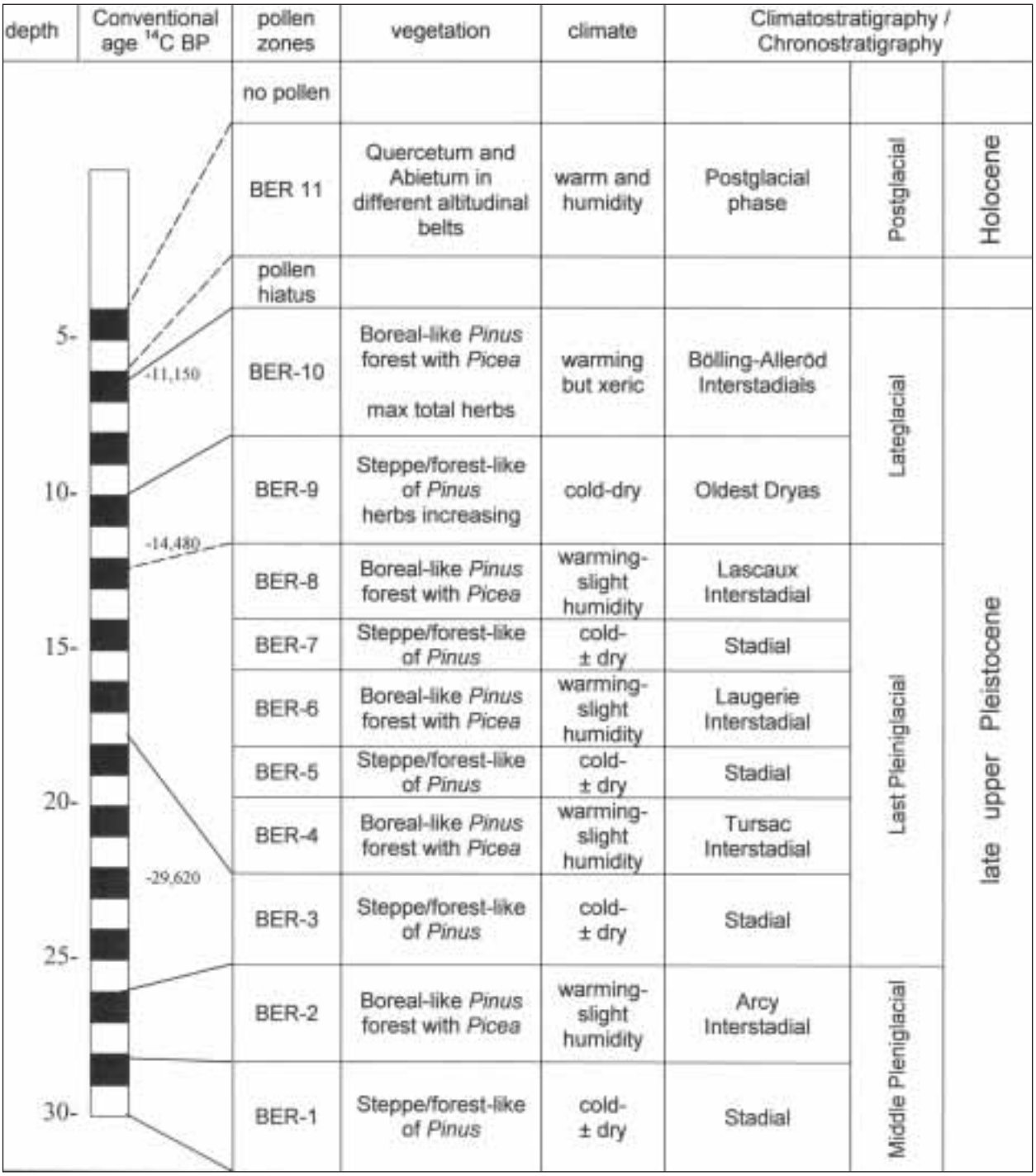

Table 4 Schema of the role of the principal arboreal and herbaceous taxa and correlation with the chronology for the Lateglacial and early-middle Holocene in the Appennino Parmense.

Schema del ruolo dei principali elementi arborei ed erbacei e loro correlazione nel quadro cronologico del Tardoglaciale e dell'Olocene inferiore e medio nell'Appennino parmense.

Chronostratigraphy and chronozones (Mangerud et al., 1974 Orombelli & Ravazzi, 1996)				Principal taxa/features			
				PAZ ^{14}C yr B.P.	BERCETO (830 m a.s.l.)	PAZ ^{14}C yr B.P.	LAGDEI (1254 m a.s.l.)
EARLY-MIDDLE HOLOCENE	6,000	middle / early	Atlantic			LGD-F -6,840	*ABIES-QUERCUS*
	8,000					-8,190	
	9,000		Boreal	BER-11	*QUERCUS-ABIES*	LGD-E	*ABIES-QUERCUS*
			Preboreal			-9,620 -D -9,900	*QUERCUS-ABIES PINUS- BETULA*
	10,300		Younger Dryas			LGD-C	*PINUS*
LATE GLACIAL	11,000	Interstadials	Alleröd / Bölling	-11,150 BER-10	*PINUS-BETULA-HERBS* *PINUS-ARTEMISIA*	LGD-B	*PINUS-HERBS* *PINUS-ARTEMISIA*
	13,000		Oldest Dryas	BER-9 -14,480	*PINUS-HERBS*	LGD- A	*PINUS-ARTEMISIA*
	15.000						

the Younger Dryas as suggested both by the fall of the AP concentrations and radiocarbon datings.

Changes in AP concentrations and fluctuations of the AP/NAP ratio in the study sections provide further information on the past altitude of both timberline and treeline during the latest Pleistocene in the Northern Apennines.

The beginning of mixed massive forestation after the LGM in the Appennino Parmense is apparently delayed with respect to other italian regions characterized by more favorable climates. Indeed, the delayed northward diffusion of both *Abies* and Quercetum elements during postwürmian times was already documented in Central and Northern Apennines (Ferrarini, 1962).

In central Italy, the diffusion of temperate deciduous trees began after the LGM and came to a completion during Lateglacial Interstadials (Follieri *et al*., 1988, 1989, 1998; Magri, 1999; Lowe *et al*., 1996; Drescher-Schneider *et al*., in press). In the Insubrian lowland areas (Northern Italy), the same process begun during the Alleröd interstadial and ended at the beginning of the Holocene (Zoller, 1960; Beug, 1964; Bertoldi, 1968; Schneider, 1978, 1985; Wick, 1996; Gobet *et al*., 2000).

Pollen data from Berceto and Lagdei-II document that the immigration of temperate deciduous trees in the Northern Apennines occurred at the end of Alleröd interstadial at low altitudes (e.g. Berceto, 820 m a.s.l.), whilst immigration and expansion of Quercetum elements occurred at the beginning of the Holocene at higher altitudes (e.g. Lagdei, 1,254 m a.s.l.).

Chronological and vegetational constraints arising from this paper shed new light on both the tempo and fashion of forest development and dynamics in the Northern Apennine area during the Lateglacial. In particular, our new data permit a reassessment of the pollen-based age model developed for the previous Lagdei pollen record by Bertoldi (1980). The latter interpretation was radically emended by Lowe (1992) and Lowe &

WATSON (1993) order to match the chronology of the Prato Spilla pollen record (Cedra Valley) (Fig.1), where a mixed forest with abundance of *Abies* and temperate deciduous trees was formerly present at the beginning of the lateglacial Interstadials.

The model of LOWE (1992) and LOWE & WATSON (1993) was challenging because of geobotanical evidence: actually, one had to infer that higher altitudes (that is, Prato Spilla at 1,350 m a.s.l.) were populated by forests rich in *Abies* and temperate elements, while concomitantly, a pioneer arboreal vegetation almost exclusively, occasionally together with *Betula*, was dominant at lower altitudes (i.e., Lagdei, 1,254 m a.s.l. and Berceto, 820 m a.s.l.). However, chronological ties presented in this paper provide evidence that the former model of the vegetational development for the Lateglacial of BERTOLDI (1980) was overall correct. Furthermore, the age model presented in this paper is supported by vegetation evidence in both Berceto and Lagdei, which are in good agreement with a number of pollen records either from central or northern Italy, as mentioned above.

5.3 Early Holocene

In the Lagdei pollen record, paz D, E and F belong to the early-middle Postglacial based on distinctive vegetational features. Further detail is provided by radiocarbon age constraints, which suggest a correlation between this interval and the Preboreal-early Atlantic chronozones (Table 4).

Vegetational development in the Northern Apennines during the Holocene is well documented so far (CHIARUGI, 1936; FERRARINI, 1962; BRAGGIO MORUCCHIO *et al*., 1978; BERTOLDI, 1980; BERTOLDI *et al*., 1986; GENTILE *et al*., 1988; CRUISE, 1990; LOWE, 1992; LOWE & WATSON, 1993; MONTANARI *et al*., 1994; WATSON, 1996). In general, the early and middle Holocene is dominated by mixed communities with *Abies* and *Quercus*, while during the middle-late Holocene *Fagus* is dominant. The immigration of *Fagus* in the Northern Apennines postdates 6,800 yr BP (this paper), while its massive diffusion took place after 5,000 yr BP (LOWE, 1992).

As stated above, the base of paz BER-11 in the Berceto record is marked by a major stratigraphic hiatus and the entire pollen zone is characterized by abundant *Abies* and Quercetum elements, while *Fagus* is absent. This vegetational assemblage suggests that paz BER-11 belongs to the early Holocene (Table 4).

6. CONCLUSIONS

The studies performed on the lacustrine sediments of Berceto and Lagdei permitted us, as a whole, to obtain new data on the vegetational and climatic features that characterized the Northern Apennines starting before 30,000 yr B.P.

The long time interval encompassed by the two sequences allowed the reconstruction of a succession of stadial/interstadial cycles that started in the latest middle Pleniglacial, where a climatic cycle likely correlated to the Arcy events was found.

The onset of the last Pleniglacial is older than of 29,620±290 yr BP and coincides with the beginning of paz BER-3, while its culmination is not settled in the pollen sequence. It is represented by alternanting stadial/interstadial events recorded in Berceto core before 14,480±50 yr B.P. We stress that the events of climatic amelioration are tentatively correlated with the well-known last Pleniglacial Interstadials: Tursac, Laugerie and Lascaux. During which a boreal-like *Pinus* forest with *Picea* existed and climatic conditions characterized by a relative improvement of the temperature and, especially, by a slight increase in humidity occurred.

The stadial phases were characterized by a steppe-woodland with *Pinus* and moreover the pollen spectra testify cold continental climatic conditions, but not very dry.

The Pleniglacial/Lateglacial boundary was recognized in a pollen succession and it is placed just before 14,480±50 yr B.P.

The pollen results demonstrate that a steppe-forest with *Pinus* existed in the mountain region during the lowest Lateglacial stadial (Oldest Dryas), while a boreal-like *Pinus* forest with low values of *Picea* and *Betula* existed during the Lateglacial Interstadials at altitudes exceeding 800-900 m. A mixed *Pinus-Betula* woodland with broad-leaved trees, mostly *Quercus* and *Corylus*, occurred at lower altitudes only at the end of the Alleröd Interstadial, precisely at 11,150 ± 70 ^{14}C yr BP. The density of these woodlands is documented by significant variations of AP concentration values.

From our pollen data the Lateglacial/Postglacial boundary, that occurred just before 9,900±80 yr B.P., is very prominent. Indeed it records the definitive fall of the pioneer arboreal vegetation (Pinus-group) and the diffusion and fast expansion of the *Abies* and of the temperate deciduous trees.

On the contrary the climatic cooling of the Younger Dryas has little evidence in the pollen spectra of the Parma Valley. Indeed it is marked overall by the sharp fall of the AP concentration curve. This fact means that during this period an open woodland occurred in the higher mountain belt. This is in agreement with some findings in southern Europe, where a diminution of the cooling effect during the Younger Dryas southwards across the continent was found (WOILLARD & MOOK, 1982; WATTS, 1985; TURNER & HANNON, 1988; ROSSIGNOL STRICK *et al*., 1992)

This palaeoenvironmental picture is in agreement with the geomorphological evidence in the Northern Apennines. This climatic event corresponds to the third glacial stage of FEDERICI & TELLINI (1983), during which glaciers were absent in Parma Valley or only small ones were confined in the cirques with an northern aspect.

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