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POLLEN ANALYSIS AND RADIOCARBON DATING OF A PEATBOG (PIAN DI NEL, 2256 m) IN ORCO VALLEY, WESTERN ALPS, ITALY

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RIASSUNTO - *Analisi polliniche e datazioni con il radiocarbonio in una torbiera (Pian di Nel, 2256 m; Valle Orco, Alpi Occidentali).* - Il Quaternario, **7**(1), 1994, 91-102 - Il presente lavoro si colloca in un più ampio studio sui rapporti tra vegetazione e sedimentazione pollinica attuale in diversi ambienti nelle Alpi Occidentali e riguarda in particolare una torbiera in località Pian di Nel (2256 m, 45° 25' N, 07° 09' E), in Valle dell'Orco, nel comprensorio del Parco Nazionale del Gran Paradiso. Sono fornite informazioni sui caratteri climatici attuali (1969-89), sul litotipo dominante e sui tipi vegetazionali sia del pianoro in cui si trova la torbiera, sia dei territori circostanti, dai quali possono giungere apporti pollinici per trasporto a media e lunga distanza. Sono state eseguite datazioni con ^{14}C su quattro livelli del profilo e da esse risulta che la base della torbiera corrisponde ad un'età convenzionale di 1990 ± 50 anni dall'attuale. Premesso che le analisi polliniche eseguite in ambienti di alta montagna non sempre forniscono un quadro reale dell'evoluzione della vegetazione esistente *in loco*, a causa dei venti di fondovalle che possono modificare la sedimentazione pollinica in senso quali e quantitativo, si può osservare un buon contingente di pollini comuni a tutto il profilo quali Gramineae, Cyperaceae, *Alnus*, *Pinus* (*sylvestris* e *cembra*), *Picea, Larix,* che testimoniano una discreta uniformità vegetazionale negli ultimi 2000 anni. Oscillazioni delle concentrazioni di pollini di *Pinus, Picea* e *Larix*, concorrerebbero ad indicare un periodo relativamente freddo dal 500-600 AD al 1000-1100 AD. Nei livelli più profondi si osservano entità mesofile (*Abies, Fagus sylvatica, Populus, Corylus avellana*). Nei livelli superiori del profilo la presenza di pollini di essenze arboreo-arbustive sarebbe dovuta prevalentemente a trasporto a media distanza.

ABSTRACT - *Pollen analysis and radiocarbon dating of a peatbog (Pian di Nel, 2256 m) in Orco Valley, Western Alps, Italy* - Il Quaternario, 7(1), 1994, 91-100 - The study was carried out as part of an ongoing research on the relationship between vegetation and pollen deposition in the Western Alps (2256 m, 45° 25' N, 07° 09' E). Information on climate, dominant lithotype and present vegetation types is reported; radiometric dating indicate a conventional ^{14}C age of 1990 ± 50 years BP. In mountainous areas, winds rising from the valley floor alter the quality and quantity of the highland pollen flora, and analysis cannot be expected to provide a realistic picture of local vegetation and of its changes over the course of time. Even so, it can be suggested that the relatively large number of entities common to the 17 layers of the studied profile (Gramineae, Cyperaceae, *Alnus, Pinus* and *Larix*) is indicative of vegetational uniformity during the last 2000 years. A cold spell between AD 500÷600 and 1000÷1100 can also be deduced from variations in the quantity of *Pinus, Picea* and *Larix* pollen. The deeper layers are rich in mesophile pollen species, such as *Abies, Fagus sylvatica* and *Corylus*, indicative of a damper climate. The samples of the sub-Atlantic period (800-500 BC) show a good uniformity of pollen composition. Comparison between the present vegetation and pollen grains in superficial layers, along with the constant predominance of tree and shrub pollens, demonstrates that most of the grains of these entities are associated with average distance transport.

Key words: Western Alps, pollen analyses, radiocarbon dating, N Italy.
Parole chiave: Alpi, analisi polliniche, datazioni con radiocarbonio, N Italia.

1. INTRODUCTION

Numerous palynological studies in recent years have added much to our knowledge of Alpine vegetation history during the late-glacial periods, while their frequent association with ^{14}C dating has produced information enabling a more objective approach to be adopted towards the interpretation of climatic and vegetational changes.

Good preservation of palynological material is ensured by peat and its formation in bogs, and these are therefore regarded as excellent sites for pollen analysis.

Peatbogs relatively close to that discussed in this work have been studied in several papers: the Arpiat bog in the Orco Valley (Arobba & Imperiale, 1981), the Rutor Glacier bog (Charrier, 1967a, 1972a; Armando *et al.*, 1975; Armando & Charrier, 1985; Burga, 1991). Other bogs have been examined near Sestrire (Charrier, 1967b) and San Sicario (Charrier & Peretti, 1977, 1978), and work has also been done in several Piedmontese pre-Alpine and hill areas (Charrier, 1972b; Charrier & Peretti, 1973, 1977).

2. THE EXAMINED AREA

As part of an ongoing research project on the relationship between vegetation and present pollen deposition in the Western Alps (Caramiello *et al.*, 1991), investigation of the Pian di Nel bog was felt to be of con-

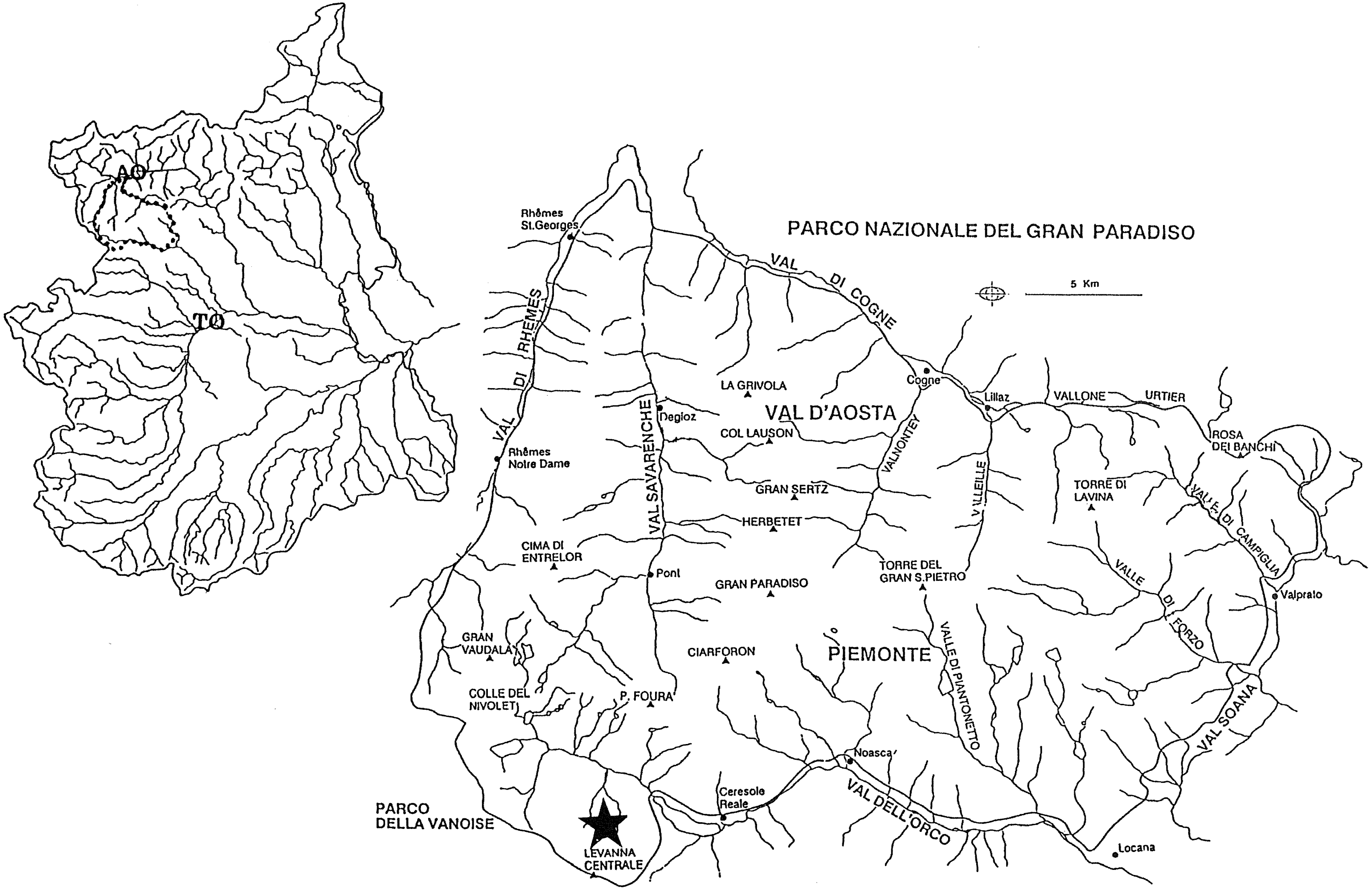

Fig. 1 - Location of the investigated site in Piedmont and in the Gran Paradiso National Park.
Localizzazione dell'area in esame in Piemonte e nel Parco Nazionale del Gran Paradiso.

siderable interest. This is located at 2256 m near the Jervis Hut on the northern side of the Levanne Group in the Orco Valley, Western Alps. Its coordinates are 45° 25' N, 07° 09' E. The area in question forms part of the Gran Paradiso National Park (Figs. 1, 2). The dominant lithotype is "augen-gneiss", a variety of granite with large orthoclase crystals.

Pian di Nel is a large lake basin filled with peat deposits. It is currently crossed by the Rio di Nel, a steam fed in spring by snow meltwaters, and in summer by runoff water from the Eastern Nel Glacier (0.4 km^2) and the Central Western Glacier (2.2 km^2), whose fronts come down to about 2550 m and are approximately one kilometre away from the bog. The Eastern Glacier front is completely buried in morainic debris, from which the stream departs, bringing with it considerable quantities of solid particles, which then form sandy and silty deposits in the plain below.

The sill enclosing Pian di Nel to the N was raised slightly around 1960 in the course of catchment operations to bring water to the Turin Electricity Board's Serrù reservoir. The flooded area of the plain is confined to the immediate vicinity of the pumping station and does not interact with the upstream bed.

2.1 Present climate

Data from the Electricity Board's Serrù Vireake Dam Weather Station (2275 m) spanning the years 1962-1989 (Mercalli, 1992) can be used to develop a picture of the Pian di Nel's climate pattern (Fig. 3).

Mean annual temperature is 0.8 °C, while mean minimum and maximum values are -3.3 °C and 4.8 °C. The lowest and highest values recorded are -30° C (1985) and 27° (1968).

Days with a minimum temperature < 0° average 241 a year (max. 299 in 1983-84; min. 214 in 1963-64), and for 108 days even the max. T is below zero.

The mean annual precipitation (rain plus melted snow) is 1183 mm (max. 2576 mm from October 1976 to September 1877; min 522 mm from October 1964 to September 1965). The distribution pattern shows a minimum in the winter and a maximum in the spring, with a second peak in autumn. Rain falls on average for 150 days (>1 mm on 118; <1 mm on 32). Snow falls throughout the year, except in July and August. An average total of 655 cm of snow (max. 1190 from October 1971 to September 1972; min. 390 cm from October 1967 to September 1968) means that the ground is covered on average for 242 days a year from October to July.

Fig. 2 - Pian di Nel.
Pian di Nel.

Table 1 - Phytosociological relevées in the examined area.
Rilievi fitosociologici nell'area studiata.

Relevée n°	1	2	3
Altitude (m)	2256	2256	2256
Slope (°)	0	2	2
Examined area (m²)	25	25	25
Herbaceous cover (%)	50	50	90
ord. *Caricion fuscae*			
cl. *Scheuchzerio-Caricetea fuscae*			
Scirpus caespitosus L.	3	1	
Carex nigra (L.) Reichard	3	1	
Carex capillaris	+	+	+
cl. Caricetea curvulae			
Nardus stricta L	+	3	3
Leontodon pyrenaicus Gouan ssp. *helveticus* (Mérat) Finch and P.D. Sell	+	1	1
Avenula versicolor (Vill.) Lainz.	+		
Carex curvula All.	1		
Festuca halleri All.	2	1	
cl. Vaccinio-Piceetea			
Homogyne alpina (L.) Cass.		+	
Vaccinium uliginosum L.		+	
Loiseleuria procumbens (L.) Desv.		2	
companion species			
Poa alpina L.		+	+
Plantago alpina L		+	+
Geum reptans L		+	+
Lotus alpinus (DC.) Schleicher		+	+
Plantago maritima L. ssp. *serpentina* (All.) Arcangeli		+	
Anthoxanthum alpinum A.D. Love			+
Ranunculus grenieranus Jordan			+
Cetraria islandica (L.) Ach.			+
Ligusticum mutellina		+	2

Snow cover is thickest in March and April. The maximum daily thickness (660 cm) was recorded in 1972.

2.2 Present vegetation

Like the rest of the Gran Paradiso National Park, the Orco Valley has not been made the subject of an exhaustive floristic and vegetational survey. Tosco has been working for many years (1973-89) on a catalogue of the Park flora, though no more than a rather limited number of families have so far been studied. Work on the Valley vegetation is confined to the data included in a doctoral thesis concerning the Park as a whole (Siniscalco, 1990). Generally speaking, the vegetation is that typical of alpine valleys not sheltered from moist air rising from the plain. Both the distribution of woods, meadows and pastures, and the floristic composition of the various vegetational types is greatly influenced by human activities in the past.

The orographic right-hand side of the Orco Valley, up to about 2,000-2,100 m, is covered with woods composed solely of larch together with some occasional red firs near the valley floor (1,500-1,600 m). As it is usual in the Western Alps, these woods also carry an undergrowth composed of *Rhododendron ferrugineum, Vaccinium myrtillus, Vaccinium uliginosum*, together with *Juniperus communis* and *Juniperus nana* in the clearings.

In phytosociological terms, they are referable to the Vaccinio-Piceion alliance (Ord. Vaccinio-Piceetalia, cl. Vaccinio-Piceetea).

The opposite side facing the peatbog is also covered by larch woods separated by large clearings once used for pasture and referable to the *Triseto-Polygonion bistortae* alliance (cl. Arrhenatheretea). Lower down, the whole of this south facing slope is dotted with groups of old houses, most of which have been abandoned in recent times, aroud wich old chestnuts groves. Clumps of *Alnus viridis* now occupy the steeper slopes, which are scarred by landslides.

The Pian di Nel lies on the north-facing right side of the Orco Valley in the Alpine Belt just above the timberline. Its geomorphological location has led to the formation of the typical Alpine peatbog phytosociologically referable to the *Caricion fuscae* order (cl. *Scheuchzerio-Caricetea fuscae*), with *Scirpus caespitosus* and *Carex nigra* as the dominant species (Table 1, relevée 1). This was regularly used for pasture, as can be deduced from the presence of a hut and a series of still efficient ditches used for drainage purposes and to improve fodder quality. The drained area carry *Nardus stricta, Leontodon pyrenaicus* ssp. *helveticus, Avenula versicolor, Carex curvula* and *Festuca halleri*, along with other species characteristic of alpine pastures on acid substrates (cl. *Caricetea curvulae*) (Table 1, relevée 2). Some relatively dry areas that have formed some way from the flooded zones and some 50-70 cm above the level of the peatbog have very different communities with *Nardus stricta, Loiseleuria procumbens, Cetraria islandica* and *Vaccinium uliginosum* (cl. Vaccinio-Piceetea), and other

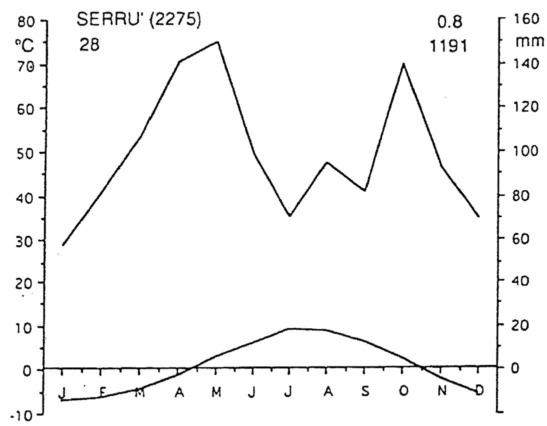

Fig. 3 - Climodiagram of Serrù Lake (1962-1989).
Climodiagramma del Lago Serrù (1962-1989).

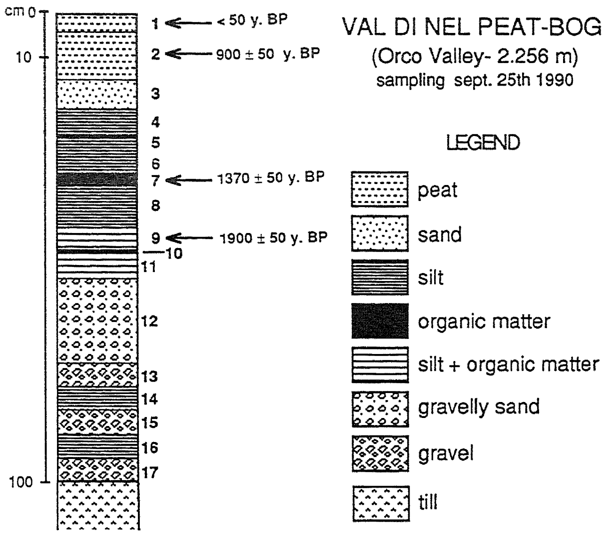

Fig. 4 - Soil profile.
Profilo del suolo.

species belonging to Alpine and sub-Alpine dwarf shrub communities, such as *Salix herbacea* (Table 1, relevée 3). Above 2000-2100 m, the alpine pastures are joined by plant formations on large block débris with fragmented vegetation cover.

The *Flora Europaea Nomenclature* was adopted (Tutin *et al.,* 1964-80). The vegetation was recorded in accordance with the phytosociological method.

3. MATERIALS AND METHODS

3.1 Sample collection

Sediment samples were collected in autumn 1990 from a meander of Rio di Nel displaying a natural soil section produced by erosion (Fig. 4). The total height of the profile from the pebble and gravel base to the grass surface is about 100 cm. It comprises silt or sand layers interdigitating with layers of peat and organic residues. A total of 17 layers from 0.5 to 10 cm thick were examined.

3.2 Pollen extraction

A 10 g soil sample from each layer was treated with 10% HCl for 30 min, cold 40% HF for 24 h (Bertolani Marchetti, 1960), and boiling 10% NaOH for 10 min. Some particularly silica-rich samples required a second 24 h HF treatment.

The number of grains per gram of substrate was calculated by means of the *Lycopodium* it tablet method. Readings were only regarded as exhaustive when not less than 100 arboreal pollen grains representing at least five of the fourteen entities were counted.

Pollen determination was carried out with general analytical keys (Moore *et al.*, 1991; Faegri & Iversen, 1989), and with specific keys, as for the Pine family (Beug & Firbas, 1961), particularly the *Pinus* genus (Accorsi *et al.*, 1978). Clearly identifiable *Pinus sylvestris* and *P. cembra* pollen grains were found in all samples, although accompanied by numerous deteriorated grains that could not be assigned to either species. Reference is thus made to *Pinus* alone.

Results of the pollen analysis are shown in Figure 5. Since the sampling depths are not shown, comparisons must be made by referring to Figure 4.

3.3 ^{14}C datings.

Samples were dated at the "Centro di studio per la geochimica applicata alla stratigrafia recente" (Rome, Italy). Two peat and two organic clay samples were first examined under a stereoscopic microscope, and then subjected to the standard acid-alkali treatment to remove contaminating carbon (Alessio *et al.*, 1970). Organic matter was transformed into benzene for counting using Belluomini *et al.* 's modification (1978) of the chemical procedure suggested by Broecker *et al.* (1959).

4. RESULTS

4.1 Radiometric datings

The results of the radiocarbon ^{14}C age measurements are shown in Table 2 together with the calibrated ages of samples analysed.

4.2 Palynological findings

The pollen percentages in each layer are shown in Table 3, while the entity patterns are illustrated graphically in a diagram (Fig. 5). The AP/NAP ratio is indicated.

A description of the characteristics of the pollen pattern found in the 17 samples with increasing age is given here after.

Sample 1: *Pinus* pollen dominate (48.2%) with associated *Alnus* (8.9%) and some *Abies, Picea, Betula, Quercus* and *Castanea.* Arboreal pollen accounts for 62.5 % of the total.

The absence of the corresponding trees suggests that these pollen grains are brought to the bog by average or long-distance transport. *Gramineae* pollen makes up 23% of the total. In the present vegetation, this family is represented by *Nardus stricta, Festuca halleri* and, to a lesser extent, *Poa alpina* and *Anthoxanthum odoratum.* The Umbelliferae portion (5.2%) is provided by *Ligusticum mutellina*, a typical alpine herbaceous species. The presence of Chenopodiaceae grains is the result of short-distance transport from species *(e.g. Chenopodium bonus-henricus*) growing in nitrate-rich areas around huts. *Artemisia* pollen, too, can be regarded as brought by short-distance transport from debris areas populated by the alpine *Artemisia mutellina* and *A.*

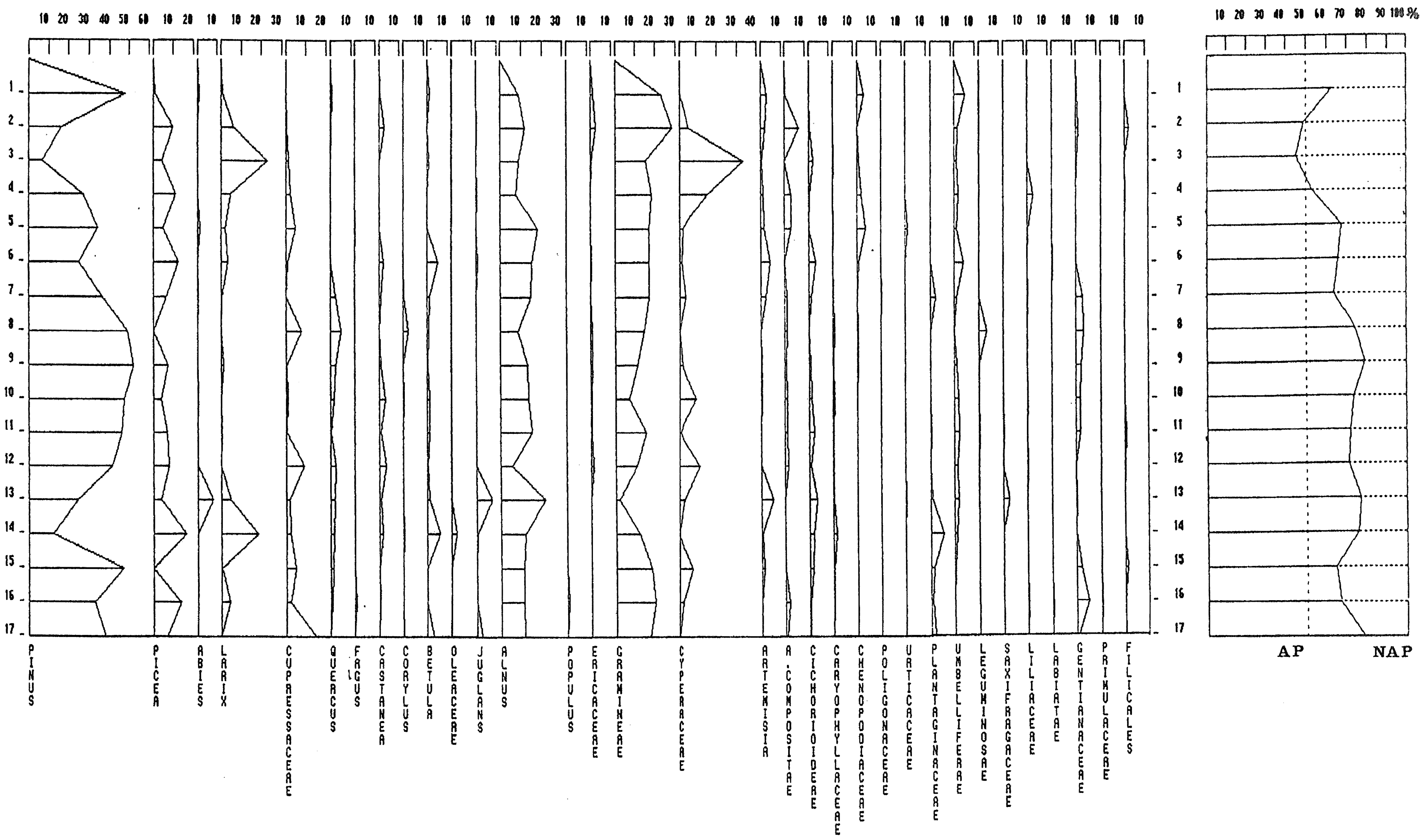

Fig. 5 - Pollen diagram of the Pian di Nel deposit and AP/NAP ratio.
Diagramma pollinico del deposito del Pian di Nel e rapporto AP/NAP.

Table 2 - Radiocarbon datings of the samples.
Datazioni radiocarbonio dei campioni.

Sample Ref. No.	Material	Depth cm	$\delta^{13}C$ (***) ‰	Radiocarbon ^{14}C age (*) years	Calibrated ages (**) 95% confidence 2σ
R-2161 (Nel 1)	Peat	5	-27.07	< 50	
R-2164 (Nel 2)	Peat	15	-27.04	900 ± 50 BP	1021 AD ÷ 1257 AD
R-2162 (Nel 7)	Organic clay	35	-30.79	1370 ± 50 BP	607 AD ÷ 773 AD
R-2163 (Nel 9)	Organic clay	50	-28.53	1990 ± 50 BP	126 BC - 92 AD

(*) Radiocarbon ages are calculated using Libby's (1955) half-life $T_{1/2}$ = 5568 ± 30 years, and are expressed as years Before Present (BP) with 1950 as the standard year of reference. Statistical error is = 1 s

(**) Calibrated ages or "probably true ages" are calculated using Stuiver & Reimer (1993) tables, where ^{14} C ages are referred to a T 1 2 = 5568 ± 30 years and ages are expressed as Before Christ (BC) or Anno Domini (AD) years. Calibrated ages include error (2 s) in their range.

(***) Correction of ^{14}C activity using delta ^{13}C values has been introduced into the calculations of the radiocarbon ages.

umbelliformis, since its long-distance transport from the valley-floor *A. absinthium* would seem unlikely. An analytical key for the species identification of *Artemisia* grains should emerge from a current series of studies on the pollen of this genus (Caramiello *et al.*,1984;1987;1990).

Samples 2-3: there are great variations in the pollen percentages. *Pinus* is drastically reduced to 6.9% (sample 3) and 16.5% (sample 2), while *Picea* now rises to 42% and 10.1% respectively. *Larix* is also abundant: 22.9% in sample 3, 64% in sample 2. Cyperaceae now account for 33.2% of sample 3 and 5.6% of sample 2. High values are also found for the Gramineae, where as Chenopodiaceae, *Artemisia* and Umbelliferae values fall.

Sample 4: the percentage of tree pollen grains is still low (53.3%), with *Pinus* at 27.1%, *Picea* at 11.2% and *Larix* at 4.7%. Cyperaceae are still relatively abundant (15.4%). The other non-arboreal grains include Gramineae (18.2%), other Compositae, Chenopodiaceae and Umbelliferae.

Sample 5: the AP/NAP ratio increases due to the contributions of *Pinus* (34.5%), *Picea, Larix,* Cupressaceae and *Alnus* (18.4%). The Gramineae values remain constant, whereas those of Cyperaceae decrease considerably.

Sample 6: a relative decrease in *Pinus* grains is offset by an increase in *Picea* and *Betula* grains. High values are also recorded for *Alnus.*

Samples 7-13: marked *Pinus* dominance (36.2%) with high values (36-52%) throughout this set of samples, and is accompanied by marked uniformity of the floral assemblage of *Picea* (min. 3.9% in 10, max. 8% in 12), Cupressaceae, *Betula, Quercus, Castanea* (min. 0.8 in 11, max. 3.5 in 12), and *Alnus* (21.6 in 13). The NAP entities are rather constant until sample 12, whereas Umbelliferae and Chenopodiaceae decline. The Cyperaceae values vary greatly from one sample to another. The AP percentage remains constant and high (60-70%) compared to more recent periods.

Sample 14: *Picea* (16.4%), *Larix* (18.2%) and *Betula* (6.3%) increase, whereas *Pinus* decreases (12.6%). Cyperaceae are not represented; Gramineae are dominant (11.8%) and Plantaginaceae values are high (6.3%).

Sample 15: the AP/NAP ratio decreases, even if the *Pinus* percentage is very high (47%). Cupressaceae (4.6%) and *Alnus* (11.1%) are still present, whereas *Larix* and *Picea* are poorly or not represented. The position of the herbaceous species remains constant: Gramineae 18%, Cyperaceae 7.4% and Gentianaceae 2.8%.

Sample 16: *Pinus* (32.9%), *Alnus* (10.8%), *Larix* (4.4%) and *Picea* (13.7%) are always present. *Fagus* (0.8%), *Castanea* (0.4%) and *Populus* (0.8%) are indicative of mesophilic conditions. Of the herbaceous genera, Gramineae dominate (19.7%), together with Gentianaceae (6%) and Cyperaceae (2.8%).

Sample 17: The AP value is about 78%, with dominant *Pinus* (38.1%), Cupressaceae (15%) and *Alnus* (11.6%). *Juglans, Betula* and *Picea* are also present. The herbaceous plants include Asteroideae, Cichorioideae and Cyperaceae, with modest values.

These findings are summed up in a pollen diagram

Tabella 3 - Pollen percentages in each sedimentation layer.
Percentuali polliniche nei singoli livelli di sedimentazione.

Sample n°	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
depth (cm)	0-5	5-15	15-21	21-27	27-31	31-35	35-37	37-46	46-50	50-52	52-57	57-75	75-80	80-85	85-90	90-95	95-100
Pinus	48.2	16.50	6.90	27.10	34.50	24.90	36.20	49.30	52.20	47.70	46.30	41.80	24.60	12.60	47.00	32.90	38.10
Picea	1.00	10.10	4.20	11.20	5.20	12.70	6.60	.	7.50	3.90	7.10	8.00	4.10	16.40	.	13.70	6.80
Abies	1.00	.	.	.	1.70	.	0.50	.	.	0.40	.	.	7.60	.	.	.	.
Larix	1.00	6.40	22.90	4.70	2.30	3.50	0.50	.	1.60	.	0.60	.	4.70	18.20	0.50	4.40	.
Cupressaceae	.	0.40	1.50	2.30	4.60	1.20	.	7.90	0.60	1.20	0.20	9.00	1.80	2.50	4.60	2.00	15.00
Quercus	1.00	0.50	.	.	.	.	2.60	5.30	2.80	1.90	0.20	2.50	2.30	1.90	1.40	0.80	.
Fagus	.	.	.	.	0.70	.	.	.	.	.	.	.	.	.	.	0.80	.
Castanea	0.50	2.60	.	.	.	2.30	1.00	.	0.90	3.10	0.80	3.50	1.20	1.90	.	0.40	.
Corylus	.	.	.	.	.	.	0.50	2.60	.	0.40	.	.	.	0.60	.	.	1.70
Betula	1.00	.	0.80	.	.	5.20	1.00	0.70	0.30	1.20	1.30	0.50	1.20	6.30	.	.	3.40
Oleaceae	.	.	.	.	.	.	.	.	.	.	.	.	.	2.50	.	.	.
Juglans	.	0.70	.	0.50	.	1.20	.	.	.	.	.	.	7.60	0.60	.	.	2.70
Alnus	8.90	11.60	8.80	7.50	18.40	15.00	14.80	8.60	12.80	13.60	15.30	5.50	21.60	11.90	11.10	10.80	11.60
Populus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.80	.
Ericaceae	1.00	2.20	0.40	.	.	0.60	.	0.70	0.60	0.40	0.20	1.00	.	.	.	.	.
Gramineae	23.00	28.50	15.30	18.20	17.20	17.30	17.30	14.50	11.30	7.00	15.50	10.90	1.80	11.90	18.00	19.70	17.00
Cyperaceae	0.08	5.60	33.20	15.40	2.30	1.70	4.60	.	2.50	9.70	1.00	11.40	3.50	.	7.40	2.80	0.70
Artemisia	3.10	2.20	0.80	1.40	1.70	4.60	2.60	.	0.60	0.80	.	.	5.80	0.60	1.40	.	.
Other Compositae	0.70	7.10	.	3.30	3.40	.	1.00	1.30	0.60	1.20	1.30	1.50	.	.	.	2.00	0.70
Cichorioideae	.	0.40	2.20	0.50	.	3.50	1.50	.	0.90	1.60	2.90	1.00	4.10	2.50	1.80	0.40	0.70
Caryophyllaceae	.	.	0.40	.	0.60	.	0.60	0.70	0.30	0.80	0.30	0.50	0.60	1.90	0.50	0.40	.
Chenopodiaceae	3.70	.	1.10	2.30	4.60	1.20	0.50	0.70	0.70	0.40	0.30	0.50	.	.	.	.	.
Polygonaceae		.	.	.	.	.	0.50	.	.	.	.	.	.	.	.	.	.
Urticaceae		.	.	.	1.10	.	.	.	.	.	.	.	0.60	.	.	.	.
Plantaginaceae	.	.	.	.	.	.	2.60	.	.	.	0.60	.	1.20	6.30	1.80	0.80	2.00
Umbelliferae	5.20	1.90	1.10	2.30	1.10	4.60	1.00	.	1.30	2.30	2.50	1.50	2.30	1.40	0.50	.	.
Leguminosae	.	.	.	.	.	.	.	3.90	.	.	0.20	.	.	.	.	.	.
Saxifragaceae	.	.	.	.	.	.	.	.	.	.	0.30	.	2.90	.	.	.	.
Liliaceae	.	.	.	2.80	0.60	.	0.50	.	.	0.40	.	0.50	.	.	.	0.40	.
Labiatae	.	.	.	.	.	0.50	.	.	.	.	.	.	.	.	.	0.40	.
Gentianaceae	0.70	1.10	0.40	.	.	.	3.60	3.80	2.50	2.00	2.30	.	0.50	.	2.80	6.00	0.60
Primulaceae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.50	.
Filicales	.	2.20	.	0.50	.	.	.	.	.	.	0.80	0.40	.	.	1.20	.	.

only. It was felt that evaluation of the pollen influx (Berglund,1986) was not convenient: the peatbog is located at the base of two glaciers. In addition, the stratigraphy within the profile indicated by the ^{14}C dating was incomplete. Since the dates thus determined show that the peatbog was formed in the pest-glacial period, there were evidently no trees above it, and one can assume that the arboreal pollen it contains was brought by medium or long-distance transport.

5. CONCLUSIONS

In mountainous areas, winds rising from the valley floor alter the quality and quantity of the highland flora, and pollen analysis cannot be expected to provide a realistic picture of its changes over the course of time. It is not impossible, however, to draw some conclusions from the results of this study.

Radiometric datings of samples 1, 2, 7, 9, calibrated to in the profile on account of their apparent richness in organic matter, shows that the deepest layer (sample 9) has an age of 1990 ± 50 years from the present, calibrated to 165 BC to 210 AD.

The age of sample 7 is 1370 ± 50 years (corresponding to 580-770 AD); sample 2 is 900 ± 50 years (corresponding to 1025-1245 AD), while sample1 illustrates recent sedimentation over a period of 50 years. There is no palynological evidence at the base of the profile to support that peat was formed during the preceding sub-Boreal period, indicating that the deposit is composed of sediments of sub-Atlantic age.

The flora is marked by species common to the whole profile, namely Gramineae, Cyperaceae, *Alnus, Pinus* (*sylvestris* and *cembra*), *Picea* and *Larix*, pointing to overall vegetational uniformity over the last 2000 years.

Persistence of a conifer wood is particularly evident. This has been dominated to a varying degree by *Pinus* (correctly represented according to Heim,1970) accompanied by *Picea* and, in some samples, by *Larix* and *Abies* (heavily under-represented).

The pollen data for samples 2-6 suggest that the timberline was lower than that for samples 7-13. In particular it is possible to observe a high number of Cyperaceae (*Carex*), Gramineae (*Nardus*), *Artemisia* and other Compositae. This fact, together with lower percentages of *Pi-nus* pollen grains and higher *Picea, Larix* and Cyperaceae percentages, indicates a relatively cold period from AD 500/600 to 1000/1100. Also dendrochronological data (La Marche & Hirschboek, 1984; Baillie & Munro, 1988) confirm the climatic characteristics of the period.

The unfavourable position of the area in which the peatbog lies makes it unlikely that the line of this wood has ever been lowered as result of human activities.

Samples 7-13 come from a warmer period with maximum qualitative and quantitative uniformity, dominated by *Pinus* accompanied by *Quercus, Castanea* and Cupressaceae that would seem to have begun some centuries before Christ and ended between 580 and 700 AD. The presence of *Quercus* pollen can also be seen as evidence of a trend towards more humid conditions.

The uniformity of the pollen composition of samples 9-13 may reflect climatic and vegetational uniformity ascribable to the sub-Atlantic period *s.s.*, which began between 800 and 500 BC according to Mayr (1969).

The deepest layers (samples 14-17) reveal the more substantial presence of mesophilic types, such as *Abies, Fagus sylvatica, Populus* sp. and *Corylus avellana*, indicative of a damper climate.

Castanea sativa is already present in layer 16 and persists with modest levels up to the most superficial layers. This continuity points to the chestnut as indigenous to the Valley (Paganelli & Miola, 1991), while its diffusion in recent times is the result of human activities. The pollen of *Juglans*, which appears sporadically in the profile, also points to both indigenousness and farming, as do the grains of Umbelliferae and Chenopodiaceae. Comparison between the present vegetation and the pollen in the superficial layer, along with the constant predominance of tree and shrub pollen grains, as shown by the AP/NAP ratio (Fig. 5), demonstrates that most of the grains of these entities are associated with medium or long-distance transport.

As to the *Pinus* genus, some tongues of *Pinus cembra* are present about 8÷10 km from the peat-bog, and this may be related to a 48.2 *Pinus* pollen percent-age in sample 1. A comparison can thus be made with situations corresponding to a mediaeval or later rise in temperature. The general vegetational setting indicated by the pollen diagram is substantially in line with the findings of Burga (1991). Data also agree with those of Arobba & Imperiale (1981) for the Arpiat lake-peat deposit 2÷3 km away in a side branch of the Orco Valley, the although of which, without radiocarbon dating, deepest layers are dated to the sub-Atlantic period.

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