HOLOCENE POLLEN DIAGRAMS AND PALEOENVIRONMENTS OF VALCAMONICA, NORTHERN ITALY

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INTRODUCTION

The Camonica Valley is situated in the southern Alpine region of northern Italy, and is one of a series of north-south running valleys that drain the Alpine areas into the Po Plain. The shape of these valleys was determined during the Quaternary by the action of glaciers and running rivers, depending to some extent also on local tectonic lines. The Camonica Valley is presently drained by the river Oglio, which begins its course near Tonale and widens *en route* to form the lake of Iseo behind the terminal morains of the Würmian glaciers.

The Camonica Valley is developed over Precambrian cristalline rocks in the north, overlain by younger rocks farther south. The most prominent of these are the Permian clastics and the Triassic through Jurassic carbonates and shales, with some evaporites; in the southernmost parts of the Valley some Cretaceous carbonates and clastics rarely occur (Roveri, 1963). The type of bedrock has a very strong influence on the recent vegetation, since acid soil develops over the cristalline rocks and the Permian clastics, while basic soils develop over the carbonates. Trees like birch and chestnut do not grow on the carbonates, which are preferred by the oaks and pines. Since the areas of the exposed rock formations did not change much during the Holocene, this preference does not influence the pollen spectra, except for the distribution of chestnuts. As will be discussed, these were introduced to the area only in Roman times or shortly beforehand.

Two peat bogs were cored and palynologically analyzed for this study. The first is situated at an elevation of 1885 m, at *Passo del Tonale,* at the north-eastern corner of the Camonica Valley, and the other is at an elevation of 185 m, at the southern end of the Valley, in the *Torbiere d'Iseo,* which is on the southern end of the Iseo Lake. The cores were collected using a Hiller corer and consist entirely of peat. The peat in both localities overlies blue to grey plastic clay, very poor in organic material, that was not cored further down due to technical difficulties with the available corer. Samples were collected from the cores at intervals of 20-25 cm, sealed in the field in time of collection and processed according to standard techniques (Faegri and Iversen, 1964). The material is embedded in glycerin jelly and is kept in the Archaeometric Laboratory of the Institute of Archaeology, Tel Aviv University. The radiocarbon dates were carried out by Dr. A. Kaufman, Isotope Department, The Weizmann Institute of Science, Rehovot, Israel, on peat samples from the Tonale core.*

* The author is indebted to Prof. E. Anati and the Centro Camuno di Studi Preistorici, Capo di Ponte (Bs), Italy, who provided every help during the stay in this country, which made this study possible. Thanks are due to Dr. A. Kaufman, Weizmann Institute of Science, for the radiocarbon datings, and to Dr. G. Tommasi, Director of the Museo Tridentino di Scienze Naturali, for making the corer available.

THE POLLEN DIAGRAMS

In each sample 150-200 arboreal pollen grains were counted; they are taken as the basis of calculation for the pollen curves, equalling 100%. The column that displays the arboreal to non-arboreal pollen ratios is based on the total number of counted pollen grains. The first column in the diagrams displays the relations of the main constituents of the arboreal pollen spectrum. Then follow several columns for the rarer arboreal pollen, displayed separately since each forms only minor part of the spectrum. The next column compares the arboreal vs. non-arboreal pollen ratios, followed by a set of columns for the non-arboreal pollen, in which only the most important groups are given. The rest, forming a minority, are grouped under « Other N.A.P. ». The Gramineae and Cyperaceae are given jointly since some of their pollen are considerably crumpled and differentiation between the two groups is frequently dubious.

A. The Passo del Tonale diagram

The lowermost sample of the Tonale core, from depth of 330 cm, consists of plastic clay in which *Juniperus* and *Artemisia* prevail, together with some *Pinus* pollen grains. Other arboreal pollen are indicated only by rare occurrences of *Quercus* and *Alnus*. The arboreal pollen share about 35% of the total spectrum. The Gramineae and Cyperaceae share is small and other non-arboreal pollen are practically absent. This pollen spectrum is unique and never occurs again within the pollen diagrams of the Camonica Valley.

The three samples that follow, up to approximately 260 cm, of which the lowest still comprises plastic clay, display a totally different pollen spectrum. Among the arboreal pollen, that still comprise 30-40% of the total, *Pinus* prevails up to 90%. Other arboreal pollen that form only minor part of the spectrum are *Alnus, Quercus, Corylus, Betula* and rare *Juglans*. The non-arboreal pollen spectrum is almost totally dominated by the Gramineae and Cyperaceae. A radiocarbon date of 9720±380 years B.P. is given for the peat sample collected at depth of 290-300 cm below surface (Weizmann Institute of Science, Isotope Department sample No. 374 B). The relative amount of Gramineae and Cyperaceae as compared with the arboreal pollen forms a peak in the middle of this zone and drops towards its upper part.

The pollen zone above, from 260 up to 185-190 cm, displays relatively high percentages of arboreal pollen, mounting to more than 60%. The composition of the arboreal pollen spectrum is totally different than during the preceding stage. *Pinus* drops abruptly and its share is taken mainly by *Alnus* and *Picea*, with slight increases also in *Quercetum mixtum* and *Corylus*. *Salix* also appear in this part of the column. Among the non-arboreal pollen Gramineae and Cyperaceae seem to be almost the sole constituents, dropping steadily towards the top of this zone. A radiocarbon date of 7580±290 years B.P. is attributed to a sample of peat representing a mean depth of 205 cm (W.I.S., I. Dept., sample No. 374 A).

The transition to the following zone, at depth of 180-185 cm, displays a decrease both in *Picea* and *Salix* pollen and an increase of *Pinus* and *Alnus*. The Gramineae and Cyperaceae are in their lowest representation still, while occurrence of *Artemisia* is noted. Above, up to 80-85 cm below the surface, occurs a zone in which the arboreal pollen begins to drop, while the Gramineae and Cyperaceae show higher percentages, still being almost the sole constituent of the non-arboreal spectrum. Among the arboreal pollen however,

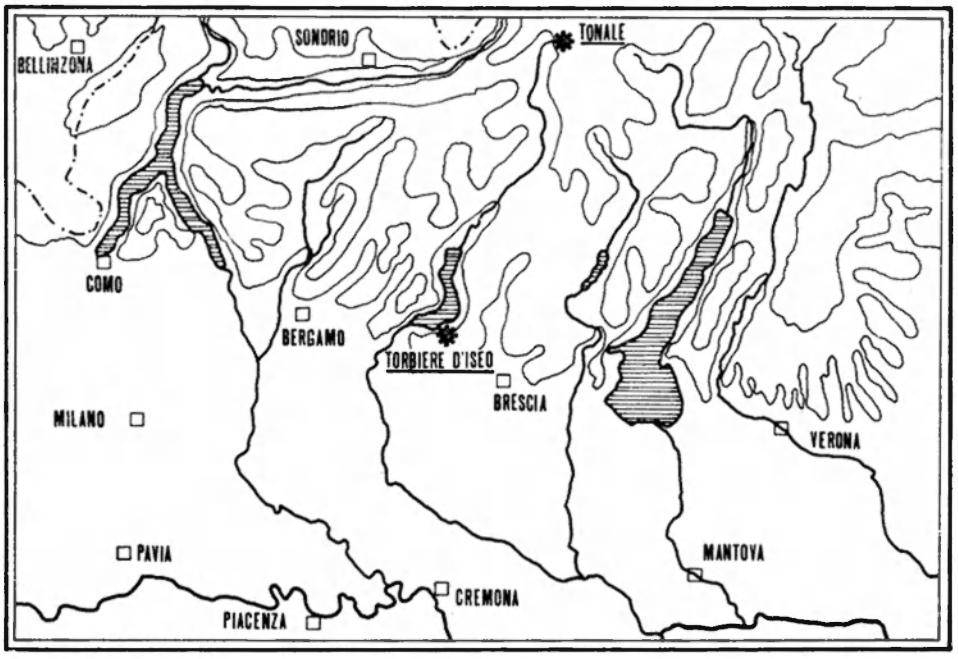

Fig. 2
Central Po Valley and Pre-Alpine area, showing the emplacement of Passo del Tonale and Torbiere d'Iseo.

significant changes are seen and the *Picea* becomes the prevailing element. *Pinus* and *Quercetum mixtum* elements maintain steady percentages, while sharp drops are displayed by the *Alnus* and *Corylus,* the latter actually disappearing. *Betula* pollen appear in this zone, but never in considerable numbers. Towards the upper part of this zone some *Abies* grains appear.

The overlying zone, up to approximately 40 cm below the surface, displays the steady increase of the Gramineae and Cyperaceae, still almost the sole non-arboreal element, and a slight decrease of the arboreal pollen. Among the latter, *Picea* drops abruptly while *Alnus* and *Quercetum* increase considerably. Almost no *Corylus* and *Salix* occur in this zone, but *Abies* shows a considerable peak. Some *Fagus* pollen also appear in this zone.

The uppermost pollen zone, from 40 cm up to the surface, still maintains the increase tendency of the Gramineae and Cyperaceae and the slight decrease in arboreal pollen. The drop of the *Picea* continues, until in the recent sample it does not exceed 5%, while *Corylus* and *Salix* reappear, together with some rare *Juniperus, Betula* and *Juglans. Abies* drops, and a new element is introduced to the spectrum — some 5% of *Castanea.* Among the non-arboreal grains the major part is still shared by the Gramineae and the Cyperaceae, but some percentage of *Artemisia* pollen also join. One sample only, collected at 35 cm, is rich in Umbelliferae pollen.

B. The Torbiere d'Iseo diagram

The lowermost samples of the Torbiere d'Iseo core did not yield pollen and seem to be slightly oxidized. The lowest sample that yielded pollen is at depth

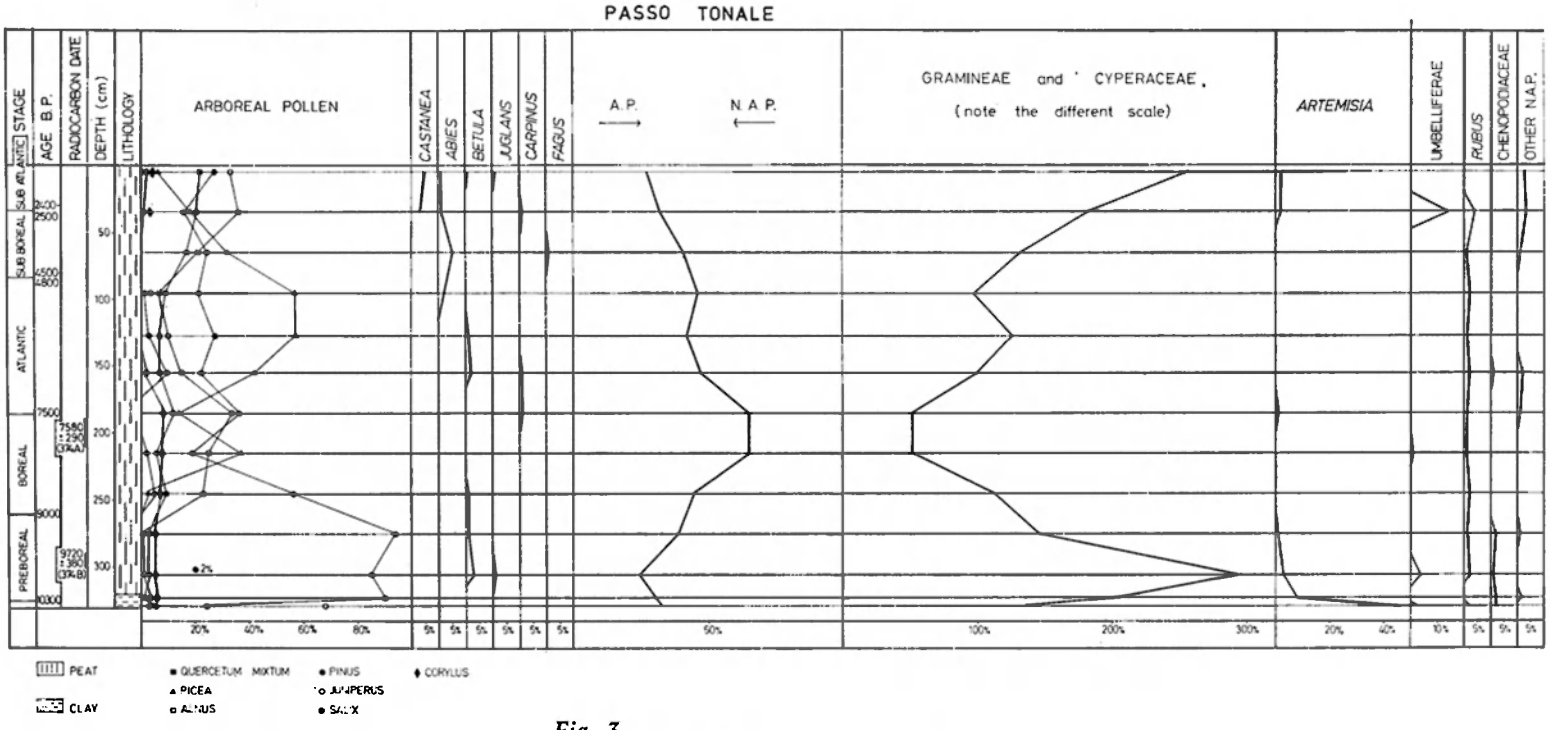

Fig. 3
The Passo del Tonale pollen diagram.

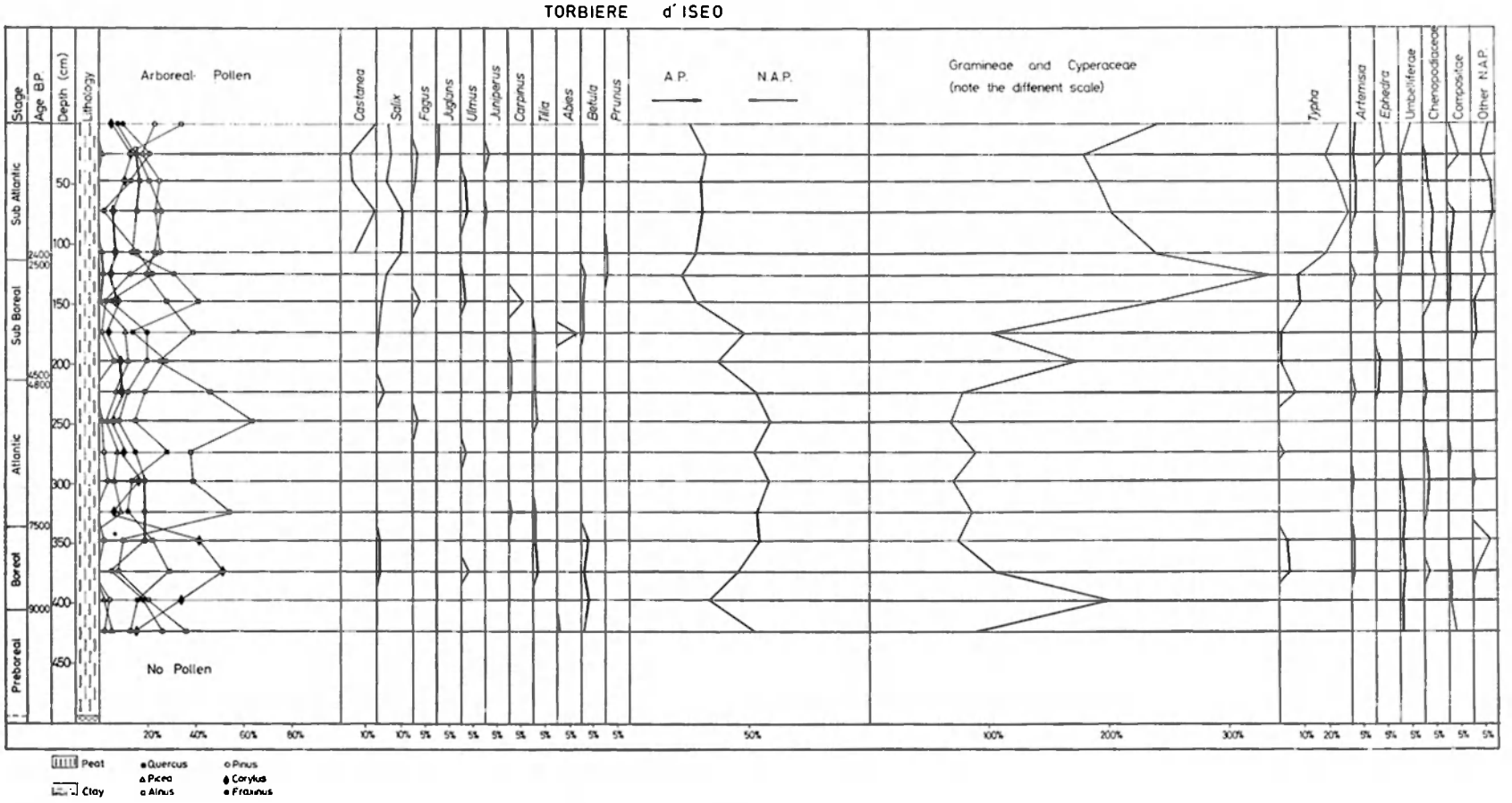

Fig. 4
The Torbiere d'Iseo pollen diagram.

of 425 cm below the Torbiere surface, the surface is covered by water, and in the time of coring (August 1970) the water was about one meter above the Torbiere surface. The depth given below for this diagram correspond to the depths below the Torbiere surface and not below the lake's water level. The lowest sample pollen spectrum is somewhat different than the overlying ones. It is characterized by high percentages of *Alnus* and *Pinus* and rather low values of *Fraxinus, Picea* and *Quercus*. The arboreal pollen share is about 50% of the total, and the non-arboreal pollen spectrum comprises practically only Gramineae and Cyperaceae.

The three samples above, up to about 340 cm, display a very pronounced peak of *Corylus*, together with an increase in the oak pollen. *Pinus* and *Corylus* drop, only to rise back towards the upper part of the zone. The arboreal to non-arboreal ratio and the total prevalence of the Gramineae and Cyperaceae among the non-arboreal pollen still maintain, as in the lowest sample.

The next zone, up to about 220 cm, is typified by a short transition in which *Corylus* drops considerably, after which it immediately increases. Typical is the great increase in *Alnus*, that in fact dominates in this part of the spectrum over the other arboreal pollen. Slight increase is seen also in the oak, *Picea* and *Fraxinum* pollen. The arboreal to non-arboreal pollen ratio also increases in this interval, reaching up to 60%. The Gramineae and Cyperaceae display a considerable decrease.

The overlying zone, up to 115-120 cm, begins with a sharp drop of the arboreal pollen and an increase in the Gramineae and Cyperaceae. The drop of the arboreal pollen is conspicuous mainly in the *Alnus*, and followed by a drop of the *Quercus*. Both, however, rise back and form the main constituents among the arboreal pollen of this zone. Notable are also the relatively high shares of *Picea* and *Fraxinus* in this zone. *Picea* drops towards the top, while *Fraxinus* begins to increase, to form the major constituent of the next zone. Among the non-arboreal, Gramineae and Cyperaceae increase almost constantly in this zone but some percentages of *Typha* and other non-arboreal pollen are encountered in the spectra. The arboreal to non-arboreal ratio decreases, following the increase in the Gramineae and Cyperaceae.

The uppermost zone is characterized by steady values of the arboreal pollen share, about 30% of the total spectrum. Among these, *Fraxinus* and *Alnus* are the main elements, accompanied by a considerable decrease of the oak and relatively steady amounts of the *Corylus* and the pine pollen. A new arboreal pollen that appears somewhat after the beginning of this zone is *Castanea*, mounting up to 14%. Among the non-arboreal pollen a drop in the Gramineae and Cyperaceae is compensated by a considerable increase of the *Typha* share, together with some others.

DISCUSSION

The arboreal to non-arboreal ratios and the composition of the non-arboreal spectra, except for some rare cases, in the pollen diagrams of the cores collected from the peat bogs in the north and south of Valcamonica seem to indicate mainly the local conditions of the localities of deposition rather than the general climatic trends. Since most of the non-arboreal spectra comprise Gramineae and Cyperaceae, that are typical constituents of the peat bogs close environment, no special attention is drawn here to those pollens. The climatic interpretations are therefore based mainly on the composition of the forest.

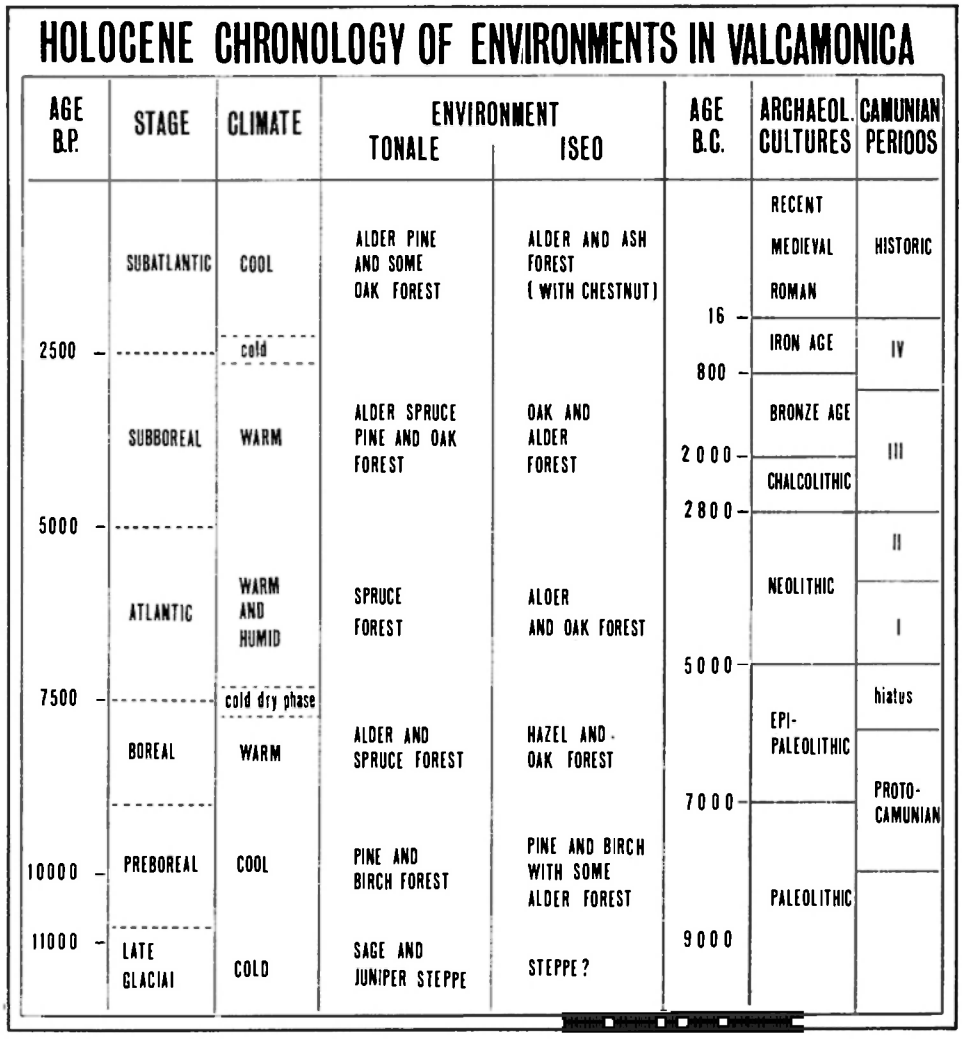

Fig. 5
Chronological chart with correlation between environments, archaeological cultures and Camunian rock art.

The dates given in the present context are based mainly on the two available radiocarbon datings for the Tonale diagram, while some correlations are suggested with the well dated Holocene pollen diagrams for the Swiss Alps (Welten, 1952).

The rate of peat deposition in the lower part of the Tonale core seem to have been constant up to the end of the Atlantic, being approximately 2400 years per meter. In the upper part of the Tonale core deposition of the peat was much slower, although it continues until the present day, probably because of higher influence of the backward erosion of the rivers that already begin to capture the peat bog area. The peat deposition in the Torbiere d'Iseo seems to have been constant throughout the entire Holocene, which seems

clear when comparing the palynological zones of both peat bogs. The rate of peat deposition in Iseo is approximately 2000-2100 years per meter.

The basal sample of Tonale, with the prevalence of *Juniperus* and *Artemisia* together with some *Pinus*, probably indicates periglacial climatic conditions that follow the retreat of the Late Glacial glacier from the Passo del Tonale area. The beginning of the peat formation is suggested at approximately 10300 years B.P. in this area, but the time of the ice retreat should be considered as somewhat earlier since the topmost clay sample contains a typical post-glacial pollen spectrum. A date of 10500-11000 years B.P. seems in good accordance with the presented data.

This cold and dry steppe vegetation was rather quickly substituted by a well developed pine forest, with some birch, that seems to be represented by the lower pollen zone of Tonale. The prevalence of this pine-birch forest ended about 9000 years ago, and it seems to correspond well with the Preboreal Stage of the Holocene. The samples collected from the Torbiere d'Iseo that probably represent the same period did not yield any pollen, so that the comparison on the palynological basis is dubious. The lowermost sample that yielded pollen from the Iseo core may however represent the uppermost part of the Preboreal Stage since it is rich in pine and alder pollen, and resembles the recent sample from Tonale, although the latter contains more oak grains. On the lithological basis, comparing the two cores, this correlation seems justified. The climate of the Camonica Valley in Preboreal times, from 10.500 to 9.000 years ago, was cool and rather dry, but comparing to the preceding Late Glacial times there was a considerable amelioration that enabled the rapid spreading of pine-birch forest in the north of the Valley, while in the south some other elements, mainly alder but also some hazel, oak, spruce and ash began their appearence, especially towards the termination of the Preboreal Stage.

The following pollen zone represents approximately the time interval of 9.000 to 7.500 years ago, according to the radiocarbon dates. This zone is characterized in the Tonale diagram by a drop of the pine and birch and an increase of the alder and spruce. In the Iseo diagram this zone is suggested as the lower well defined one, characterized by the increases in hazel and oak. These trends indicate a relatively warmer climate than during the preceding zone, and it is suggested to relate this zone to the Boreal Stage of the Holocene. The radiocarbon dates are in good accordance with this suggestion.

The next zone is characterized in Tonale by a conspicuous peak of the spruce and in Iseo by a peak of the alder. Both seem to represent a rather humid climate, that still remains warm as it was in the preceding Boreal Stage. This climatic phase seems to correlate well with the «Climatic Optimum», or the Atlantic Stage of the Holocene. It lasted from about 7.500 up to about 4.500 years ago, based on the correlation with the Swiss Alps and estimates of the rate of deposition in the Torbiere d'Iseo. The same climatic and vegetational characteristics are recorded for the Atlantic Stage also in the area of the Lagoon of Venice (Horowitz, 1966-7).

The next zone represents sediments that were deposited in both basins from 4.500 to 2.400-2.500 years ago, based on the rate of deposition in the Torbiere d'Iseo. An increase of the oak and pine in Iseo and a decrease of the spruce in Tonale indicate a drier, but still warm climate as compared with the Atlantic. It corresponds well with the Subboreal Stage of

the Holocene, and the climatic trends resemble those known for Switzerland (Welten, 1952) and the Venetian Lagoon.

The last pollen zone, represented by sediments deposited during the last 2.500 years, is characterized by a further drop of the spruce and an increase of the alder, together with the reappearence of *Artemisia* in Tonale, and an increase of ash in Iseo. These seem to indicate some cooling of the climate, more pronounced in the marginal area of Tonale than on the shore of the lake, at Iseo. An interesting point that may also indicate to the dating of the uppermost part of the diagrams, is the occurrences of pollen of chestnuts. These trees were introduced to the area by the Romans (cf. discussion in Horowitz, 1966-7) approximately 2.000 years ago and are widespread since then.

Trying to relate the human cultures of the Camonica Valley (Anati, 1974-b) to the climatic succession, it seems that the earliest known occupation must be related to the Preboreal Stage. This is the Proto-Camunian period, typified by the subnaturalistic rock carvings, in which the most interesting element as the environment is concerned, is the elk (Anati, 1974-a). The elk is of the forest dweller type which lives in pine forests (Tchernov, 1974). The only suitable environment for this animal was the pine and birch forests that occupied the Camonica Valley in Preboreal times. No indication is known for the habitation of the Camonica Valley in Boreal times. The reason for this hiatus is not known. In Atlantic times, with the warm and humid climate, occupation was widespread in the Valley, and agriculture and domestication were introduced by the Neolithic people. The favorable climatic conditions only helped these people for the easy living, which could also be the reason for the beginning of the development of arts. The Chalcolithic Bronze and Iron people occupied the Camonica Valley during the warm and drier Subboreal Stage, continuing the agricultural and domestication traditions and developing those further on. The quarrying and use of metals and the interregional commerce commenced at that period. The Roman occupation of the Valley took place in 16 B.C., after the beginning of the cooler Subatlantic Stage. Chestnuts were introduced, which form today an important constituent of the forest. The habitation of the Camonica Valley in Roman and later times seems to have been rather scarce, and the Valley was in fact used by the Romans as an exile.

Resumé: L'article présente deux diagrammes polliniques portant sur des échantillons prélevés dans les tourbières situées au Nord et au Sud du Valcamonica (Tonale et Iseo). La succession des zones polliniques et les implications climatiques et écologiques témoignent d'une amélioration du climat glaciaire, dont le début correspond au retrait du glacier de la zone du Tonale, voici environ 11000-10500 ans, et du développement d'une forêt de pins et de bouleaux se substituant à la steppe périglaciaire d'*Artemisia*. Cette amélioration est caractéristique du stade Pré-Boréal, qui s'est maintenu dans la zone du Tonale jusqu'aux alentours de 9000 B.P. Le stade suivant, ou Boréal, long de 1500 ans environ, voit une diminution du pin au profit du sapin rouge (*Picea excelsa*) et du chêne, allant de pair avec une diminution des *Gramineae* et des *Cyperaceae* en raison du climat relativement plus chaud et sec qu'au stade précédent. Une brève phase froide et sèche, au cours de laquelle se retrouve quelque grain d'*Artemisia*, marque le début du stade Atlantique dans le Tonale, il y a 7500 ans environ. Ce stade est caractérisé par la diffusion de la forêt tant au Tonale que dans la zone d'Iseo. Au Nord domine le sapin rouge (*Picea excelsa*) tandis qu'au Sud prévaut l'aulne. Ce qui témoigne d'un climat chaud et humide dans toute la région. Le stade suivant, ou Sub-Boréal, s'inscrit entre 4500 et 2500 B.P. et se caractérise par la diminution du sapin rouge et le développement du *Quercetum mixtum* (chênaie mixte) au

Nord, par la diminution du aulne au Sud, et par l'augmentation des pollens non arboraux dans toute l'aire, particulièrement des pollens de *Gramineae* et de *Cyperaceae*. Le climat est plus sec qu'à l'Atlantique. Le dernier stade, ou Subatlantique, commence vers 2500 B.P. L'augmentation du aulne relativement au sapin rouge dans le Nord et la diminution du chêne dans le Sud indiquent un climat un peu plus froid durant cette période, bien que, de façon générale, il n'y ait pas de changement climatique significatif par rapport au Sub-Boréal. Le châtaignier fait son apparition dans la région après le début du Subatlantique, et fut probablement introduit par les Romains.

Riassunto: Vengono presentati due diagrammi pollinici di campioni prelevati nelle torbiere situate a nord e a sud della Valcamonica (Tonale e Iseo). La successione delle zone polliniche e le implicazioni climatiche e ambientali indicano un miglioramento del clima glaciale, che ebbe inizio con il ritiro del ghiacciaio dalla zona del Tonale circa 11.000-10.500 anni fa, e lo sviluppo di una foresta di pini e betulle in sostituzione della steppa di *Artemisia*, di ambiente periglaciale. Questo miglioramento è caratteristico dello stadio Pre-Boreale, che perdurò nella zona del Tonale fino a circa 9.000 anni fa. Il seguente stadio Boreale, che durò circa 1.500 anni, è caratterizzato da una diminuzione del pino e da un aumento dell'abete rosso (*Picea excelsa*) e della quercia, insieme ad una diminuzione delle *Gramineae* e delle *Cyperaceae*, a causa del clima relativamente più caldo e secco in confronto allo stadio precedente. Una breve fase fredda e secca, durante la quale riappare qualche granulo di *Artemisia*, indica l'inizio dello stadio Atlantico nella zona del Tonale, circa 7.500 anni fa. Lo stadio Atlantico è caratterizzato dalla diffusione della foresta sia al Tonale sia nella zona di Iseo. A nord l'abete rosso (*Picea excelsa*) è l'albero dominante, mentre a sud prevale l'ontano. Ciò indica un clima caldo e umido in tutta la regione. Il seguente stadio Sub-Boreale durò da 4.500 a 2.500 anni fa ed è caratterizzato da una diminuzione dell'abete rosso e dallo sviluppo del *Quercetum mixtum* al nord, da una diminuzione dell'ontano al sud e da un aumento del polline non-arboreo in tutta l'area, specialmente *Gramineae* e *Cyperaceae*. Il clima era più secco che durante lo stadio Atlantico. L'ultimo stadio, quello Sub-Atlantico, cominciò circa 2.500 anni fa. Un aumento dell'ontano in relazione all'abete rosso al nord e una diminuzione della quercia al sud indicano un clima un po' più freddo per questo periodo, per quanto in generale non vi sia un significativo mutamento climatico rispetto al Sub-Boreale. Il castagno fa la sua comparsa nella zona dopo l'inizio del Sub-Atlantico e fu molto probabilmente introdotto dai Romani.

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