The Pollen Sequence of Les Échets (France): A New Element for the Chronology of the Upper Pleistocene

Jacques-Louis de Beaulieu et Maurice Reille
THE POLLEN SEQUENCE OF LES ÉCHETS (FRANCE): A NEW ELEMENT FOR THE CHRONOLOGY OF THE UPPER PLEISTOCENE

Jacques-Louis de BEAULIEU and Maurice REILLE, Laboratoire de botanique historique et palynologie, ERA CNRS n° 404, Faculté des sciences et techniques Saint-Jérôme, université d’Aix-Marseille, 13397 Marseille cedex 13, France.

ABSTRACT Les Échets mire (near Lyon, France) is one of the very few European sites showing an almost continuous record from the glaciation that preceded the Eemian up to now. The pollen diagram can easily be correlated with those from Grande Pile (Vosges). On the basis of a comparison between the two sequences, the age of three clearly temperate post-Eemian episodes (Saint-Germain Ia, Ic and II at Grande Pile) is discussed. The authors correlate these episodes with the Early Würm Interstadials of Amersfoort, Brerup and Odderade described in Northern Europe and accept the chronology of Grande Pile that dates Saint-Germain I and Saint-Germain II between ca. 115 000 and 70 000 BP, thus making them equivalents of deep sea isotopic stages 5c and 5a. This leads to refute the \(^{14}C\) chronology admitted up to now that places the Early Würm between 75 000 and 55 000 BP. Considering the predominant temperate episodes during this period, the authors propose to use the term "Pré-Würm" instead of "Early Würm". During the Middle Würm, three not well-marked interstadials can be recognized. No interstadial is found during the late Pleni-Würm.

RÉSUMÉ La séquence pollinique des Échets (France): une nouvelle donnée pour la chronologie du Pléistocène supérieur. Le marais des Échets (près de Lyon, France) constitue l’un des rares sites européens qui présente un remplissage à peu près continu depuis la glaciation qui a précédé l’Éémien jusqu’à nos jours. Le diagramme pollinique peut aisément être mis en corrélation avec ceux de La Grande Pile (Vosges). À partir de comparaisons entre ces deux séquences, la position chronostatigraphique des trois épisodes très nettement tempérés post-éémiens (Saint-Germain Ia, Ic et II à La Grande Pile) est discutée. Les auteurs mettent en corrélation ces épisodes avec les interstades du Würm ancien, Amersfoort, Brerup et Odderade, décrits en Europe du Nord et acceptent la chronologie de La Grande Pile qui situe Saint-Germain I et II entre environ 115 000 et 70 000 BP et qui en font les équivalents des étages isotopiques océaniques 5c et 5a. Ceci implique que la chronologie \(^{14}C\) admise jusqu’ici et placant le Würm ancien entre environ 75 000 et 55 000 BP est totalement erronée. Compte tenu de la prépondérance des épisodes tempérés durant cette période, les auteurs proposent le remplacement de la dénomination "Würm ancien" par celle de "Pré-Würm". Durant le Würm moyen, trois interstades de faible amplitude ont été reconnus aux Échets, alors qu’aucune variation climatique positive n’est décelable durant le Pléni-Würm final.

INTRODUCTION

In the 1970's there was consensus on the main divisions of the Upper Pleistocene in Europe: after the Eemian interglacial, the Early Würm (Between ca 70,000 and 55,000 BP) was characterized by an alternation of cold periods and three interstadials [Amerstoort (ZAGWijn, 1961); Brorup (ANDERSEN, 1961); Odderade (AVERDIECK, 1967)] marked in stratotypes by a sparse woodland with _Betula_, _Pinus_, _Picea_ (in particular _Picea omorikoides_); the Würm Pleniglacial was marked by much colder climatic conditions, relatively humid at first, then more arid; the Stieflried B Interstadial (FINK, 1956) around 30,000 – 35,000 BP was the only clear warming.

In 1975 and 1978, G. WOILLARD published pollen analyses from Grande Pile, the only West-European lacustrine sequence showing a continuous record since the glaciation that preceded the Eemian. These analyses showed two “Interglacials” after the Eemian: Saint-Germain I and Saint-Germain II, characterized by phases of forest development of deciduous trees, in particular _Carpinus_; the first interglacial was divided by a median cold phase (Saint-Germain Ib) with a boreal _Pinus_ and _Betula_ forest.

Following B. FRENZEL’s concepts (1973, 1976, 1980) according to which the North-European Eemian is anterior to the Alpine Riss glaciation, and therefore to the Riss-Würm Interglacial, Woillard put forward the hypothesis that Saint-Germain I and II represent events not yet described and correspond to an interval between the Eemian and the Early Würm which probably also includes the Riss-Würm.

However, a second interpretation, that the interglacials Saint-Germain Ia, Saint-Germain Ic and Saint-Germain II are the southern equivalents of the Amerstoort, Brorup and Odderade interstadials led to an exchange of opinions in the literature (GRÜGER, 1979a, WOILLARD, 1979, BOWEN, 1979, MANGERUD et al. 1979). Evidence from the Alps for the existence during the Early Würm of forest stages intermediate between those of Grande Pile and northern Europe (GRÜGER, 1979b; WELTEN, 1982) provided support for the second interpretation. On the other hand, the recent publication of 14C dates from Grande Pile placing Saint-Germain II older than 70,000 yr BP supports the first hypothesis (WOILLARD and MOOK 1982).

Our pollen data from Les Échets (BEAULIEU et al., 1980) bring new evidence to bear on the controversy. This site resembles Grande Pile in that it provides an almost continuous sedimentary record for the Upper Pleistocene. It is located north-east of Lyon on the Pliocene Dombes Plateau, in a zone that was covered by the Rhone Riss glacier (BORNAND et al. 1976) but was ice-free during the entire Würm. It lies 200 km south of Grande Pile (Fig. 1). The upper 39 m of sediment from a 56 m boring yielded pollen, and detailed analysis of more than 740 levels will be reported elsewhere (BEAULIEU and REILLE, 1984). A summary pollen diagram based on 168 sample levels shows only the main taxa (Fig. 2). A variable depth scale is used to accommodate all the pollen zones. It intends to reflect in a minimum of space all the pollen zones evidenced; that is why the depth scale is not always the same. In fact, some very thin sections contain a great number of events, whereas other thicker sections (especially in the upper part) show more homogeneous pollen spectra.

THE LOCAL VEGETATIONAL HISTORY

The diagram is divided into zones (letters) which correspond to the main climatic events, and subdivided in subzones which are local pollen zones (numbers).

ZONE A represents the end of glacial period with a vegetation essentially dominated by herbaceous — especially steppic — formations; A2 reflects a late glacial period marked by increases of _Juniperus_ and _Betula_.

Zone A is overlain by three layers of black organic mud (gyttja) divided by silt beds; they are characterized by forest cycles all of them including a phase with _Carpinus_ (zones B, D and F).

ZONE B partly corresponds to the lowest gytta layer; the important role of _Abies_ and the presence of _Hedera_, _Buxus_ and _Taxus_ indicate the Eemian.

ZONE C presents pollen spectra including a high percentage both of N.A.P., especially steppe species, and of mesophilous trees (_Carpinus_ and _Abies_). It is very unlikely that a natural vegetation could yield such a pollen assemblage. Considering that the thermophilous pollen grains lie in silt layers with rebedded gytta fragments from underlying levels, they certainly come from the preceding interglacial. If one excluded these taxa, the herbaceous percentages would at least be doubled, which suggests a very cold phase.

ZONE D, which corresponds to the median gytta layers, includes: a) a first anathermic phase marked by the expansion of _Quercus_ followed by _Corlylus_ (divided by a short episode with spectra containing abundant N.A.P., especially _Poaceae_; it is certainly an accidental event, as it does not prevent a _Corlylus_ expansion); b) a regression phase with an open boreal forest (D3, D4); c) lastly, a new cycle (D5 to D11) of temperate forests. It is marked by a flourishing of _Carpinus_ as clear as during the Eemian and by an expansion phase of _Fagus_.

ZONE E, corresponding to siits shows the characteristics of a cold climate with an initial phase marked by deep reworkings (E1) and two “late glacial” phases with _Juniperus_ (E3) and _Betula_ (E4).

ZONE F (uppermost gytta level) also shows a temperate forest cycle whose catathermic episodes include a phase of climatic deterioration (F6) followed by a forest recurrence (F7).

ZONE G to L: between 29,40 m and 24 m, the sedimentation shows alternations of siits and more or less sity gyttja. All the pollen spectra suggest a considerable deterioration of climate with abundant heliophytes and, among the A.P., a predominance of _Pinus_ pollen, which points out to the existence of small regional stands and/or long-distance transports.

ZONES H, J and L, corresponding to more organic levels, are interstadials; the two first ones are characterized by small maxima of _Betula_ and _Picea_, the third one, much
weaker, is only marked by a maximum of Pinus and a peak of Juniperus.

ZONES M, N, O are characterized by more abundant heliophytes than zones G to L in which as a whole persist taxa requiring much humidity, such as Calluna, Filipendula and Sanguisorba officinalis.

There is no indication of interstadials in these zones from the Upper Pleniglacial, dated with $^{14}$C. Toward 15 000 BP, a marked increase in Artemisia percentages indicates a denser steppe cover, reducing the part played by long-distance pollen transports. This event suggests a climatic improvement, recorded also at sites in southeastern France (BEAULIEU et al., 1983).

CORRELATION WITH GRANDE PILE

a) Below 29.40 m, lithologic as well as biostratigraphic correlations with Grande Pile are quite obvious. At both sites, the well-marked Eemian is followed by two forest cycles divided by woodless stadial episodes corresponding to a rather thin sedimentation of short duration. The optimum of both cycles is marked by Carpinus expansion; at Les Échets, perhaps even more clearly than at Grande Pile, the older cycle includes a cool intermediate episode (D3 and 4) without any change in the lithology. Therefore, the equivalences noted on the right of the diagram (Fig. 2) are evident. But Les Échets sequence shows several distinctive features:

- absence of a Taxus phase during the Eemian;
- more abundant pollen of Abies during the Eemian, of Quercus and Corylus during Saint-Germain Ia, of Carpinus during Saint-Germain Ic and Saint-Germain II;
- Fagus phase during Saint-Germain Ic;
- recurrence of Abies toward the end of the Eemian, and of Quercus at the end of Saint-Germain Ic, probably reflecting positive oscillations during catathermic periods;
- more modest role of Picea.

Except for the absence of a Taxus phase which may be due to a hiatus, these differences may be ascribed either to the more southern latitude of Les Échets or to the proximity of the Southern Alps and the Rhône valley as potential refuge zones for mesophilous taxa during the previous glacial.

b) Above 29.80 m, correlations with Grande Pile are much more difficult because the sedimentation rate is quite different. Zone F7, which is a prolongation of the last temperate cycle, clearly corresponds to Ognon I of Grande Pile. We share GRÜGER's doubts (1979b) concerning the existence, at Grande Pile, of the interstadials Ognon II and Ognon III.

whose pollen assemblages seem to reflect reworking phenomena. In fact, there are no equivalents of these interstadials at Les Échets. The interstadium referred to as "Pile", which corresponds to the very organic uppermost levels of the Würman sequence and contains Picea pollen might correspond to zone J of Les Échets. Lastly, the general equivalences between Lanterne III and zones M-N-O-P representing the end of the Pleni-Würm, are supported by 14C datings.

**COMMENTS**

In many respects Les Échets and Grande Pile appear to be twin pollen sequences. Les Échets, while it confirms the general validity of the Grande Pile record, provides new data that resolve the Upper Pleistocene stratigraphic problems noted above. In particular:

1°) the local zones D and F, equivalents of Saint-Germain I and II, show more temperate vegetation, thus confirming the expected evidence of a latitudinal climatic zoning;

2°) in spite of this zoning, at Les Échets as at Grande Pile, taxa indicating a climatic interglacial optimum (Vitis, Hedera, Ilex, Viscum) are absent during the Saint-Germain episodes, which, in terms of Holocene bioclimate, places Les Échets and Grande Pile near the northern limit of extension of deciduous trees. In this respect the status of "Interglacial" for the Saint-Germain episodes can be refuted;

3°) at Les Échets, the existence of a phase of Fagus forest during the part of D that corresponds to Saint-Germain Ic shows that both climatic and historical factors may have controlled contemporaneous biogeographic areas;

4°) the preceding remarks support the idea that the temperate vegetation of the Saint-Germain episodes may have been contemporaneous with vegetation suggesting a much colder climate in Northern Europe. One should mention here that the correlations made by Wijmstra (1969) at Tenaghi Philipon between temperate episodes favourable to the expansion of oak groves (Doxaton, Drama and Eleuthero polys) and the Amersfoort, Brorup and Odderade did not raise any objections at the time;

5°) remark No. 4 undermines Woillard and Mook's hypothesis (1982) that the Amersfoort, Brorup and Odderade interstadials might correspond to the interstadials Ogon I, Ogon II and Ogon III of Grande Pile, respectively;

6°) the complex forest history of cycles D and F lasted as long as the Eemian, at least for cycle D.

Therefore, we conclude that Saint-Germain Ia, Saint-Germain Ic and Saint-Germain II are equivalents of the Early Würm interstadials. But remark No. 6 leads us to suggest that the duration of ca 15 000 years attributed to these interstadials is not consistent with that of the Saint-Germain episodes. We are convinced that biostratigraphic arguments should prevail over datings and we consider that the chronology established by Woillard and Mook must be acknowledged and that, consequently, the Early Würm should be placed between 115 000 and 70 000 BP thus contradicting the generally admitted ages for this period.

This view is confirmed by the following points:

1. Woillard (1978) showed a correlation between Grande Pile and deep sea cores sequences; the chronology of the latter is in agreement with Grande Pile dates.

2. The numerous inconsistencies in the dates supporting the "classic" chronology of the Early Würm show that in most cases these dates can be considered only as minimum ages.

3. The first results of ionium dating give an age of 115 000 BP for the end of the Eemian and tend to give an age older than the one admitted for the interstadials at the beginning of the Würm (Vogel, 1982; Gremmen, 1982).

The corollary of the proposition attributing an older age to the Early Würm is that the Pleniglacial [Lower and Middle Pleniglacial according to Van der Hammem (1971)] started earlier than was formerly thought (at about 70 000 BP instead of ca 55 000 BP as had been suggested by Grootes (1977)).

On the other hand, the pollen analyses of Grande Pile and Les Échets show that the Early Würm is essentially made up of clearly temperate phases divided by colder shorter periods followed immediately by a continuously cold climate which lasted until the Holocene. Therefore the term "Early Würm" may in some respect seem incorrect; the term "Pre-Würm" would probably be more appropriate.

Though our propositions have raised new, unsolved problems, it is most desirable that the long continuous sequences from the European Upper Pleistocene should constitute the basis of a confrontation of the regional stratigraphic conceptions, leading to a refinement of ideas about the latest Glacial.

**ACKNOWLEDGEMENTS**

We are indebted to Prof. J.C. Ritchie for revising this manuscript translated into English by Ms. Pellet. We also thank Prof. S. Occhietti for his useful comments. This manuscript was submitted on August 17, 1984.

**REFERENCES**


THE POLLEN SEQUENCE OF LES ÉCHETS


GRÜGER, E. (1979a): Comment on Grande Pile peat bog: a continuous pollen record for the last 140 000 years by G.H. Woillard, Quaternary Research, 12, 152-153.

——— (1979b): Speitriss, Riss-Würm and Frühwürm am Samerberg in Oberbayern — ein vegetationsgeschichtlicher Beitrag zur Gliederung des Jungspliozäns, Geologica bavarica, 80, 5-64.


——— (1979): Reply to Comment by E. Gruger, Quaternary Research, 12, 152-155.
