# A POST-ATLANTIC POLLEN SEQUENCE FROM THE TOURBIÈRE DU TANET (VOSGES, FRANCE)

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SOMMAIRE. — L'analyse pollinique d'une tourbière bombée sur la crête des Hautes Vosges montre le développement régional de la végétation depuis 3200 ans. Une civilisation préhistorique, la période gallo-romaine, les grandes migrations et la période carolingienne se reflètent dans le diagramme pollinique par les valeurs minimales et maximales des plantes herbacées. Discussion des variations des courbes des principales essences forestières.

## Introduction.

The investigation of the tourbière du Tanet presented in this paper is part of a palaeobotanical project in the central Vosges, including analysis of pollen and macrofossils in cores and surface materials. The tourbière du Tanet is a medium-sized raised bog located at the crest of the main chain of the Vosges mountains. Because of the size and location of the bog much of the pollen deposition is supposed to be regional in character and will reflect vegetational changes from a wide area.

As usual it is not possible to interpret the various pollen assemblages in terms of vegetation from just one pollen diagram, simply because we do not have any accurate knowledge of the origin of pollen and spores. But because of the presumed regional character of the deposition of upland pollen types, this pollen diagram may serve as a standard against which future studies in the area may be measured. The tourbière du Tanet has been studied earlier by HATT (1937) and OBERDORFER (1937).

## Location and recent vegetation of the bog and surroundings.

The tourbière du Tanet is located 4 km. north-east of the Col de la Schlucht (fig. 1, 2) and west of Lac Vert at an altitude of 1230 m

above sea-level. It measures 250 m. across and is at present surrounded by *Fagus silvatica* shrub, that in the Vosges constitutes the tree limit, usually at altitudes around 1400 m. (ISSLER, 1942 : 173).

To the north and south of the bog open grass- and heath lands (the Hautes-Chaumes) are present at altitudes around 1300 m. Much of these open areas do not have a natural origin but arose by grazing. The Tanet bog is markedly raised and shows on its surface a pattern of hollows and hummocks. In the flarks *Sphagnum cuspidatum, Scheuchzeria palustris* and *Carex limosa* are dominant. On the hummocks we find species such as *Calluna vulgaris, Vaccinium oxycoccos, Empetrum nigrum, Trichophorum caespitosum* and *Cladonia sp.. Andromeda polifolia* often occupies the gradient areas between hummocks and hollows.

## Methods.

### FIELD METHODS.

A core of 360 cm. length was obtained by means of a DACHNOWSKI corer of 6 cm. diameter and an effective length of 40 cm.

### LABORATORY METHODS.

Sampling of the core was done in the laboratory and the samples were subjected to standard pollen-analytical preparation methods including sieving, boiling with KOH 10 % and acetolysis for 5 minutes. Slides were mounted in silicone oil 2000 CS without stain. Whole number of slides were counted.

### POLLEN SUM.

Pollen percentages were calculated on the basis of an upland pollen sum, including all the pollen types that presumably did not come from local bog species, thus trees and shrubs and upland herbs (pollen groups 1, 2 and 3a).

Monolete fern spores, although originating from upland vegetation, however, have been excluded from the pollen sum. In the Vosges ferns of the Polypodiaceae usually are not abundant in herbaceous stands but they are often common in the understory of upland forests, and thus do not contribute to reconstruction of extent of the forested areas. Moreover, the curve for fern spores behaves in a rather erratic fashion, difficult to interpret. Also pollen of Poaceae have been excluded from the pollen sum, mainly because they may have originated from grasses (e.g. *Molinia coerulea*) growing on the bog surface.

## POLLEN DIAGRAM.

### *Arrangement of pollen types.*

The pollen diagram (fig. 3) consists of a composite diagram showing the curves for *Pinus*, *Abies*, *Quercus* and *Fagus* and a total curve

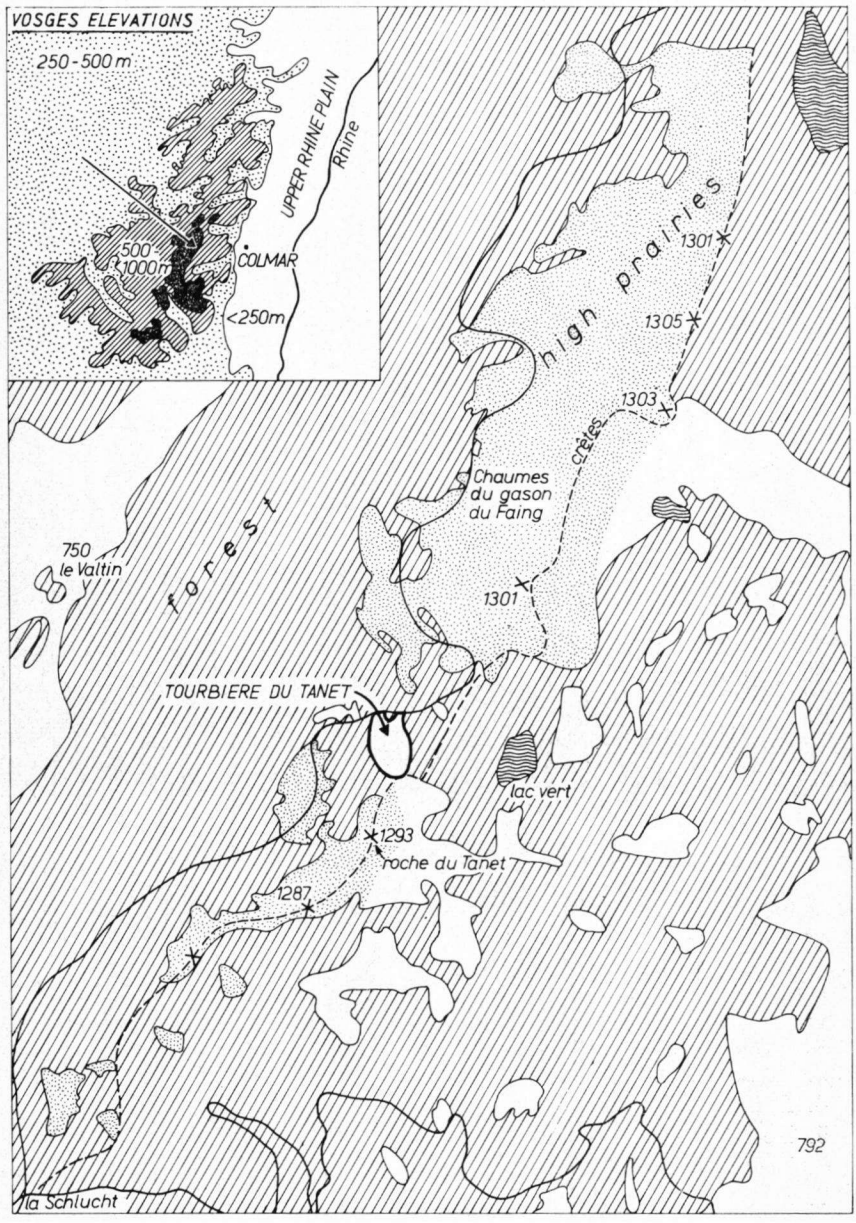


FIG. 1. — Location of the Tourbière du Tanet.

for upland herbs (NAP). The values of the NAP curve may seem low, but one should realize that the NAP does not include types such as Poaceae and Cyperaceae.

The remainder of the pollen curves have been shown in black silhouettes.


FIG. 2. — View from the Roche du Tanet looking north
A. Tourbière du Tanet surrounded by *Fagus* shrub.
B. Hautes-Chaumes of the Gazon du Faing.

The pollen types have been arranged in ecologic-physiognomic groups as follows :

1. Trees and shrubs.
2. Upland herbs from predominantly open treeless areas.
3. Upland herbs from forests.
4. *Salix* and Poaceae.
5. Fen types.
6. Bog types.
7. Ecologically indeterminate types.

*Zonation.*

The diagram can be zoned in various assemblage zones on the basis of fluctuations in the curves for upland herbs (group 2) and some trees such as *Alnus* and *Carpinus*.

At present, according to ISSLER (1942, p. 177), the upper limit of *Alnus glutinosa* is at 1000 m. above sea-level, that of *Carpinus betulus* at 800 m. Likewise taxa such as *Plantago lanceolata*, *Artemisia sp.*, Chenopodiaceae, *Secale* (according to ISSLER up to 950 m) and *Pteridium* do not occur in the present chaume vegetation.

The altitudinal limits of these taxa may have been different in the past, but for the interpretation of the Tanet bog diagram it is assumed that the bulk of the pollen of these taxa comes from lower elevations.

Especially pollen of *Carpinus betulus*, a species that demands a base-rich soil must have come from a large distance, because these soils do not occur in the central part of the Vosges, where mostly hercynic igneous rocks are found. Base-rich soils are found 30-40 km east and west of the main crest, where today *Carpinus* is abundant on calcareous soils from the Muschelkalk. This view is supported by the values found in recent surface samples from the Hautes-Chaumes (unpubl.).

Fluctuations in the values of these pollen types therefore probably reflect vegetation changes in a large area and a zonation based upon these pollen types is applicable for such a large area. This zonation therefore may serve as a basis for synchroneity for all the future diagrams from the Vosges.

On the basis of pollen stratigraphy it is possible to fit the zones in the scheme described by FIRBAS et al. (1948) for other diagrams of the Vosges. These zones may not be synchronous with those established by FIRBAS (1949) for Central Europe. In order to stress the biostratigraphic character of the zones and to avoid any time-stratigraphic implications, the zones established for the Tanet bog are designated by a site symbol (TAN) followed by a number-letter combination. In this way we hope to avoid, *a priori*, a time correlation with similar assemblage zones in other diagrams, a procedure by which a possible zonation of the vegetation in the mountains may go undetected.

Of course the synchroneity of the subzones described for the Tanet bog with those elsewhere is even less certain.

## Results and discussion.

LITHOSTRATIGRAPHY.

No detailed investigation of the composition of the peat core was done, but a small part of the material was suspended in water and

slides were prepared from peat remains in order to obtain some insight in the various kinds of peats.

The gross lithostratigraphy of the core is as follows :

0 - 25 cm : undecomposed, light coloured *Sphagnum* peat with some leaf sheats of *Eriophorum sp.*

25 - 90 cm : *Sphagnum-Eriophorum* peat with some roots of *Calluna.*

90 - 340 cm : *Sphagnum-Eriophorum* peat with various amounts of *Eriophorum,* especially at 115-130 cm, 165-180 cm and 205-215 cm.

340 - 360 cm : terrestrial Cyperaceae peat.

POLLEN STRATIGRAPHY.

Like in HATT's (1937) diagram, the present diagram covers only the last phase of the postglacial characterized by the presence of pollen of *Fagus* and *Abies.*

*Zone TAN-8.*

The base of the diagram shows, in contrast to the rest of the diagram, high percentages of *Corylus* and *Tilia* but rather low percentages of *Fagus* and *Abies.* This zone is similar to the later phases of zone VIII from other sites in the Vosges (FIRBAS et al., 1948).

*Zone TAN-9 and zone TAN-10.*

*Zonation, dating and culture phases.*

A C-14 date from the base of zone TAN-9 is 3205 ± 35 B.P. (GrN-6125) rather early and consequently zone TAN-9 may represent a different time unit than zone IX established elsewhere.

At any rate the date agrees more or less with a date from a similar biostratigraphic transition in the Fagnes des Savoureuses in the southern Vosges (3650 ± 200 B.P. : DRESCH *et al.,* 1966).

As mentioned before the zone may be subdivided on the basis of the NAP and of *Carpinus.*

In subzone TAN-9a the NAP is low but from subzone TAN-9b on there is a rise of pollen from plants preferring a treeless environment, especially *Plantago lanceolata, Pteridium* and *Rumex acetosella.* Also pollen of *Secale* and that of other Cerealia appear, indicating agricultural activities. A C-14 date from the base of subzone TAN-9b is 2250 ± 90 B.P. (GrN-6299).

After a maximum of the NAP at the base of subzone TAN-9, the NAP values decline and remain constant.

In subzone TAN-9c there is a renewed increase of pollen of the NAP. Cerealia and *Secale* show a continuous curve.

A C-14 date from the base of the zone is 1900 ± 90 B.P. (GrN-6070), thus at about 50 A.D. Most likely therefore this subzone represents the time of Roman occupation.

In subzone TAN-9d there is a strong decline of the NAP and an increase of pollen of *Carpinus* followed by an increase of pollen of the NAP and a decrease of pollen of *Carpinus* in subzone TAN-10a.

A C-14 date of the base of subzone TAN-10a is 1245 ± 65 B.P. (GrN-6123) thus around 700 A.D. Subzone TAN-9d therefore represents the time of the Invasions, in western Europe generally characterized by a decline of the population and a decrease of agricultural activities (SLICHER van BATH, 1963 ; DARBY, 1956).

The date of 700 A.D. for the base of subzone TAN-10a agrees well with the dates of the foundation of convents in the Vosges (FIRBAS *et al.*, 1948 : 62). In 660 A.D. for instance the Benedictine Abbey in Münster was founded (SCHMITT, 1963). During subzone TAN-10a we find in the NAP two minima. Especially around spectrum nr. 24 the minimum is well marked. It is accompanied by a temporary rise of *Carpinus*.

A C-14 date of this level is 1200 ± 65 B.P. (GrN-6071) in fact similar to the date from the lower part of the subzone. It does not seem probable that some 25 cm of peat accumulated in such a very small interval of time and therefore one of the two dates must be in error, possibly GrN-6071.

At any rate, a date from the base of subzone TAN-10b is 1040 ± 50 B.P. (GrN-6473) thus the beginning of medieval times and consequently the fluctuations in the curve for the NAP in subzone TAN-10a must be dated between 700 A.D. and 1000 A.D.

Subzone TAN-10b is characterized by a strong increase of the NAP, and a decrease of *Carpinus*. At the base of the subzone especially *Pteridium* shows a maximum whereas towards the top there is an increase of the values of pollen of the Cerealia.

Perhaps this is a reflection of deforestation followed by agricultural occupation in medieval times.

In subzone TAN-10c there is a decline of the values of pollen of the Cerealia but an increase of that of *Plantago lanceolata*. The values of pollen of *Carpinus* increase slightly. In this subzone percentages of pollen of *Fagus* decrease strongly, those of *Abies* and *Pinus* increase.

*Poaceae.*

From the middle of subzone TAN-9a there is a clear positive correlation of the curve of the Poaceae with that of the NAP. Although

pollen of Poaceae were not included in the pollen sum it seems likely that most of the Poaceae pollen grains come from the same source area as those of the NAP.

*Corylus, Betula and Alnus.*

As mentioned before the upper limit of *Alnus glutinosa* is at 1000 m. above sea-level and it is therefore absent from the crest of the mountains.

*Corylus avellana* is represented by one shrub in a protected site in the Hohneck region but otherwise this species is also no part of the vegetation at the crest.

At lower elevations on siliceous Cambrian rock *Corylus* is not abundant at all. However, it is found more abundantly on calcareous soils to the west and east of the main chain.

Most of the pollen therefore must have come from the valleys. It may be significant in this connection that often the values of *Alnus* and *Corylus* are negatively correlated with those of the NAP : there is a decline from the base of subzone TAN-9b, followed by an increase.

During the Roman phase (subzone TAN-9c) the values of *Corylus* and *Alnus* show a minimum but in subzone TAN-9d they rise again. In zone TAN-10 the correlation is less clear but some smaller fluctuations of the values for *Alnus* are mirrored by those of the NAP.

From this one may conclude that in the valleys man actually interfered with stands of *Alnus glutinosa* and of *Corylus*. During minima of human activities these species were able to expand after suppression.

Pollen grains of *Betula* may have come partly from *Betula pubescens* generally occurring along the margin of bogs. A correlation with cultural events in the valleys therefore seems less likely. Its curve, however, matches that of *Corylus* and *Alnus*, in subzone TAN-10a even in detail, suggesting that pollen grains of *Betula* do not come from the immediate surroundings of the bog but like *Alnus* and *Corylus* from the valley floor.

*Fagus and Abies.*

Unlike the species dealt with so far, *Fagus* and *Abies* are constituents of the vegetation that today is part of the mountain vegetation in upper elevations. *Fagus silvatica* is dominant in the upper reaches (today up to 1200 m) whereas *Abies alba* is the dominant tree at medium elevations.

Up to subzone TAN-9c there are striking fluctuations in the curves for *Fagus* and *Abies* but there is no general trend. In subzone TAN-9c the values for *Abies* decline followed by a slow increase in

subzone TAN-9d. This increase continues, with interruptions during maxima of the NAP, right up to the subzone boundary TAN-10a/10b. In subzone TAN-10b there is a strong decline in the values for *Abies*. In the upper part of the subzone the values for *Abies* reach 3 %, very low indeed.

A strong decline of the pollen values for *Abies* (and *Fagus*) during the Subatlantic was also observed in pollen diagrams from podzols on Permian sandstone at much lower elevations east and west of the Central Vosges (GUILLET, 1971). *Abies* pollen belongs to a group of pollen types that is dispersed over short distances and it is therefore not very probable that the *Abies* decline in our diagram is a reflection of vegetational events outside the Central Vosges. The same applies for *Fagus*. The fluctuations in the curve for *Abies* must be more a reflection of changes in the vegetation at a much closer distance, in the mountains themselves. These fluctuations may be explained by assuming that *Abies* was more or less confined to the lower slopes in the mountains, just like today, where it was most susceptible to man's activities, such as grazing of cattle in the forest, especially during the middle-ages up to the 19th century. In the Tanet diagram the values for *Abies* are often negatively correlated with those of *Corylus*, *Betula* and *Alnus*. There is a decline in the values for *Abies* at the levels where *Corylus* and *Betula* show increased values *i.e.* at the base and in the upper part of subzone TAN-9b, at the top of subzone TAN-9c and at the base of zone TAN-10b. This may indicate that *Abies* forests were replaced by pioneer species such as *Corylus* and *Betula* that are able to expand after or during human occupation. Also GUILLET (1971) holds human influence responsible for the *Abies* decline in soil diagrams from sandstone areas in the Low-Vosges.

An alternative explanation would be to assume that a worsening of the climate depressed the upper limit of *Abies*, resulting in declining values for *Abies* in samples from the crest region. According to CARBIENER (1963) *Abies alba* is like *Fagus silvatica* a tree from a suboceanic climate, not resistent to cold winters, but unlike *Fagus* more resistent against strong winds. However the final decline of the *Abies* values starts at a time when the general climate was even more favourable than today.

It seems clear however, that the rise of the percentages of *Abies* in subzone TAN-10c is connected with the modern management of the forest that from the 19th century on, selectively protects *Abies* for commercial purposes (LEMÉE, 1963). According to DION (1970) *Abies* and *Fagus* expanded spontaneously at lower elevations at that time, because of an increase of the period of rotation of the forest.

Also the values for *Pinus* and *Picea* low throughout the diagram increase in zone TAN-10c as a result of plantations east and west of the crest, pines especially on sandstone (GUILLET, 1971).

The curve for *Fagus* is more or less the counterpart of that of *Abies,* a general feature of dominant pollen types in a relative diagram. In our opinion it is therefore not yet possible to offer reasonable explanations until more pollen data from bogs at various elevations in a restricted area are available.

*Dryopteris.*

The *Dryopteris* curve shows a conspicuous break at the transition from subzone TAN-9b/TAN-9c. Ferns are common in forest vegetation in the Vosges and the decline may be connected with human activities that may have lowered the upper limit of the *Fagus* shrub. In recent surface samples (unpublished results) there is indeed a strong decline in the percentages of fern spores at increasing distance from the *Fagus* shrub. However, there is no increase in the values for fern spores in subzone TAN-9d. Perhaps the bog itself had expanded laterally at that time, resulting in an increasing distance from the coring site to the *Fagus* shrub.

*The Hautes-Chaumes (high prairies).*

According to BOYÉ (1903) the Hautes-Chaumes came into existence during the Carolingian period thus in subzone TAN-10a.

It is possible that the curves for the NAP and the Poaceae reflect an extension and regression of prairie vegetation at higher elevations. However, as has been mentioned before, most of the pollen of the NAP is thought to originate from vegetation at lower elevations east and west of the main chain of the mountains. Most of the components of the NAP are not exclusively indicators of the vegetation of the hautes-chaumes, therefore they can not be used to indicate chaume vegetation at higher altitudes.

The only pollen types that may indicate hautes-chaumes vegetation are *Arctium* type and *Lycopodium clavatum* type, occurring in the upper part of subzone TAN-10b, and *Anemone* type, occurring from subzone TAN-9b on.

There is, however, in *Anemone* type no clear correlation with the fluctuations of the synanthropic pollen types. Perhaps also fluctuations in the curve for *Calluna* are a measure for the extension of the high prairies. Again detailed pollen studies in a small area will be necessary to settle these problems.

*Development of the bog.*

In zone TAN-8 the local vegetation does not show the character of an ombrogeneous bog yet. The values for Poaceae are high and

pollen grains of Apiaceae, Sparganium type, *Potentilla* type and of *Polygonum bistorta* are most abundant. This may indicate that the bog was a wet meadow (*Molinietalia*). There is also no indication that the bog started its existence by paludification of *Fagus* shrub.

In zone TAN-9 and zone TAN-10 the mire vegetation consisted mainly of *Sphagnum sp.* and *Eriophorum sp.* and in the samples pollen of *Andromeda* and *Drosera* are regularly found.

A peak in the values of pollen of *Empetrum* is noteworthy in subzone TAN-9c.

From subzone TAN-9b upwards there is an increase of pollen of *Calluna* and *Empetrum*, culminating in maxima in the upper part of subzone TAN-10b. Apparently the bog surface became much drier.

In subzone TAN-10c the values for the Cyperaceae rise dramatically. Most likely these pollen grains come from *Trichophorum caespitosum*, that today is a dominant herb on the bog surface.

ISSLER (1942) reported an invasion of this species since around 1870, a fact that agrees well with the trend in the pollen curve.

*Some notes on individual pollen types.*

*Ephedra distachya* type.

*Ephedra sp.* is today not native to the Vosges. It is known to travel over very long distances (MAHER, 1964 ; BORTENSCHLAGER, 1967). It may have come from the Atlantic coast.

*Buxus.*

Scattered occurrences from subzone TAN-10b on. *Buxus sempervirens* is today abundant in *Fagus-Cornus mas-Fraxinus excelsior* woods on calcareous soils on sunny slopes west of the Vosges (DURIN, MULLENDERS and VANDEN BERGHEN, 1964). *Buxus* is also present east of the Vosges.

*Castanea, Juglans.*

At present *Castanea* and *Juglans* pollen come from areas east of the Vosges (upper limit at an elevation of 700 m). According to ZOLLER (1967) *Castanea sativa* and *Juglans regia* were introduced in the Celto-Roman period along the southern rim of the Alps from where it spread towards the north. This agrees with the first occurrence of these pollen types in subzone TAN-9c, thus during the Roman period. Macroremains of *Juglans* have been found in prehistoric sites north of the Alps before that time (cf. discussion in ZOLLER, 1967). Also DRESCH *et al.* (1966) found some pollen grains of *Juglans* much before the Celto-Roman period. It might be that *Juglans* arrived in the Vosges quite early, but this view is not sup-

ported in the Tanet diagram. Also towards the north pollen grains of *Juglans* are not found prior to the Celto-Roman period (MUNAUT, 1967). In the Tanet bog diagram the values for *Castanea* and *Juglans* increase from subzone TAN-10b on.

*Vitis.*

Occasional grains of *Vitis* have been found in subzone TAN-9b, TAN-9c and TAN-10a. The curve is closed from subzone TAN-10b on. The pollen comes probably from *Vitis vinifera* cultivations east of the Vosges.

*Centaurea cyanus.*

Pollen of *Centaurea cyanus* occur where there is an increase in the values of Cerealia in subzone TAN-10b.

*Cannabis.*

All the pollen grains of the *Cannabis-Urtica* type over 25 μ in size have been scored as *Cannabis*. They occur from zone TAN-10a on.

**Summary.**

The pollen analyse of a raised-bog on the High Vosges crest shows the vegetation regional development since 3200 years. A prehistoric civilization, the Gallo-roman period, the great migrations and the Carolingian period are reflected in the pollen diagram by N.A.P. minima and maxima. A discussion on curves fluctuations of the main A.P. follows.

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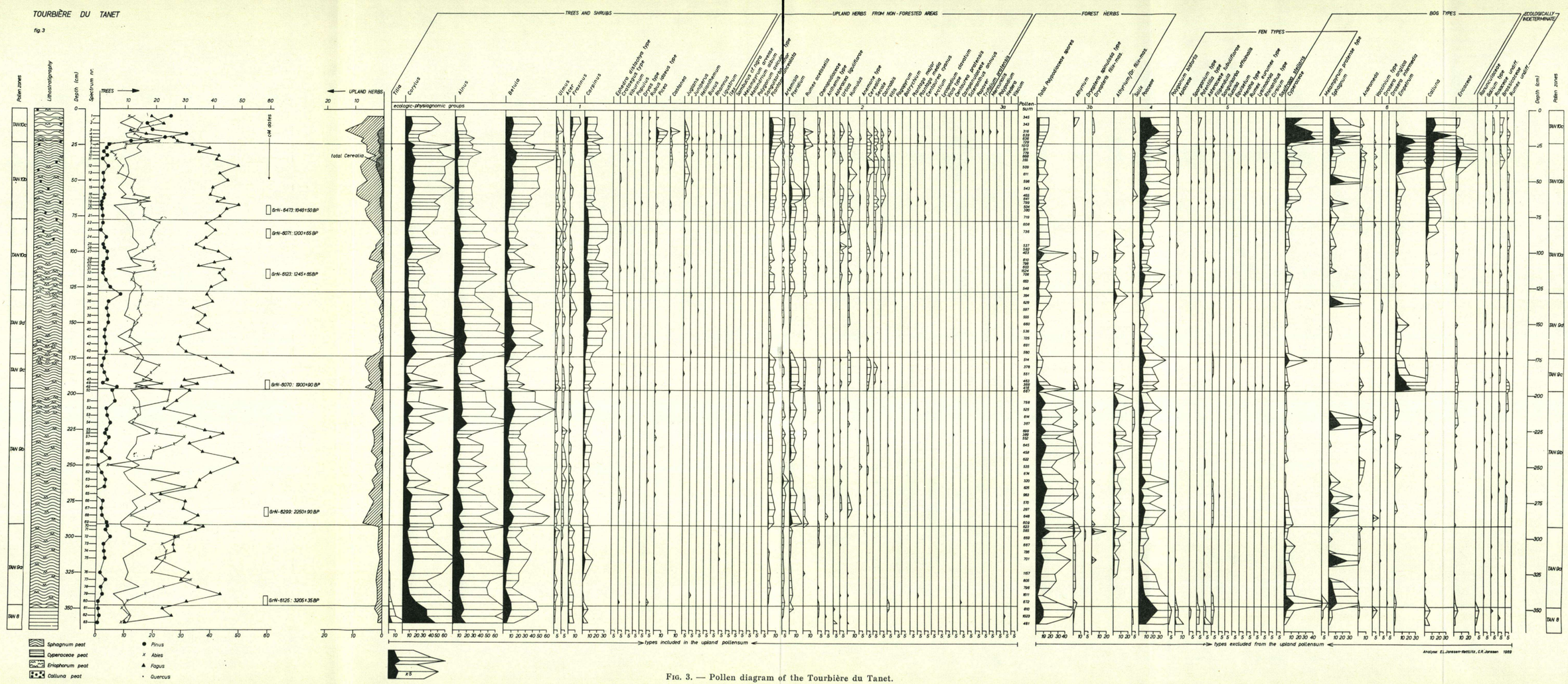


FIG. 3. — Pollen diagram of the Tourbière du Tanet.

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