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NEW HIGH-RESOLUTION POLLEN RECORD FROM HAUTES-FAGNES, BELGIUM

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Abstract: We present here the results of pollen analysis of one sequence of about 60 cm length, originating from sediments of Hautes-Fagnes peat bogs (Eastern Belgium). 49 pollen spectra reflect the local vegetation evolution and also the evolution of the forestry surroundings. The results of these investigations are correlated to the results of other studies previously carried out in the area. Our data suggests human occupation and intensive land use in the region. Aspects regarding a Roman/Merovingian paved road, at present covered by a layer of peat that can reach 1 m thickness in some places, are also debated in the present paper. The origin and functionality of this paved road have not yet been fully elucidated, despite the studies already performed.

Keywords: vegetation history, pollen spectra, peat-bog, Hautes-Fagnes, Belgium, human impact.

Introduction

Located in the Eastern Belgium, The Hautes-Fagnes Plateau records the coldest climate and the most abundant precipitation in Belgium. These conditions favored especially between 500 and 694 m altitude, the forming of many ombrotrophic peat bogs, maintained from the beginning of Holocene (Damblon, 1994).

Peat bogs are true vegetation archives, due to the fact that pollen is very well preserved in an acidic and anaerobic environment. Aside from these conditions, deposition is also very important: pollen grains need to be incorporated in the sediments that will preserve the chronology of their deposition, which will progressively accumulate in time. Thus, the reconstruction of palaeovegetation and of palaeoclimate is possible. The quantitative and qualitative analyzes of spores and pollen grains found in such anaerobic environments allow the evaluation of the human activities influence on the palaeoenvironment.

Many studies regarding the vegetation evolution in the Hautes-Fagnes Plateau have been carried out (Damblon, 1978, 1994; Dalemans and Streel, 1986; Dricot, 1960; Streel et al., 2007).

As to the human influence in the analyzed area, it is interesting to observe the anthropic impact on the palaeoenvironment as regards the building of an old paved road (*Via Mansuerisca* or "Pavé de Charlemagne"). This road, now covered by peat that reaches 1 m in thickness in some places, is about 6 km long and 6 m wide and roams the Plateau in NW-SE direction. The background and performance of the road have not yet been fully elucidated, many questions still remain opened, despite the studies already performed

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(Corbiau, 2005). Dricot (1960) sustains the hypothesis of the roman background, based on a single ^{14}C date. Subsequent studies doubt this hypothesis, assigning this road to the Merovingian age (Corbiau, 1981; Dalemans and Streel, 1986). Other investigations carried out in 2004 (Renson et al., 2005; Streel et al., 2005), reveal that this road was established in the late Roman Empire, at the beginning of the IVth Century, thus, at the limit between the Roman Period and the Merovingian era.

We present in this paper the palynological analysis of a new core. The results allow the reconstruction of the vegetation evolution along time, in the studied area. Also, we compare the data of these analyses to the results of other palynological profiles carried out previously, thus confirming certain hypothesis and pleading new elements of interpretation.

Materials and methods

In 2010, a new core (numbered W VII) has been retrieved at the side of the paved road, at a distance of approximately 11 m to the side (coordinates Belgian Lambert_1972 271408; 135909). With the help of a Wardenaar corer (Wardenaar, 1986), a sequence of deposition of about 63 cm in length has been collected (Fig. 1).

In order to obtain an image of the palaeovegetation evolution as detailed as possible, we carried out the sampling of each centimeter (from 15 cm up to 63 cm in depth). 49 samples have been obtained, each having about 1 cm^3.

Sediment samples were processed for pollen analysis, using standard techniques (Fægri and Iversen, 1989). They were treated with HCl (10%), NaOH (10%), HF (40%), and 8 min acetolysis.

In order to assure a statistical analysis, at least 400 pollen grains of terrestrial plant have been counted for each slide. Spores were excluded from the pollen sum. We took into account that *Alnus* Mill. pollen is over represented.

Pollen grains were identified based on a reference collection, keys (Beug, 2004) and photographs (Reille, 1992). The pollen spectra were graphically represented using TILIA and TGView software (Grimm, 1991). The frequencies of pollen for each taxon were calculated as percentages of total sum (arboreal pollen + herbs pollen). Local Pollen Assemblage Zones (LPAZ) were established in order to facilitate description and interpretation of pollen diagram, with respect to vegetation changes.

In order to highlight the human impact in the area (more exactly a mineral substance input), another series of samples were analyzed, identically sampled as for the pollen analysis. These samples have been weighed and then put in a drying oven at 105 °C for 24 hours, then weighed again to find out the dry peat weight. Subsequently, the samples have been exposed to a temperature of 500 °C, for 6 hours, in order to eliminate the entire organic matter. At the end of this operation, the samples have been weighed again to find out the weight of the cinder. The rate between the ash percent and the dry peat weigh percent has been calculated for each sample.

Results and discussions

The diagram obtained as a result of the 49 pollen spectrums shows the changes in the vegetation evolution along time in the studied area (Fig. 2). Based on the percentages and the dynamics of the main vegetal taxa, three Local Pollen Assemblage Zones (LPAZ 1 - 3) have been delimited, each of them described as follows:

LPAZ 1 (from 63 cm to 57.5 cm) is dominated by *Corylus* L. and *Alnus*, whose percentages correlate with the percentages of mineral substance. The dominance of *Fagus* L. pollen compared to *Quercus* L. pollen is observed. *Quercus* pollen overcomes 10% only at the end of this period, whereas *Fagus* shows percentages of approximately 30%. *Carpinus* L. is present in the forest composition, being very modestly represented (below 5%). Amongst *Alnus, Corylus* and *Betula* L., the local flora is mirrored by *Calluna* Salisb. pollen (not exceeding 30%), Cyperaceae Juss. pollen (maximum 10%), and also *Poaceae* Barnhart pollen (that reach 40% once in this zone). The anthropogenic pollen indicators are weakly represented (maximum 10%), from which pollen of *Cerealia* Ands., *Plantago* L., *Rumex* L., and *Artemisia* L. can be mentioned.

LPAZ 2 (from 57.4 cm to 19.6 cm) represents an intermediate phase during which the AP/NAP ratio abruptly decreases from 90% to 40%. Regarding the forestry area, it can be observed an inversion of the percentages achieved by *Fagus* versus *Quercus*. This time *Quercus* becomes dominant, reaching values up to 35%. *Fagus* remains yet well represented, the average value being of approximately 15%. *Carpinus* has the same modest values (under 5%). The percentages of *Corylus* and *Alnus* suddenly decrease as compared to the first local pollen zone. *Betula* keeps overall the same values, scarcely decreasing below 10%. *Pinus* L. records a slightly increasing curve, especially by the end of this pollen zone. As regards the local taxa, *Calluna* registers overall diminished percentages compared to LPAZ 1. While in the first half of LPAZ 2 the percentage of *Calluna* is higher but fluctuating, it decreases in the upper half of this area, but certain stability can be observed. The Cyperaceae show an overall increase. The anthropogenic pollen indicators are very well represented in this zone. Significant percentages (even up to 20%) throughout the period are observed. As regards *Cerealia* pollen, the percentages are modest (under 5%) in the beginning of this zone. Subsequently is recorded a tendency to increasing the weighting of this anthropogenic indicator, even if there are many fluctuations.

LPAZ 3 (from 19.5 cm to 10 cm) is a phase dominated by coniferous trees (*Pinus* and *Picea* A. Dietr.). The curve of *Pinus* pollen was already increasing by the end of LPAZ 2, while a sudden increase of the *Picea* pollen percentages is registered later (reaching within a short time span over 20% by the end of this zone). *Fagus* and *Quercus* show curves that are decreasing at the end of this zone. *Carpinus* percentages, although modest (maximum 5%), remain stable in time. *Calluna* pollen registers increasing percentages compared to the previous zones, sometimes exceeding 15%. This situation does not apply to Cyperaceae, which register modest percentages, and a decreasing curve. The anthropogenic indicators (*Juglans* L., *Plantago major / media* type, *Plantago lanceolata* type, *Artemisia*, Chenopodiaceae Vent., *Cerealia*, *Fagopyrum* Mill., *Rumex*, *Urtica* L., etc.) have, in the first half of this zone, percentages as high as in LPAZ 2, but they register a sudden decrease by the end of this period.

The pollen diagram shows aspects of the local vegetation evolution as well as aspects of the surrounding environment. The specific floristic composition of peat bogs are represented by taxa as Ericaceae (especially *Calluna*) and Cyperaceae. The specific trait of this type of ecosystem is also rendered by the presence of certain trees (*Alnus, Betula*) in the floristic composition. An important role in the data interpretation is played by *Alnus* pollen, taxon of whose presence is justified by the existence of a small rivulet (Helle) that crosses the peat bog close to the paved road. *Fagus, Carpinus, Quercus* were the main wood essences of the forestry surroundings. Previous studies (Dricot, 1960; Persch, 1950) suggest the dating of the pollen diagrams according to the evolution of beech through time, precisely according to the maximum values recorded by this taxon. Nevertheless, this type of dating is not reliable in the absence of absolute dating and consequently it is not decisive for this goal. In the last zone of diagram (LPAZ 3), the dominance of the coniferous trees (*Pinus* and *Picea*) can be very well noticed. The sudden increase of *Picea* pollen predominance is in accordance with the fact that at the beginning of the XXth century, plantations of this woody essence started to become important in the area (Damblon, 1994).

Although the human impact is noticeable among the whole deposition sequence, it is difficult to point out, only based on the anthropogenic pollen indicators, the moment when the building of the paved road took place. It is supposed that a sudden decrease of the *Alnus* pollen percentage is strictly related to the cut down of the alder wood for the construction of the paved road. Nevertheless, this argument is not sufficient to reflect the human activity in the area at that moment. That is why, besides the data at our disposal from our core, we will also use data obtained from other previous cores.

W III and W IV cores (Dalemans and Streel, 1986) are correlated between them by a level of significant and also sudden decrease in *Alnus* pollen percentages (Fig. 3). This decrease concurs with as sudden an increase in the weighting of some rock fragments that exceed 0.5 mm. It is for sure the proof of the "erosion" of the road, phenomenon that takes place at the same time with the artificial opening of the alder woods settled along Helle rivulet. This aspect could not be highlighted in our core. On the contrary, this new core outlines the mineral substance contribution that has been already observed in the bottom part of the peat bog formed during W III and W IV sequences. An obvious correlation exists between 52 and 63 cm, between the percentages of ash (of approximately 40%) and considerable percentages of *Alnus* and *Corylus* pollen. As regards *Corylus* pollen, it obviously derives from the border of the forest, upstream of Helle rivulet and it has been probably moved to the place of the core by the subsequent flooding of this rivulet. Another aspect can be observed in our core: between 41 cm - 42 cm the content in ash suddenly reaches 20%. This fact is most probably caused by another factor than a natural one. A local event (the construction of the paved road) seems to take place now, taking into account the percentages of *Alnus* that decrease, and the anthropogenic pollen indicators that reach higher percentages. Moreover higher values of the rate between the ash percent and the dry peat weigh percent indicate a certain local event or an input of mineral substances. We presume that it is strictly related to the moment of the paved road building.

On the other hand, our core (W VII) is more similar to W III core than to W IV core. Furthermore, from a topographical point of view, W VII core is closer to W III than W IV. Some common elements can be observed (traceable for W VII in LPAZ 2, and for W III in Ea and Eb zones):

- the ratio AP/NAP falls almost definitively below 70%, starting from 51.5 cm in W VII (Fig. 4), and from 62.5 cm in W III;
- Cyperaceae pollen increase significantly immediately beyond this limit;
- the fluctuation of the ratio AP/NAP remains between 50 % and 70% (between 51.5 cm and 30.5 cm in W VII, and between 62.5 cm and 37.5 cm in W III, respectively); In this interval, there are 2 moments in each core in which *Fagus* has higher percentages than the

other essences of wood (the first one approximately at the level of the maximum peaks of ash).
- the rate AP/NAP falls definitively below 50% over 30.5 cm in W VII and over 37.5 cm in W III. Beyond this limit, the other Ericaceae pollen can have the same importance as *Calluna* pollen.

Based on this criterion, we can concede that the area comprised between 51.5 cm and 30.5 cm (21 cm in length) from W VII corresponds to Ea + Eb zone (about 25 cm in length) from W III.

The dating of a 5 cm thick sample has been successful for the W III core. The specimen has been sampled right above the median area of the mineral deposit (zone E). After calibration, a dating of around 1282 +/- 57 AD has been obtained (Dalemans and Streel, 1986) (Fig. 3). This date approximately corresponds to the ending of the paved road being used (thus, the end of XIIIth century). We have taken into account the comparisons with reference cores (01W and 06W) carried out in Misten peat bog of the Plateau (De Vleeschouwer et al., 2010). This date (1282 +/- 57 AD), as shown in figure 5 by a vertical thickened line, ranges itself in Xa pollen zone (06W core) in the beginning of the oak dominant period, at the transition between the medieval warm period and Little Ice Age. The entire E zone seems to correspond to the Xa pollen zone (01W and 06W cores), whose beginning would be situated by the end of the XIth century (Fig. 5).

Pollen analysis show modest percentages of *Alnus* registred in W VII (except the bottom part of the core, visibly contaminated during the water flow induced by the flooding of Helle rivulet) compared to the considerable percentages from C and D zones, noticeable in W III and W IV cores. Therefore, in W VII, we will not be able to observe the initial point of building of the paved road due to this natural contamination by water flow. Thus it can explain the lack of rock fragments bigger than 0.5 mm.

Conclusions

W VII core brings to light new peculiarities of local vegetation evolution in this area of the Hautes-Fagnes Plateau, but also aspects of regional vegetation evolution. Our investigations highlight also, through the anthropogenic pollen indicators, the existence of human activities in the region, strikingly manifested in LPAZ 2. An external mineral matter input is detected, concomitantly with the decreasing of the *Alnus* pollen weight and with the growths of the anthropogenic pollen indicators percentages. This could correspond to the moment of maximum use of the paved road. After the corroboration of all the available data, we conclude that the use of the paved road has ceased at the end of the XIIIth century.

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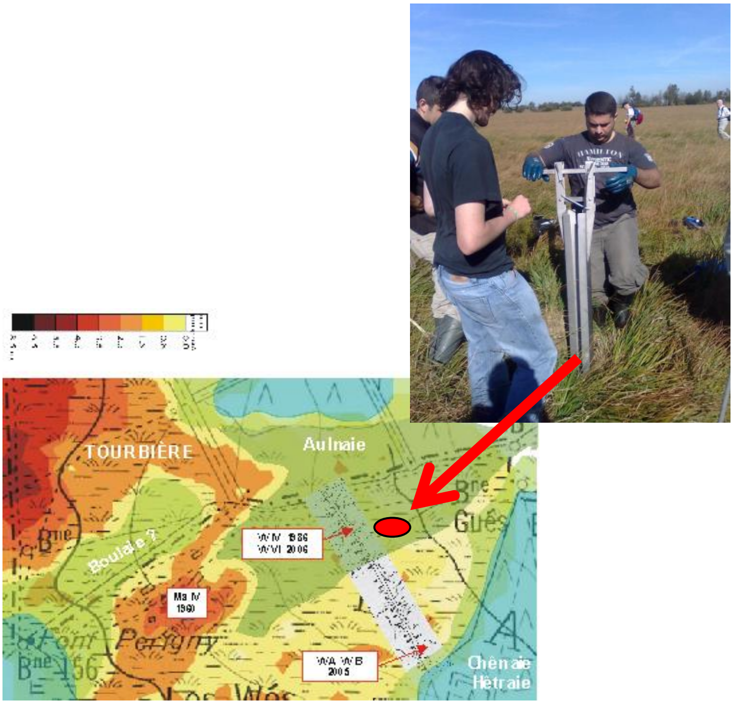

Figure 1. W VII core location (map after Streel et. al., 2007)

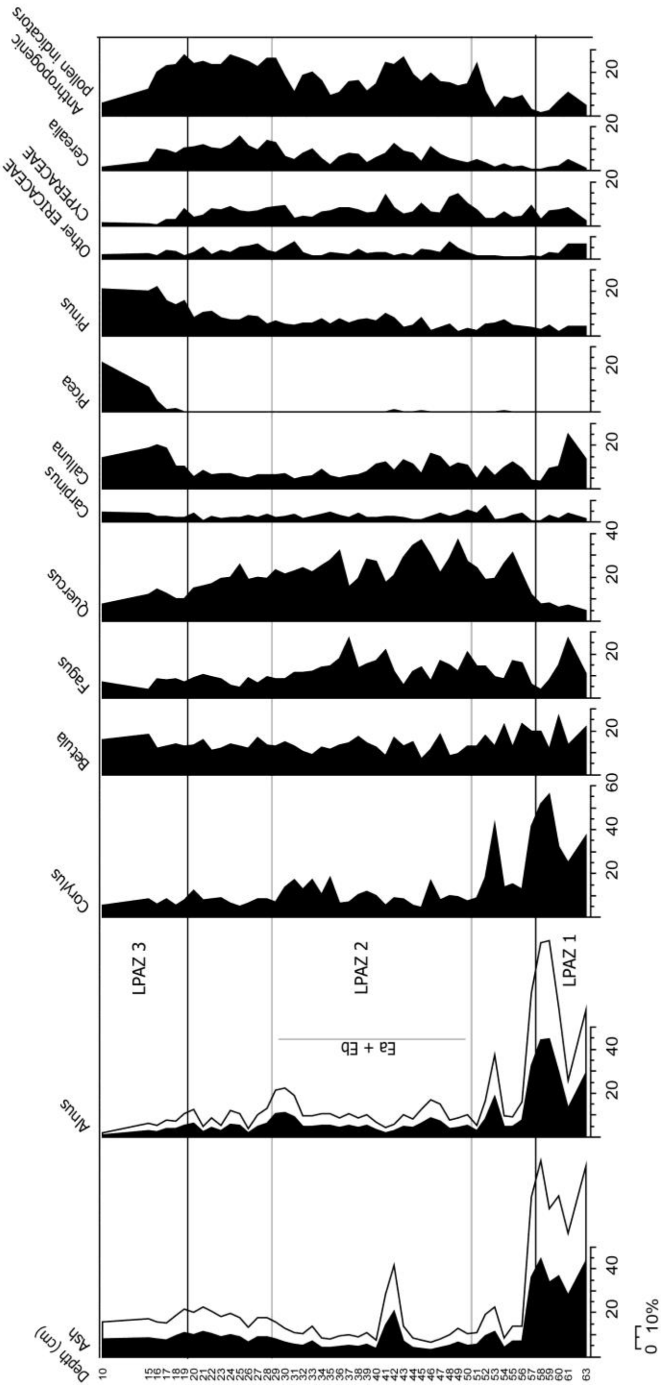

Figure 2. Simplified pollen diagram of W VII core

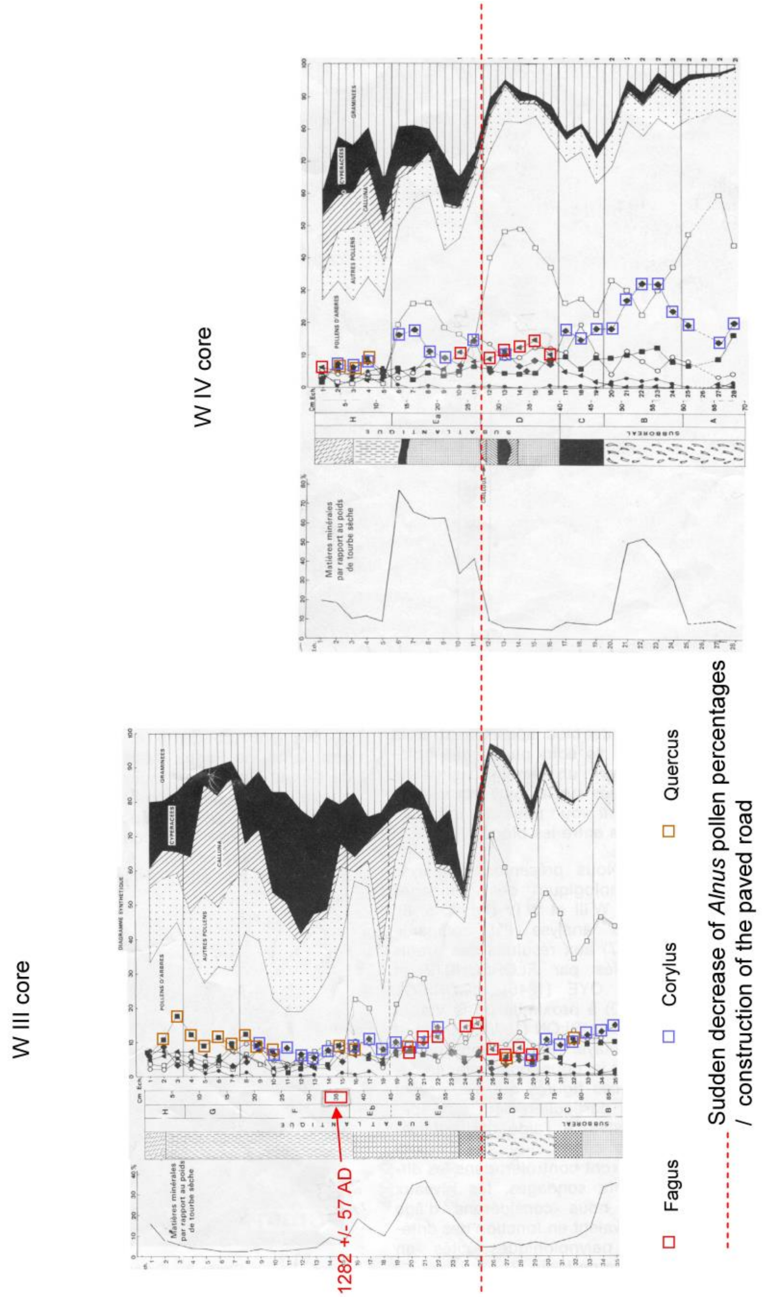

Figure 3. Comparison of pollen diagrams for W III and W IV cores (after Dalemans and Streel, 1986)

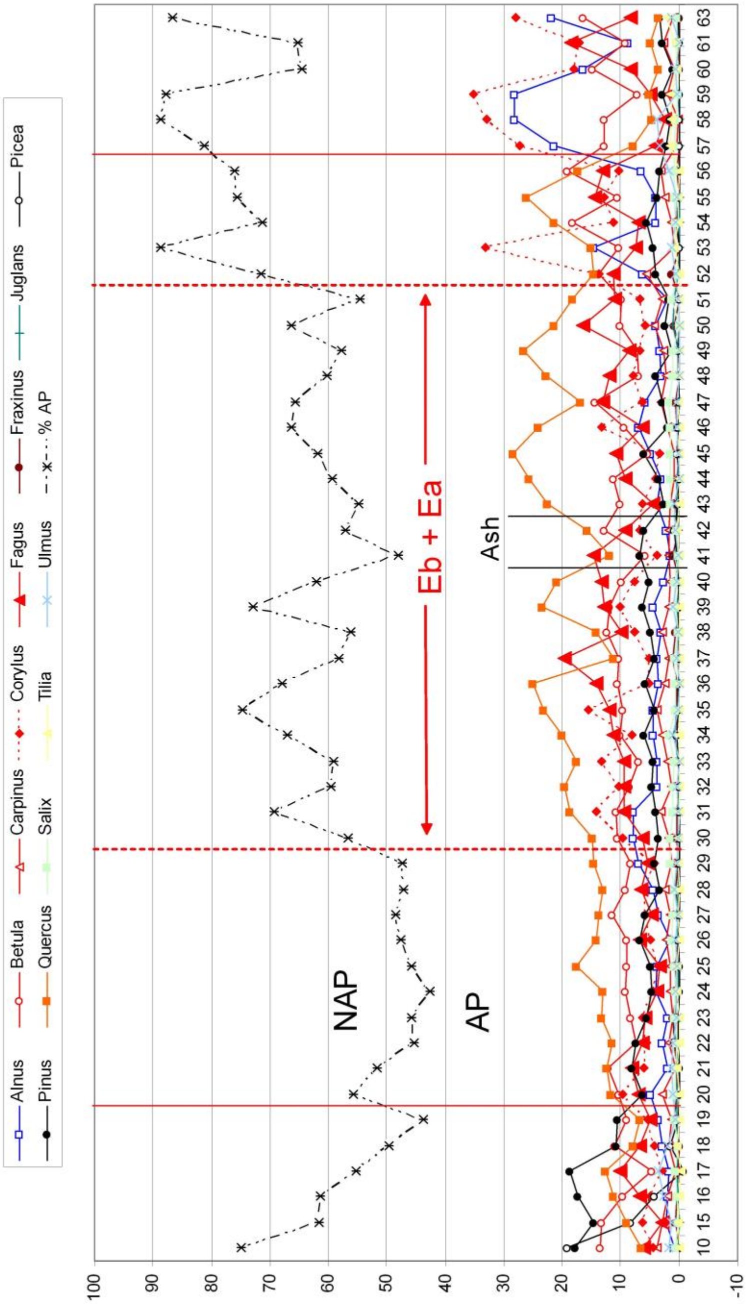

Figure 4. AP / NAP ratio – W VII core

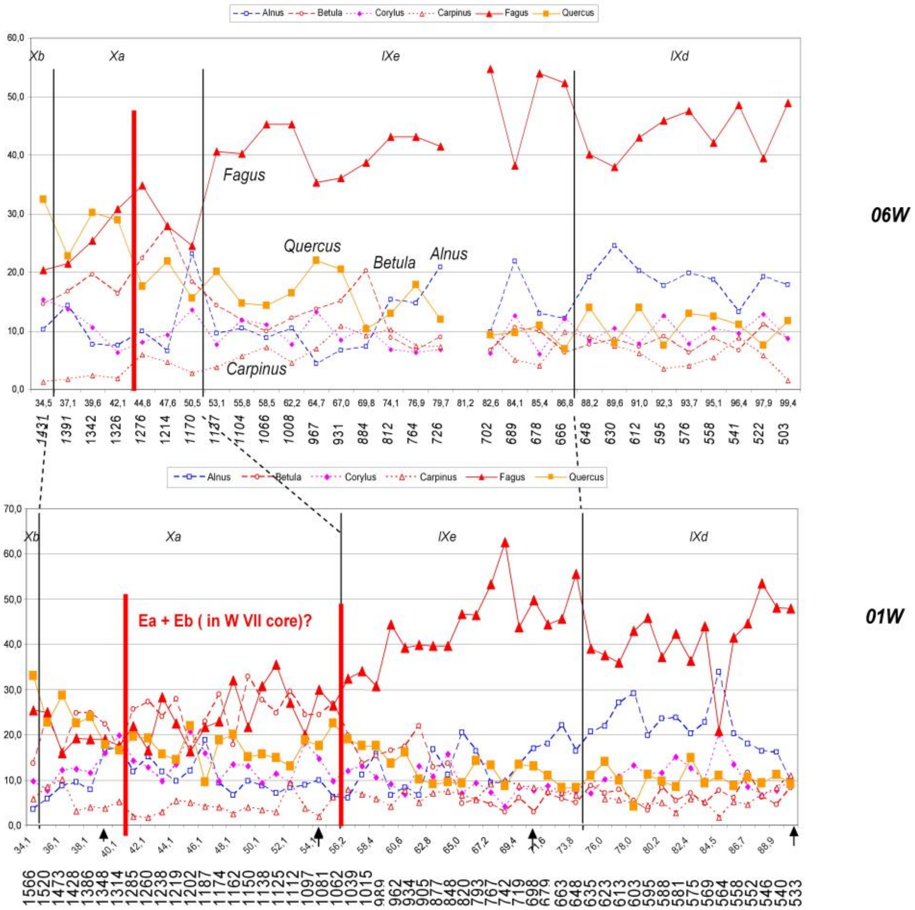

Figure 5. Pollen zones of 01W and 06W cores (after De Vleeschouwer et al., 2010, redraw)