

## PHYTOHISTORICAL ASPECTS OF THE NATURA 2000 SITE "MARAMUREȘ MOUNTAINS"

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**Abstract:** This paper presents the results obtained through palynological analysis of a core sequence from the Cristina glacial cirque (Latitude 47°50'07"N, Longitude 24°37'07"E, altitude 1573 m). It is a relatively short sequence, reaching 300 cm in depth, but the first 145 cm could not be taken, as it consisted of wet and very loose peat. Three C<sup>14</sup> datings performed on samples taken from the analyzed sequence, at the Radiocarbon Laboratory in Poznan, Poland, have provided the following ages: Cr 250 - 6190 ± 40 BP; Cr 265 - 5200 ± 50 BP; Cr 300 - 7150 ± 40 BP. For the basal sample of the sequence the dating assigns an Atlantic age. Pollen spectrum analysis from the depth of 150 cm, not yet dated, suggests a Sub-Atlantic age, through the presence of beech and fir pollen.

**Keywords:** Maramureș Mountains, Natura 2000 site, glacial cirque, peat bog, palynology, Holocene

### Introduction

In a recent study conducted within the Natura 2000 site „Maramureș Mountains”, certain aspects of Late-glacial and Holocene vegetation history of the region were approached through palynological analysis. With this purpose, sequences from former glacial cirques and torrent collection basins, situated near the Bardău and Mihăilescu peaks, were analyzed.

This paper presents the results obtained in the Cristina peat bog (Latitude 47°50'07"N, Longitude 24°37'07"E, altitude 1573 m). The Cristina peat bog is situated in the Northern Maramureș Mts, in the Pietrosul Bardăului massif (1850 m), within the glacial cirque of the same name (Figs. 1–3).

The Northern Maramureș Mts are not very high, barely reaching 1900 m altitude and having large gentle ridges with an average altitude of 1500–1600m. The main characteristic of this montane area is the presence of denudation surfaces.

The transverse geological profile through this mountain area shows metamorphic schists and Cretaceous conglomerates above. On the northern slope of Pietrosul Bardăului and on the Cristina Mountain sedimentary rocks are present in limited areas. Pleistocene deposits are represented by moraine, and peri-glacial deposits as scree, or resulting from solifluxion.

Near the sampled site there are some gentle, relatively large ridges, which in the north-eastern and eastern part have huge steep slopes that represent headwalls of the glacial cirques (Pietrosul and Cristina cirques).

The small Cristina cirque lies on the north-eastern side of the Pietrosul Bardăului peak, enclosed in the mountain mass. Today, on the bottom of the cirque can be seen the shape of a lake, partially filled by sediments. It lies behind a dam made up of a hummocky moraine. Seen from above, the cirque looks like a trough, enclosed by headwalls on three sides, and by the moraine to the front, resembling a natural garden [10].

Subalpine climatic conditions ( $t_{\text{average annual}} = 0,6^{\circ}\text{C}$ ,  $P_{\text{average annual}} = 1100$  mm at the Iezer meteorological station - Rodnei Mountains, 1785 m altitude), as well as the supplying of the peat bog almost exclusively from rainfall, led to the build-up of the peat deposits.

The Cristina peat bog is meso-oligotrophic, mainly with *Carex* and *Sphagnum* species.

Actual vegetation around the site consists of clumps of *Pinus mugo*, *Juniperus* sp., and forests of *Picea abies*. *Alnus viridis* clumps ascend the valleys in the proximity of the site, while *Abies alba* and *Fagus sylvatica* are **scattered** in the *Picea abies* forests, at lower altitudes (up to 1200m). *Carpinus betulus* forests grow only in the western part of the Maramureșului Mts, at much lower altitudes (up to 800m), together with *Quercus petraea* or *Fagus sylvatica* forests.

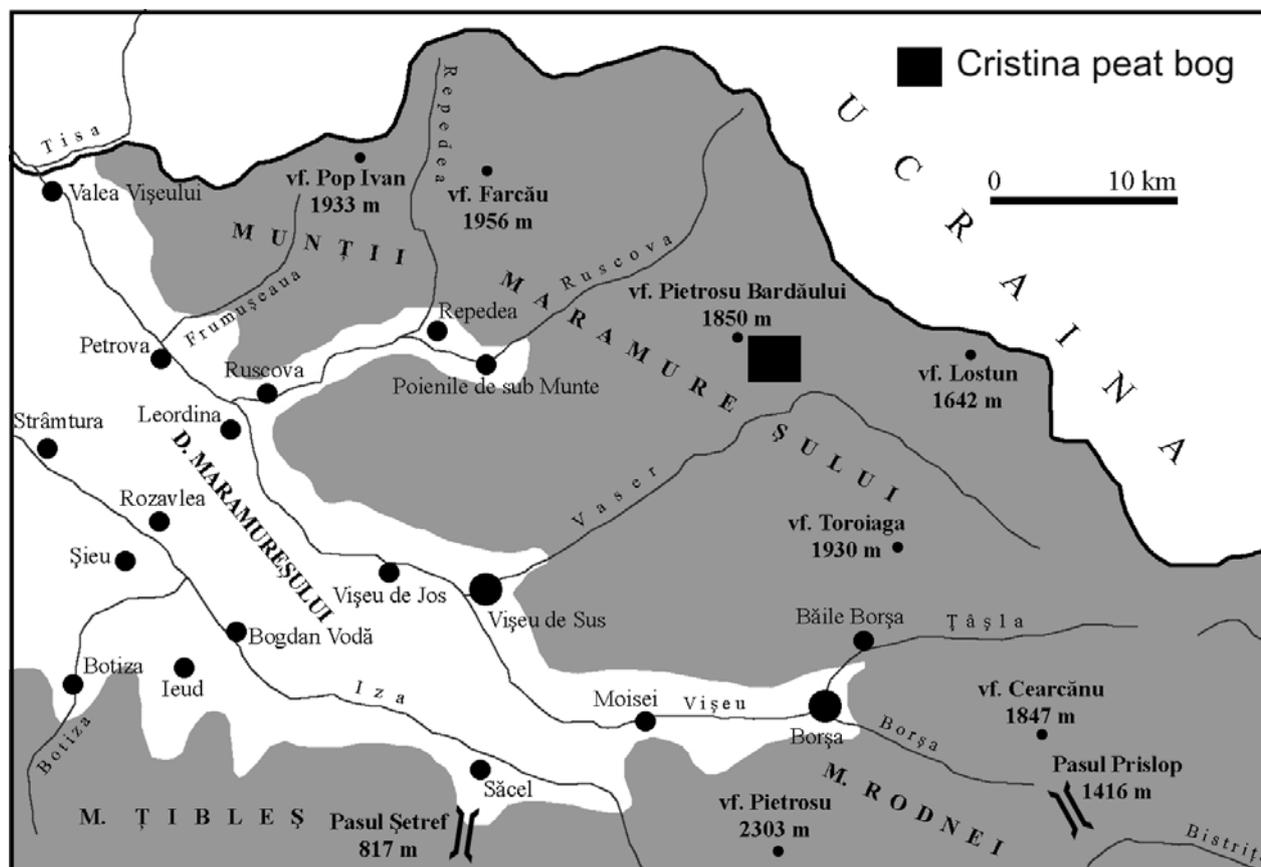


Fig. 1: Location of the Cristina peat bog.

### Materials and Methods

The sequence from Cristina is relatively short, reaching 300 cm in depth. Cores of peat sediment were taken with a modified Russian corer for pollen analysis. The first 145 cm could not be taken, as it consisted of wet and very loose peat.

These cores were sampled at equidistant intervals in the laboratory, both for chemical preparation to obtain the microscope slides and for  $C^{14}$  dating.

The amount of sediment taken for a sample was, usually, about  $1\text{ cm}^3$ . Chemical preparations were carried out following the Erdtman method [3], also known as the potassium hydroxide method, modified according to Goery & de Beaulieu [8]. Concerning the moss samples from the surface or other samples containing various vegetal fibers and coarse remnants, the procedure of filtration by a mesh of  $200\mu$  gauge **was applied**. The residues containing pollen grains and spores, obtained as the result of chemical preparations, were preserved in pure anhydrous glycerol in Eppendorf micro-tubes, being used subsequently for the microscope slides.

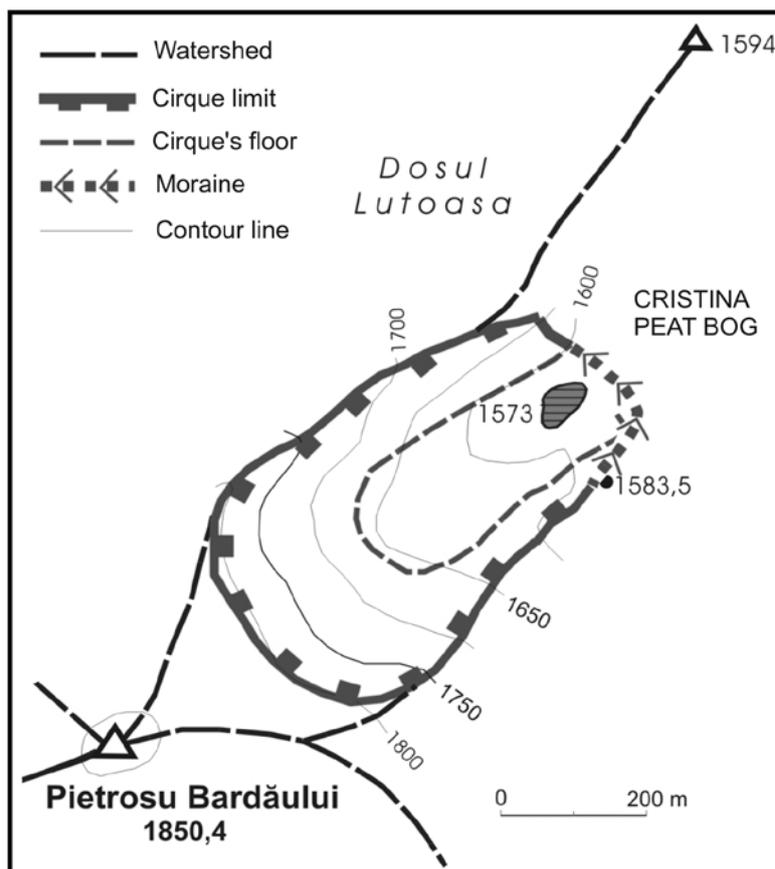


Fig. 2: Peat bog location within the glacial cirque.

Scanning of the microscope slides was performed on average for 300 pollen grains, regarding tree pollen (AP = "arborum pollen") of each slide, plus the corresponding pollen of herbs (NAP = "non arborum pollen") and spores. Identification of the pollen taxa was carried out using handbooks and determination keys [4, 5, 9, 11, 16, 17-22]. Nomenclature for vascular plants follows *Flora Europaea* [23].

The database was created with the special pollen software GpalWin [7] and includes the taxa list corresponding to the analyzed sequence, the number of samples, and the numerical values obtained for each taxon and family respectively, of each level in part. For the interpretation of the spore-pollen results, we have followed the method of pollen zones [1, 2], without using numerical methods for zoning. Empirical zoning of diagrams was based on vegetation dynamics, especially according to changes in the frequencies of major pollen taxa.

### Results

Three  $C^{14}$  datings have been performed at the Radiocarbon Laboratory in Poznan, Poland, and have provided the following ages:

Cr 250 -  $6190 \pm 40$  BP

Cr 265 -  $5200 \pm 50$  BP

Cr 300 -  $7150 \pm 40$  BP

The first dating was not taken into account, in order to allow the pollen diagram interpretation. For the basal sample of the sequence the dating assigns an Atlantic age.

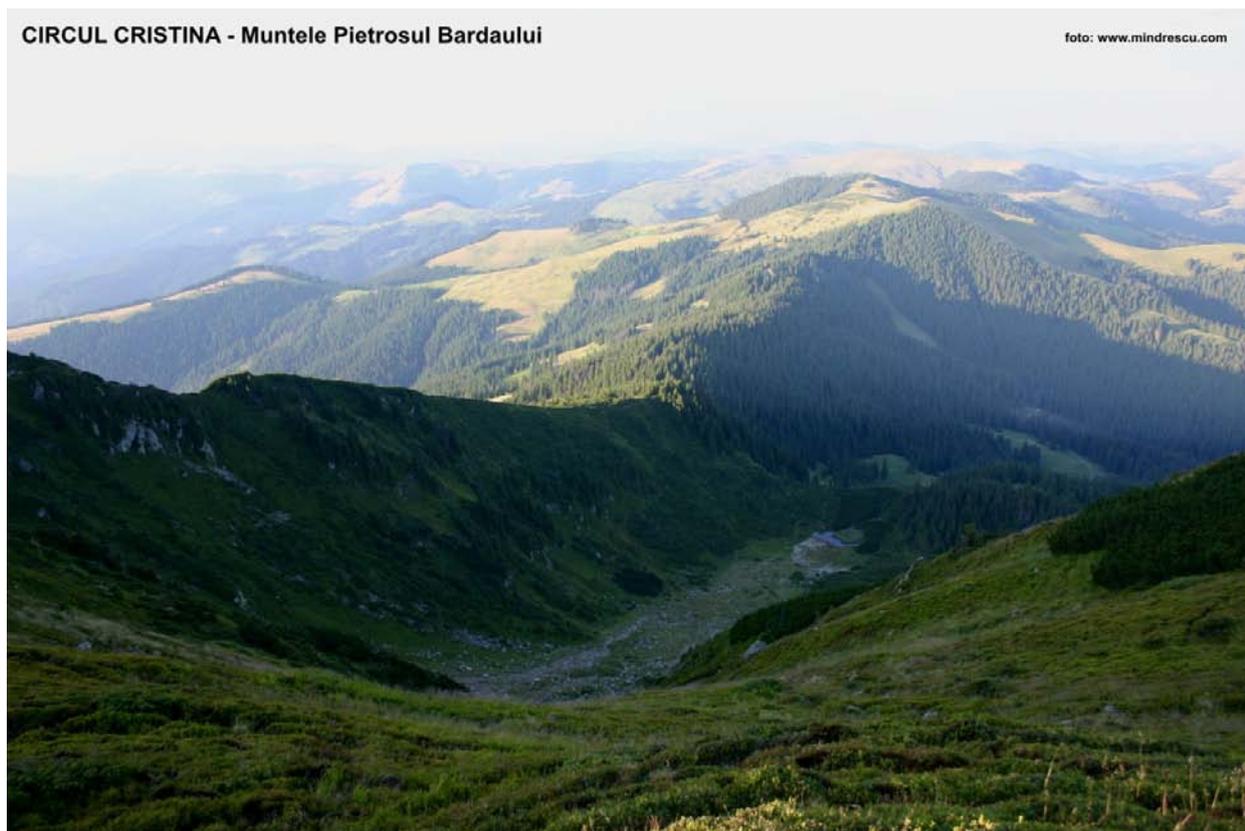


Fig. 3: Cristina glacial cirque and Pietrosul Bardaului peak (photo: M. Mindrescu, 2004).

Stratigraphic study of the cores was carried out before the laboratory sampling. The results are presented in Table 1.

**Table 1: Stratigraphic aspects of the cores analysed from Cristina sequence**

Depth (cm)	Microstratigraphic characteristics
144-180	Fine grey clay, compact, with many intercalations, macro remnants and iron oxides. Strongly red-coloured in some parts. Sandy sediment starting with 163 cm.
180-210	Light gray sandy clay, very humid, slightly compact, with iron oxides, fine gravel and many macrorests.
210-228	Sandy peat, compact, unctuous, with few macro remnants. A large piece of wood at 212 cm.
228-234	Clayish intercalations, alternating with peat layers. Unctuous, compact, fine sediment, grey-brownish, sticky, quite soft. The colour affected by iron oxides.
234-240	<i>Idem</i> , with the layer at 210-228 cm.
240-247	Dark brown soily peat, unctuous, less compact, with blackish intercalations, with silica crystals and macrorests.
247-263	<i>Idem</i> , but more compact and without obvious silica crystals.
263-280	Brown-greyish soily clay, unctuous, with brownish and blackish intercalations, more peaty, with small fragments of macrorests and silica crystals.
280-300	<i>Idem</i> , but without intercalations, more clayish and less unctuous.

By graphical representation of pollen spectra within the data base, sporo-pollen diagrams were obtained, in which each taxon and family are related to the total AP + NAP (Figs. 4 & 5). The ratio of AP and NAP is also represented in the diagrams, to better illustrate the type of dominant ecosystem, depending on the climatic period.

Palynological results show a classical succession of Holocene vegetation, as known from the Romanian palynological literature.

A total of **6 pollen zones** was established from base to surface, partially superimposed over the last three forest phases described by Pop [13, 14].

The forest phases corresponding to the last three climatic periods are:

1. The *Picea-Quercetum mixtum-Corylus* phase (during the Boreal-Atlantic periods – 9000-5000 BP)
2. The *Picea-Carpinus* phase (during the Sub-Boreal period – 5000-3000 BP)
3. The *Picea-Fagus-Abies* phase (during the Sub-Atlantic period – 3000 BP to present day).

Pollen zones 1 and 2 are assigned to the Atlantic period. The Sub-Boreal period partially corresponds to the pollen zone 3, while pollen zones 4, 5 and 6 are assigned to the Sub-Atlantic period.

#### Cristina (Maramuresului Mts.) - AP

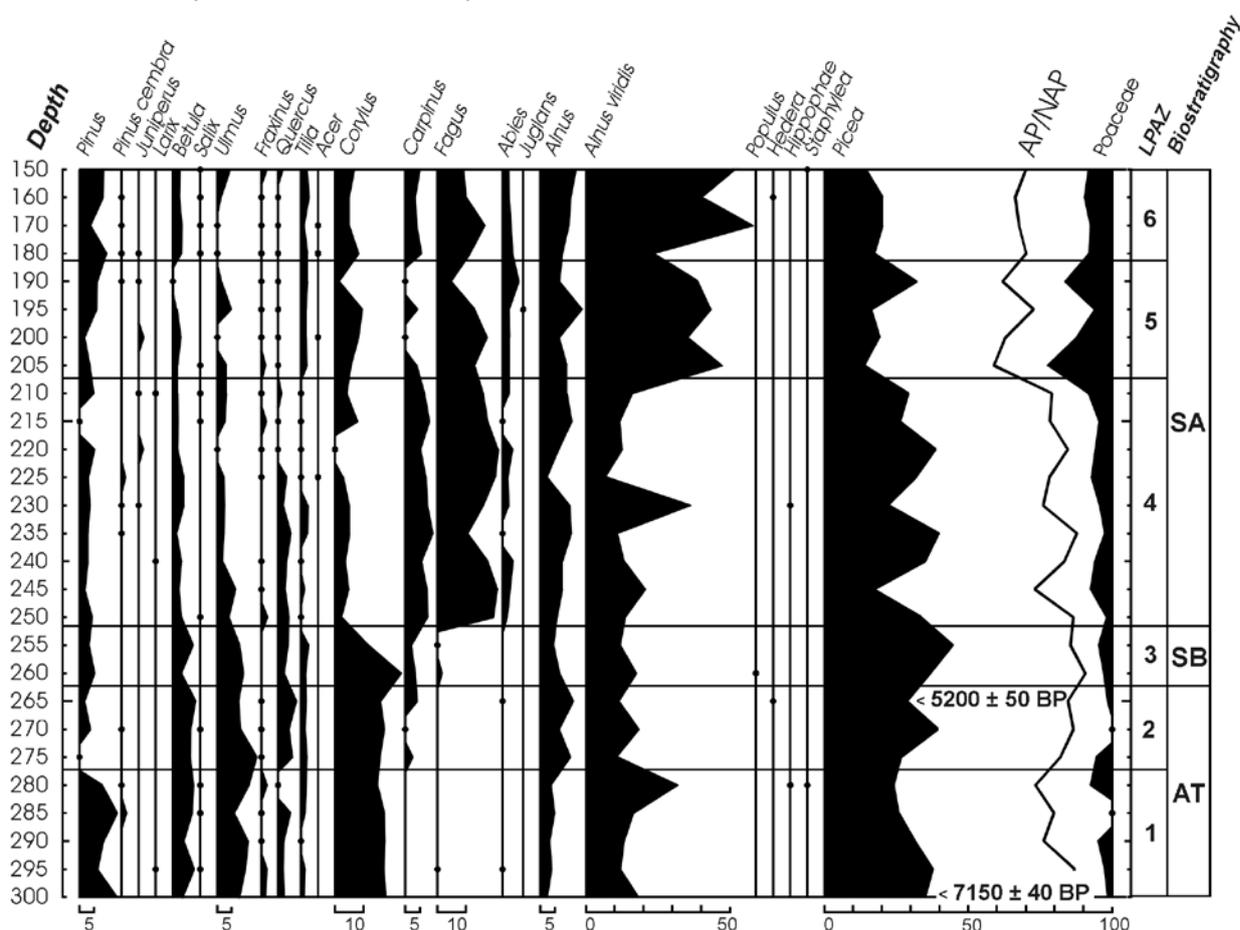


Fig. 4: Pollen diagram of tree taxa and *Poaceae* from Cristina sequence.

#### Discussion

1. The first pollen zone corresponds to the interval 300 cm – 275 cm. It is characterized by high percentages of *Picea*, *Alnus viridis* and *Corylus*, showing their presence in the proximity of the site at that time, which is similar to the present-day situation. Other well-represented pollen taxa are *Pinus mugo*, *Ulmus*, *Betula* and *Alnus* sp.

The continuous curve of hazel (*Corylus*), with high values, suggests the Atlantic period for the beginning of peat accumulation in the sequence analyzed. As can be seen in the diagram



*Picea* remains the dominant taxa in the pollen diagram, while *Pinus* and *Alnus viridis* decrease. *Ulmus* shows a second maximum, followed by *Quercus* and *Alnus*. The pollen of *Fagus* is absent from the diagram, and *Abies* occurs only once, towards the end of the interval.

Herbaceous taxa are represented mostly by Poaceae, Cyperaceae, Urticaceae, *Artemisia* and *Thalictrum*, but the AP/NAP ratio increases to the benefit of AP.

3. Pollen zone 3 (260 cm – 250 cm) corresponds to the Sub-Boreal period. In this zone both *Picea* and *Corylus* reach their absolute maximum in the diagram. After that, *Corylus* decreases quite abruptly to insignificant values. We also notice the constant occurrences of beech in the pollen spectra, with low percentages, while fir pollen is absent.

*Quercetum mixtum* taxa (*Ulmus*, *Quercus*, *Tilia*) slowly decrease during this interval.

Hornbeam (*Carpinus*), supposed to be well-represented in its own phase (*Picea-Carpinus* phase), has a very low presence in this pollen zone, both because of the high altitude of the site, and its distance from the hornbeam forests in the region.

The same situation was reported by Pop *et al.* [15], at Tăul Băiții (1450m altitude), not far from the Cristina peat bog.

We also assume a lack of sedimentation, caused by climatic factors, and reflected in the pollen diagram by low hornbeam values, and by the sudden increase of beech starting with the next pollen zone.

The high AP/NAP. ratio corresponding to this pollen zone denotes the presence of dense forests in the area at that time.

4. The fourth pollen zone is the largest (250 cm – 205cm), partially corresponding to the Sub-Atlantic period. The main characteristics are the presence of *Fagus* pollen with high values over this zone and the beginning of the continuous curve of *Abies*, even with small percentages.

*Picea* shows several maxima, in asynchrony with the *Alnus viridis* and *Fagus* curves. *Quercetum mixtum* is represented in the pollen diagram by smaller values, the same as *Corylus* and *Betula*. Other taxa, such as *Pinus*, *P. cembra*, *Juniperus*, *Larix*, *Salix*, *Fraxinus* and *Acer* are, more or less substantially, present in the diagram.

The Poaceae, Cyperaceae and Urticaceae curves are increasing during this interval. “*Cerealia*”, *Secale*, *Artemisia* and *Cannabis* pollen is also present in the diagram at persistent values, evidence of human activity. Nevertheless, the AP/NAP ratio is still high.

5. Pollen zone 5 covers the interval 205cm – 180cm. We can notice here the over-representation of *Alnus viridis* pollen, which affects the presence of *Picea*, *Fagus*, *Carpinus* and *Abies* pollen in the diagram. *Picea* shows an increase only towards the end of interval, corresponding to the decrease of *Alnus* and *A. viridis* pollen along with *Fagus* and *Corylus*.

This pollen zone is also characterized by the large amount of spores. The sudden increase of fern spores in the pollen diagram, as well as the presence of some pollen of herbaceous plants, suggests human activity in the region.

6. In the pollen zone 6, *Picea* decreases towards the surface, as well as *Fagus*, *Abies* and *Carpinus*, while *Alnus* and mostly *Alnus viridis* largely increases. This over-representation is probably edaphically and not climatically induced, but it disturbs the real representation of the other taxa in the diagram. It can also be related to forest clearing affecting spruce fir and beech, as we can see these days.

*Pinus*, *Betula* and *Corylus* show a slight increase towards the surface, like in many other diagrams from Romanian Carpathians, as a result of clearing, which favoured the growth of these pioneer trees instead of spruce or beech.

The increase of fern spores can be noticed once again in the pollen diagram. Among the herbaceous plants, Poaceae, Cyperaceae, Asteroideae, Urticaceae, Rosaceae, Fabaceae, Rubiaceae, *Artemisia* and “*Cerealia*” are well represented.

These palynological results are confirmed by the pollen analysis carried out in the glacial cirque Tăul Mare-Bardău (Fig. 6), situated nearby [6], and in Tău-Băiții [15].

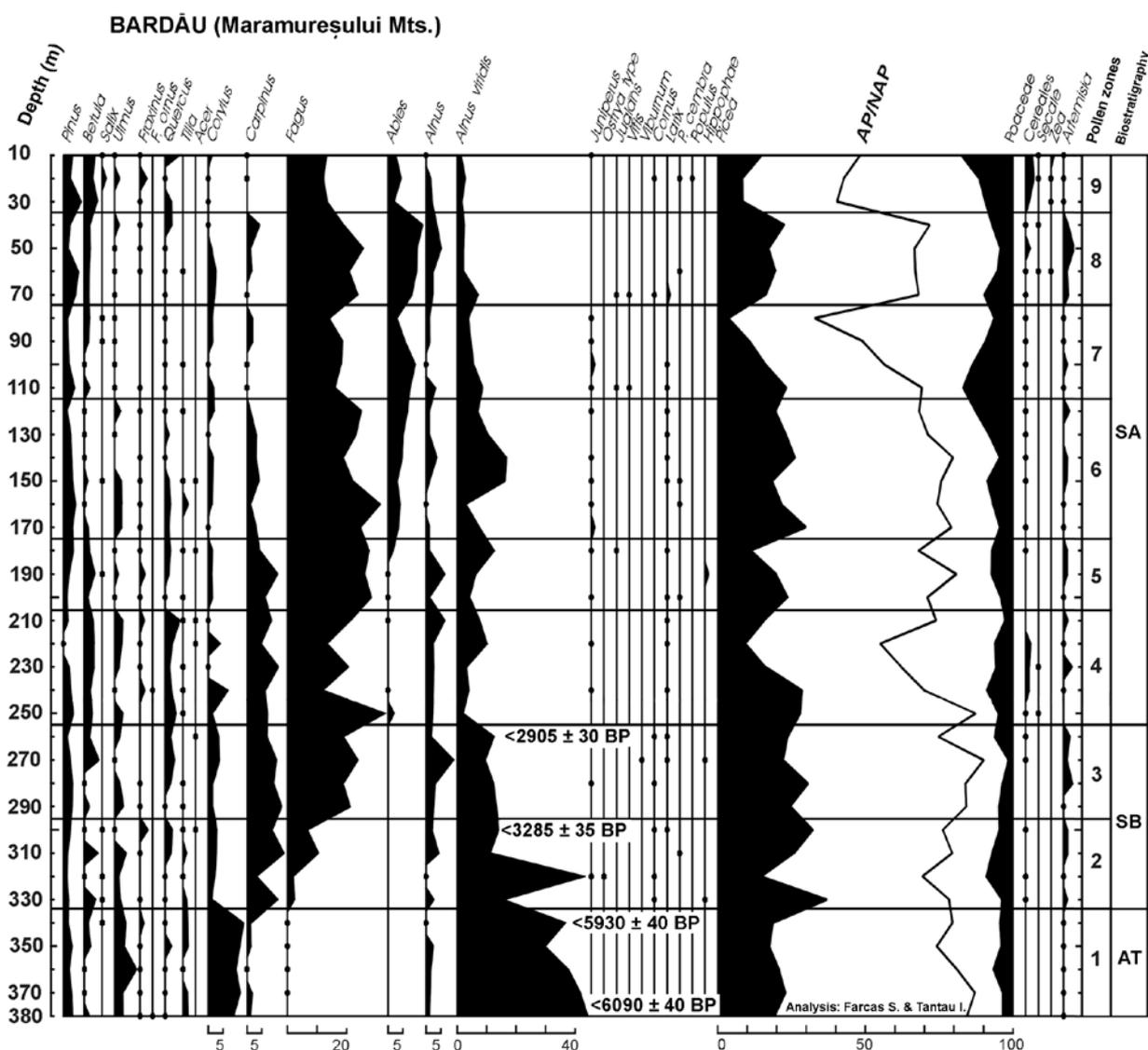


Fig. 6: Pollen diagram of tree taxa and the principal herbaceous taxa from the Tăul Mare - Bardău sequence (Fărcaș *et al.*, 2009, in press)

By comparing the pollen diagram of the Cristina sequence with that from Bardău (another site studied in Pietrosul Bardău, latitude 47°50'09"N, longitude 24°35'44"E, altitude 1623m), the similarity between these two sites in what regards the dynamics of the main taxa is quite remarkable even though the sequence from Cristina is older (7150 BP) than the Bardău one (6090 BP).

In both of these diagrams *Picea*, *Alnus viridis* and *Fagus* are well represented; *Carpinus* is poorly represented; the maximum of *Corylus* is not relieved; *Abies* appears after *Fagus* with quite reduced rates; *Pinus* persists in all the diagrams at small percentages.

### Conclusions

The sequence from the Cristina peat bog is not very old, whereas the dating of the basal sample has provided an age of  $7150 \pm 40$  BP. According to the Holocene chronology [12], the beginning of peat deposition in this sequence corresponds to the Atlantic period.

Concerning the dynamics of the main tree taxa in the sequence from Cristina, some general aspects can be emphasized.

The presence of spruce (*Picea*) in the Late-glacial or early Holocene cannot be certified, since the age of the sequence is not old enough. At the base of the sequence, at 300 cm depth, the spruce values prove its already significant presence in the region, which continues through the entire sequence.

Alongside *Pinus* (probably *P. mugo*) but less continuous and poorly represented in the diagram, we notice the presence of *Pinus cembra*, a glacial relict, now with a quite reduced distribution in the Romanian Carpathians.

The curve of hazel (*Corylus*), well represented in the pollen diagram from the base confirms the Atlantic period for the beginning of peat accumulation in the analyzed sequence.

Mixed oak elements (*Quercetum mixtum*) appear under-represented in the sequence because of the high altitude of the site. The elm curve (*Ulmus*) is higher at the base of the sequence, while the other elements of the mixed oak (*Quercus*, *Tilia*, *Acer*, *Fraxinus*) are poorly represented.

The maximum of hornbeam (*Carpinus*) percentages, specific to its own phase, was not found, because of the high altitude of the site and of its distance from the hornbeam forests in the region. We also supposed a lack of sedimentation, due to climatic conditions.

The continuous curve of beech (*Fagus*) is reported from the Sub-Boreal period, with very low percentages. At the beginning of the Sub-Atlantic period its curve suddenly reaches high values, which persist in almost the entire interval, certifying its substantial and not very distant presence in the region.

Fir (*Abies*) pollen occurs continuously in the diagram only during the last period, the Sub-Atlantic, at low percentages, which denote its modest presence in the forests of the area.

The decrease of the AP/NAP ratio, as can be observed in the last two pollen zones, reflects the increasing human intervention in the region, mostly by the clearing and cutting of spruce and beech forests.

Since the upper part of the sequence from Cristina (from 145 cm up to the surface) was unavailable, the diagram could not represent the more recent changes in vegetation structure caused by human activities.

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#### ASPECTE FITOISTORICE DIN SITUL "NATURA 2000" "MUNȚII MARAMUREȘULUI"

##### (Rezumat)

În cadrul unui studiu recent desfășurat în situl „Natura 2000” „Munții Maramureșului” au fost urmărite și aspecte privind istoria vegetației din regiune, prin analize palinologice. În acest scop au fost analizate secvențe provenind din foste circuri glaciare, respectiv bazine de colectare torențială, situate în apropierea vârfurilor Bardău și Mihăilescu. Lucrarea de față prezintă rezultatele obținute prin analiza palinologică a secvenței din circuitul glaciar Cristina (latitudine 47°50'07" N, longitudine 24°37'07" E, altitudine 1573 m). Este o secvență relativ scurtă, care atinge 300 cm adâncime, dar din care primii 145 cm nu s-au putut preleva, fiind constituiți din turbă umedă, foarte laxă.

Pe eșantioane prelevate din secvența analizată au fost efectuate trei datări  $C^{14}$ , în Laboratorul de Radiocarbon din Poznan, Polonia, care au furnizat următoarele vârste: Cr 250 - **6190 ± 40 BP**; Cr 265 - **5200 ± 50 BP**; Cr 300 - **7150 ± 40 BP**. Datarea eșantionului bazal prelevat din secvență îi atribuie acesteia o vârstă atlantică. Analiza spectrului polinic de la 150 cm adâncime, pentru care nu dispunem încă de datări  $C^{14}$ , sugerează o vârstă subatlantică, atestată de prezența polenului de fag și brad.

Dinamica principalelor specii lemnoase se încadrează în tiparul clasic al evoluției vegetației holocene din Carpații Românești, cu trăsături specifice derivate din amplasarea sitului, condițiile microclimatice și edafice locale.

Valorile mari ale molidului din baza secvenței demonstrează prezența sa deja semnificativă în regiune, care se continuă până la ultimul nivel analizat. Curba alunului, bine reprezentat în diagrama polinică din bază, confirmă vârsta atlantică pentru începutul depunerii turbei în secvența analizată. Elementele stejărișului amestecat apar subreprezentate în secvență, din cauza altitudinii mari a sitului, care maschează și maximumul de carpen specific fazei sale din Subboreal. La această subreprezentare a carpenului contribuie și distanța relativ mare a pădurilor de carpen din regiune față de situl analizat, dar probabil și existența unei lacune de sedimentare datorate condițiilor climatice. Curba continuă a fagului începe în Subboreal, cu valori foarte reduse, care cresc brusc la începutul Subatlanticului și persistă pe întregul interval studiat, atestând prezența acestuia în regiune. Bradul apare reprezentat continuu doar în Subatlantic, cu procentaje modeste.

Descreșterea raportului A.P./N.A.P. observată în ultimele două zone polinice reflectă creșterea intervenției umane în regiune, mai ales prin defrișări și exploatarea molidului, bradului și fagului.

Aceste rezultate palinologice sunt confirmate de analizele palinologice efectuate în circuitul glaciar Tăul Mare - Bardău, situat în apropiere (Farcas *et al.*, 2009 – sub tipar).