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EARLY HOLOCENE VEGETATION HISTORY IN THE FĂGĂRAŞ DEPRESSION

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Abstract: Pollen analysis from a peat core 5.20 m in length, taken from a bog near Arpaşu, in a low-altitude area of the southern part of Transylvania, is used to reconstruct the Early Holocene vegetation history of the region. The vegetation record starts during the Younger Dryas stadial, being characterized by open arboreal vegetation dominated by *Pinus* and *Betula*. The arboreal vegetation was strongly affected by the cooling of the Younger Dryas period. At the beginning of the Holocene the pollen diagram shows a general reduction of open grass communities (*Artemisia*, Chenopodiaceae, Poaceae). During the Preboreal period dense forests in which *Pinus*, *Betula* and *Ulmus* were most frequent occurred in the area. During the Boreal period *Ulmus*, *Quercus*, *Tilia*, and *Fraxinus* dominated the dense forests, but *Pinus*, *Betula*, *Alnus* and *Picea* were also common.

Key words: Pollen analysis, forest dynamics, vegetation history, Early Holocene, Făgăraş Depression, Romania.

Introduction

Numerous studies show a clear response of vegetation to the distinct climatic fluctuations during the Late Glacial-Early Holocene period in Europe [1, 15, 20, 22, 29].

In Romania, and particularly in Transylvania, the forest succession during the Holocene period is well known, largely due to the work of the Cluj palynological school [5, 16, 17, 18]. Early Holocene forest dynamics in Romania was subdivided by Pop [17] into different forest phases: *Pinus-Picea* dominated, with some *Quercus*, *Ulmus*, *Tilia*, *Fraxinus*, *Acer* and *Corylus* (Preboreal and early Boreal); and mixed *Picea-Corylus* and *Quercetum mixtum*, including *Quercus*, *Tilia* and *Ulmus* (Boreal and Atlantic). Recently, re-investigations of previously studied sites have provided well-dated and complete vegetation successions for the Late Glacial and Holocene [2, 3, 6, 8, 9, 10, 11, 12, 25, 26, 28].

The main objective of this paper is the study of vegetation history in the Făgăraş Depression, during the Early Holocene period, based on pollen analysis. The analyses were performed on a peat core taken from the peat bog "Mlaca Tătarilor", near Arpaşu de Sus (Fig. 1).

Following Pop's description [19], the peat bog "Mlaca Tătarilor" is *c*. 9 m in depth, but recent studies [7] have shown a total sequence of 16 m in depth, of which approximately 13.5 m are represented by peat. Of the 16 m sequence, the first 4 m (from the upper part of the sequence) was analyzed by Fărcaş *et al*. [7] and the last 4 m (from the lower part of the sequence) by Tantau *et al*. [27]. These palynological analyses emphasized the existence of the Late Glacial [27] and the last two forest phases, developed during the Sub-Boreal and Sub-Atlantic periods [7].

Our study is focused on 5.24 m of the sequence situated at 8.00–13.24 m.

The study area

The peat bog "Mlaca Tătarilor" or "Lacul Tătarilor" (45°43'00" N, 24°39'07" E) is located in the Făgăraş Depression, 3 km south of Arpaşu de Sus, at 540 m altitude, on a higher terrace on the right side of the Arpaşu Mare river (Fig. 1). This *Sphagnum* peat bog occupies an area of about 3 ha and it has developed above fluvial Pleistocene deposits.

From a phytogeographical point of view, the peat bog from Arpaşu is located on the borderline between the Transylvanian and Carpathian provinces [4].

The vegetation is typical for peat bogs, the main association being *Sphagnetum magellanici* Malcuit, 1929, dominated by the species *Sphagnum magellanicum* and *Eriophorum vaginatum*.

In the Arpaşu de Sus peat bogs are found species such as *Menyanthes trifoliata, Alnus glutinosa, Salix* spp., *Betula pubescens, B. hybrida, Populus tremula, Rhamnus frangula, Eriophorum vaginatum, E. gracile, E. angustifolium, Bruckenthalia spiculifolia, Carex lasiocarpa, Scirpus sylvaticus, Peucedanum palustre, Epilobium palustre, Myosotis palustris, Caltha laeta, Ranunculus flammula, Thelypteris palustris, Alisma plantago-aguatica, Scutellaria galericulata, Vaccinium vitis-idaea, V. myrtillus, Rhynchospora alba, Riccardia chamaedryfolia, R. multifida, R. palmata, Cephalozia connivens, Calypogeia sphagnicola, Lophocolea bidentata, Aneura pinguis* and *Cephaloziella rubella* [23].

The region is characterized by a temperate continental climate with cold winters and cool summers. The annual precipitation is >850 mm. The mean annual temperature is 5°C and the mean summer temperature is 17°C [24].

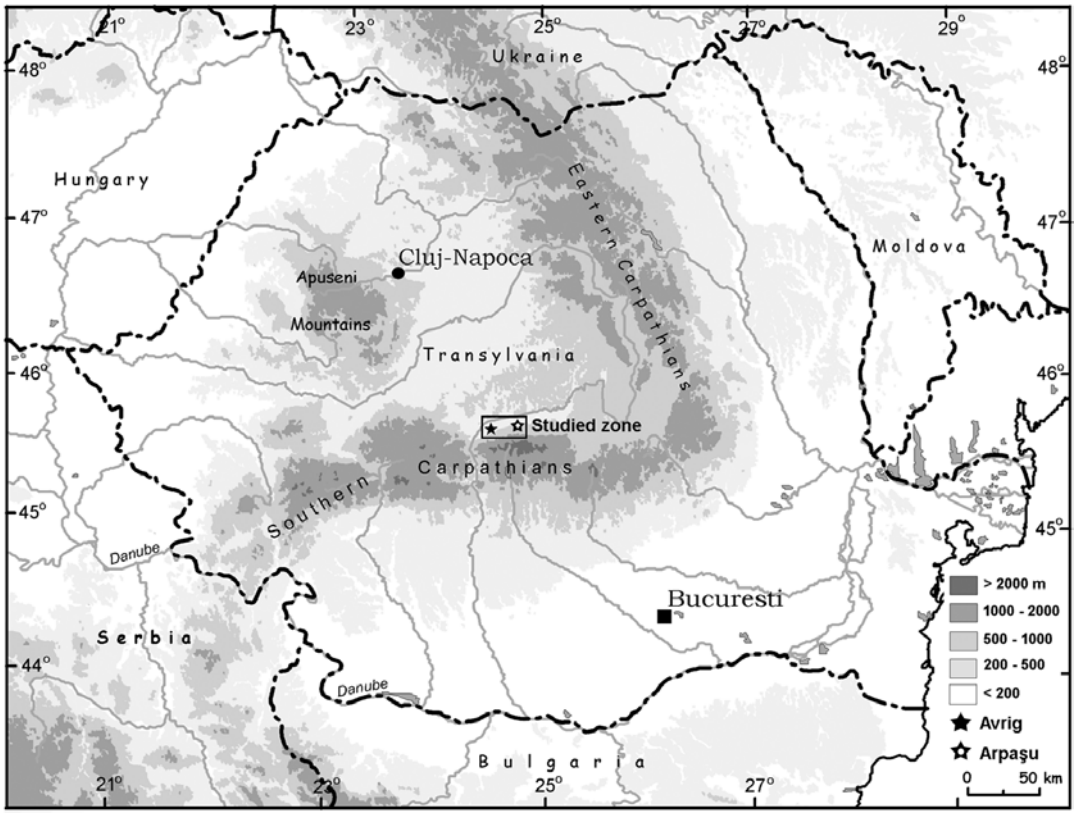

Fig. 1: Location map of the studied zone near Făgăraş Mountains

Material and Methods

Our cores were taken with a hand-operated "Russian sampler" providing cores of 8 cm in diameter. The core from the centre of the peat bog reached basal sediments at 16.00 m. The cores were described in the field, thereafter placed in half PVC tubes, and wrapped in plastic film. Before laboratory sub-sampling, all cores were carefully cleaned and described again.

The cores were regularly sub-sampled (1 cm^3) at 4 or 5 cm intervals for pollen analysis. The sample preparation followed a standard procedure: acetolysis in the case of peat and gyttja samples, flotation with Thoulet liquid [16] for clay samples. Microscope slides were prepared from the residue and scored for pollen. For each sub-sample a minimum of 250–300 grains of tree pollen was counted, except when pollen concentration was low.

Pollen diagrams were prepared using GpalWin software [13]. The frequencies of pollen for each taxon were calculated as percentages of the total sum (AP+NAP). For ecological reasons spores and cyperaceous pollen were excluded from the pollen sum. In the pollen diagram (Fig. 2) pollen values lower than 0.5 % are represented by dots.

In the absence of radiocarbon dating for the Arpaşu sequence, relative ages (chronozones) were assigned by comparison with the Avrig sequence [26], a locality situated in the same region and where a complete dating series (Fig. 1) had been carried out.

Results

Lithostratigraphy

A simplified stratigraphic sequence of the analyzed deposit, at 8.00–13.24 m is presented in Table 1.

Table 1: Simplified stratigraphic description of the sequences from Arpaşu

08.00 – 09.40 m	*Carex-Sphagnum* peat, fibrous, light brown, slightly humified, with macro-remains.
09.40 – 10.30 m	*Carex* peat, fibrous, brown, very humified.
10.30 – 11.40 m	*Carex* peat, fibrous, dark brown, slightly humified, with macro-remains.
11.40 – 13.24 m	*Carex* peat, fibrous, light brown, slightly humified.

Pollen analysis

For this section of the Arpaşu sequence, 105 pollen spectra were analyzed and 76 taxa were identified. To facilitate the description and interpretation of the pollen diagram with respect to vegetation changes, nine Local Pollen Assemblage Zones (LPAZ 1-9) were established for the Arpaşu sequence (Fig. 2). These zones were established visually by comparing frequencies and dynamics of the principal taxa, and each zone boundary denotes significant changes in pollen deposition and represents major changes in vegetation cover.

The pollen zones are described below.

LPAZ 1

The characteristic feature of this zone is the low percentages of *Picea* pollen (sometimes below 1%), associated with a high frequency of *Betula*, over 50%. Among trees, participation of over 1% is recorded by *Salix* and *Alnus.* A pronounced representation of non-arboreal pollen (Poaceae, Chenopodiaceae and *Artemisia*) is observed.

The presence of mesophilous deciduous trees (*Quercus, Corylus, Ulmus, Tilia, Fagus* and *Carpinus*) can suggest the existence of some glacial refugia in the region. The very early presence of *Fagus* and *Carpinus* can be also be explained by an anomaly due to an error in coring [25].

LPAZ 2

The beginning of this period is characterized by a decrease of *Betula* (10%), a figure which gradually increases until the end of the zone (30%). The frequency of *Pinus* species exceeded the figure of 50%. Mesophilous deciduous trees were present. By comparison with the

end of the previous zone, here can be observed an increasing frequency of herbaceous plants: Poaceae (17%), Chenopodiaceae (10%) and *Artemisia* (20%).

LPAZ 3

This zone is attributed to the beginning of the Holocene and is marked by a sudden increase in mesophilous deciduous trees (especially *Corylus*, *Carpinus* and *Fagus*) and a strong decline in *Betula*. These extraordinary peculiarities, may suggest an anomaly due to an error in coring. The frequencies of herbaceous plants decrease.

LPAZ 4

Ulmus is the first mesophilous tree to be found continually in the sequence, starting at the beginning of this zone, and the pollen of *Quercus*, *Fraxinus* and *Tilia* is present in some spectra. *Pinus* values remain at 60–70%, while the rates of *Picea* increase. Herbaceous species decrease. At this time, the vegetation surrounding the site was probably a *Pinus* forest with a presence of *Betula*, *Picea*, *Alnus* and *Ulmus*.

LPAZ 5

One of the major characteristics of this zone is the decrease of *Pinus* and the increase of *Betula*. This zone also contains the first peak of *Ulmus* (10%) and the beginning of the first continuous curve of *Quercus*. The rates of *Picea*, which exceed 5%, suggest a presence close to the site, but the locally dominant forest type was an open *Ulmus* forest.

LPAZ 6

Both *Ulmus* and *Fraxinus* reach their highest percentages of the sequence in this zone (respectively > 30% and > 5%). There is a regular increase in *Quercus*, and the continuous curves of *Corylus* and *Tilia* start. *Betula* percentages drop to 5%.

LPAZ 7

One of the major characteristics of this zone is the decrease of *Pinus* and *Betula*. *Picea* and the mesophilous deciduous trees replace these pioneer trees. This zone also contains the beginning of *Ulmus* dominance (>30%) and the beginning of continuous curves of *Fraxinus* and *Tilia*. The rates of *Picea*, which exceed 5%, suggest a presence close to the site, but the locally dominant forest type was an open *Ulmus* forest.

LPAZ 8

This zone corresponds to the expansion of all mesophilous deciduous trees, *Ulmus* being the dominant taxon. We have assigned this zone to the beginning of the Boreal. The vegetation signal in the pollen spectra corresponds to a diversified "*Quercetum mixtum*".

LPAZ 9

The decline of *Pinus* and *Betula* values finishes in this zone. *Quercus* and *Tilia* reach a maximum, the percentages of *Fraxinus* remain at the same level as the preceding zone, and a slight decrease in *Ulmus* occurs. In contrast, the values of *Corylus* constantly increase in this zone.

Vegetation history

Late Glacial

The last climatic manifestation of the Late Glacial (Younger Dryas) was recorded in the first zones of the Arpaşu sequence. This period corresponds to an episode of sharp climatic deterioration. The vegetation was dominated by open woodlands (with *Pinus*, *Betula* and some *Picea*, *Salix* and *Alnus*) and grass communities (*Artemisia*, Chenopodiaceae, Apiaceae and Poaceae), similar to other regions studied in the Romanian Carpathians [2, 3, 6, 8, 25, 26].

The low representation of *Picea* in this region, as in other regions of the Romanian Carpathians [2, 3, 6, 8, 25, 26], can be explained by the cold conditions of this period.

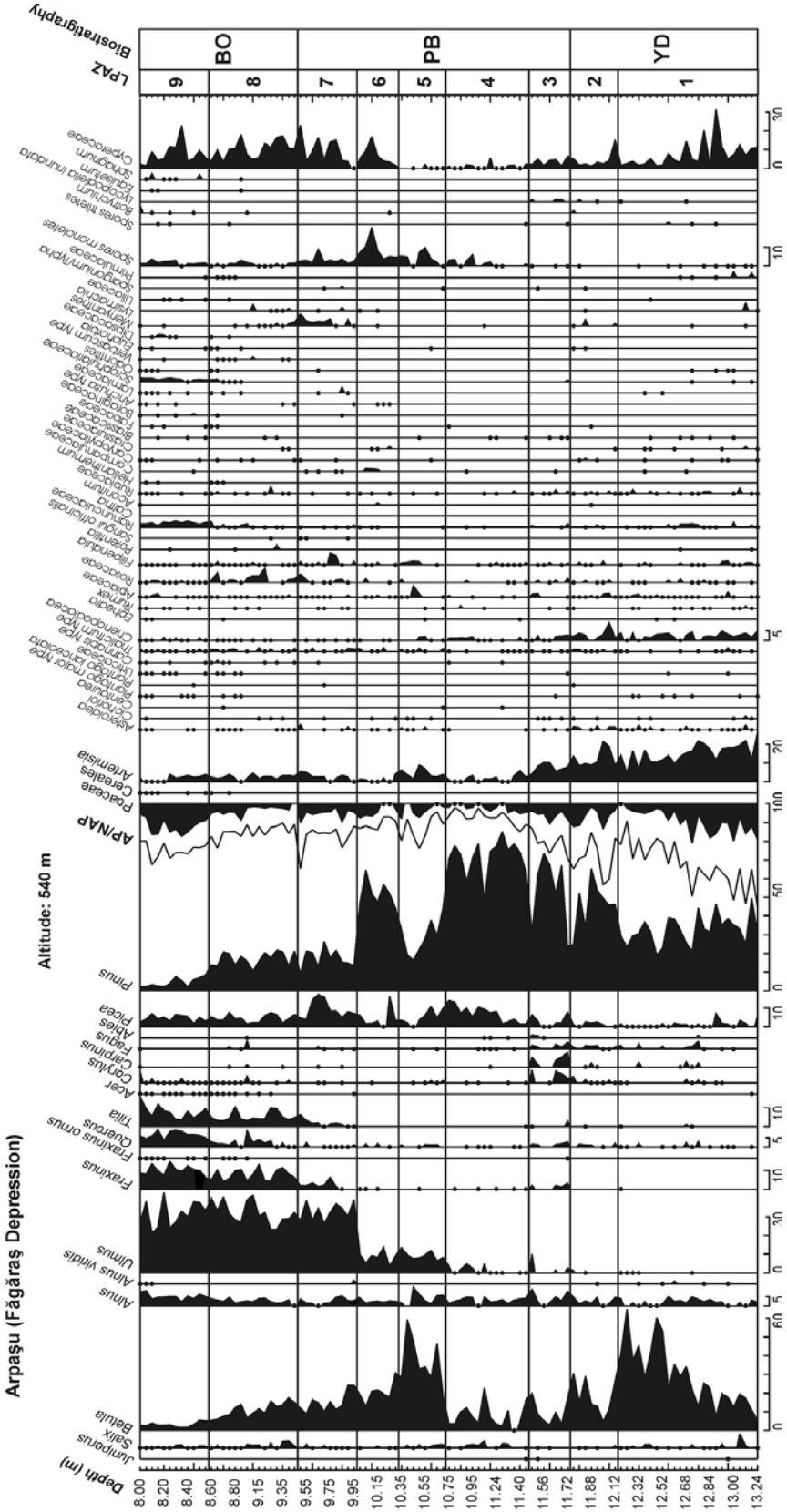

Fig. 2: Pollen diagram from Arpaşu: YD-Younger Dryas, PB-Preboreal, BO-Boreal.

In most of the sequences described in Romania [3, 6, 25, 26] this episode is associated with a dramatic decrease of *Betula* pollen. The sequences of Arpaşu and Avrig [26], located in

the same region, are exceptions, as *Betula* reaches a maximum. Increased values of *Betula* may point to a wide distribution of these pioneer trees in open forests.

The pollen spectra of the Younger Dryas indicate a substantial restructuring of the Late Glacial vegetation cover, with treeless landscapes and cold steppe communities becoming dominant.

Early Holocene

Preboreal (10,000 yr BP–9,000 yr BP)

At the beginning of the Holocene, the pollen diagram shows a general reduction of open grass communities (*Artemisia*, Chenopodiaceae, Poaceae), accompanied by slightly increasing values of *Pinus* and *Betula*. *Picea*, *Alnus*, *Ulmus*, *Quercus* and *Salix* were also part of these earliest Holocene woodlands, but in lower quantity. Pollen analyses from other sites in Romania show a concurrent expansion of *Pinus*, *Picea*, *Betula* and *Alnus* [2, 3, 6, 8]. These taxa spread almost synchronously at all sites studied, suggesting that they had widespread refugia across the Romanian Carpathians [12].

At Arpaşu, as in other regions of the Romanian Carpathians [2, 3, 8, 25, 26], the low values of *Picea* pollen at the onset of the Holocene can be explained by a large reduction of *Picea* woodlands, during the cold Younger Dryas.

The relatively slow establishment of mesophilous forest during the Holocene suggests that, in general, the vegetation was strongly affected by this cold period.

The increase of *Ulmus* pollen percentages from the beginning of the Holocene is similar to that found in all recently investigated localities and suggests an early Holocene establishment of *Ulmus* in the Romanian Carpathians [2, 3, 6, 8, 25, 26]. The early expansion of *Ulmus*, at the beginning of the Preboreal, may suggest that either it was present in regional refugia or it migrated from outside Romania during the Late Glacial period.

During the Preboreal period dense forests in which *Pinus*, *Betula* and *Ulmus* were most frequent occurred in the area. The immigration of mixed-oak taxa (*Fraxinus*, *Quercus* and *Tilia*) occurred after the expansion of *Ulmus*. Competition with existing species (*Ulmus* and *Picea*) and higher temperatures during the growing season may also have played a significant role in their spread [8]. The mixed oak taxa appear almost simultaneously in the other areas of Romanian Carpathians [2, 3, 6, 8, 25, 26].

During the Boreal period, *Ulmus*, *Quercus*, *Tilia*, and *Fraxinus* dominated the dense forests, but *Pinus*, *Betula*, *Alnus* and *Picea* were also common. At the end of this period a new increase of open grass communities (especially Poaceae) accompanied by decreasing values of *Pinus* and *Betula* is recorded.

Conclusions

The peat sequence from Arpaşu provides a high-resolution record of Early Holocene forest and climate history in the southern part of the Făgăraş Depression. The forest succession is as follows:

(1) The rapid establishment of *Pinus* and *Betula* at the transition to the Holocene, which can be explained by their presence in the area during the Late Glacial period.

(2) The rapid expansion of *Ulmus* might be due to the survival of this genus in close proximity to the site. This delay is probably due to the fact that only small tree populations survived the severe climatic conditions during the Late Glacial period.

(3) The establishment and expansion of other deciduous tree genera (*Quercus*, *Fraxinus* and *Tilia*) was delayed in comparison with *Ulmus*.

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ISTORIA VEGETAȚIEI HOLOCENULUI INFERIOR DIN DEPRESIUNEA FĂGĂRAŞULUI

(Rezumat)

Analiza palinologică a unei secvențe turboase de 5,30 m lungime, prelevată într-o zonă din Depresiunea Făgărașului fost utilizata pentru a reconstitui istoria vegetației de la începutul Holocenului, din această regiune. Turbăria "Mlaca Tătarilor" se găseşte la 3 km sud de Arpaşu de Sus, la o altitudine de 540 m. Deoarece nu a fost încă posibilă realizarea datărilor de vârstă absolută pentru secvența de la Arpaşu, am folosit pentru corelare datările de la Avrig, turbărie situată în apropierea celei de la Arpaşu. Corelarea rezultatelor obținute în cele două situri permite o mai bună interpretare a istoriei vegetației din regiunea studiată.

Înregistrarea istoriei vegetației în secvența studiată, divizată de noi în 9 zone polinice, debutează în timpul Dryasului Recent (Younger Dryas), când vegetația forestieră a fost puternic afectată de răcirea climatică din această perioadă. Vegetația identificată a fost dominată de păduri cu *Pinus* şi *Betula* şi de ierboasele stepice (*Artemisia* şi *Poaceae*). Ameliorarea climatică de la începutul Holocenului a favorizat expansiunea pădurilor dominate de taxoni ce alcătuiesc *Quercetum-mixtum* (*Ulmus, Quercus, Tilia* şi *Fraxinus*).

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