

Late Holocene vegetation history in Harghita Mountains (Romania)

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ABSTRACT: We present here the pollen analysis of two sequences originating from two peat bogs from Harghita Mountains. The vegetation record, which is supported by five ¹⁴C dates, starts in the Subboreal (age) with the *Carpinus* optimum. During the Subatlantic (age) the vegetation is dominated by *Fagus*. Indications of human impact (especially agricultural activities) in the region occur at the beginning of the Subboreal (at ca. 4200 years BP).

KEY WORDS: vegetation history, forest dynamics, pollen analysis, Late Holocene, Harghita Mountains

1. Introduction

The Late Holocene represents the last period from geologic history and includes the Subboreal period which is characterized by the optimum of *Carpinus betulus* and the Subatlantic period, which is dominated by beech (*Fagus sylvatica*) forests. During this period of the Holocene which started about 5000 years BP several climatic oscillations were identified in Romania: the 'Medieval warm period' and the 'Little Ice Age' which had a strong influence on flora and fauna (Feurdean et al., 2009, 2011; Geanta et al., 2012).

In Harghita Mountains are few studies about the vegetation history. First simplified palynological analysis in this zone was made by Szalai (1943) that published a sequence from Luci with 540 cm in depth, and the bottom attributed to the Preboreal.

After few years, palynological and botanical investigations in this zone were made by Pop (1962) that show a detailed description of the vegetation from Mohoş and Luci. Pop (1960) also showed in his work the presence of a glacial relict *Betula nana* at Luci site.

In 1967 Pop and Diaconeasa published pollen analysis of two sequences from Mohoş peat bog that shows the vegetation history in this zone, but they don't mention *Fraxinus* in their pollen diagram. After almost 40 years Tanţău (2003, 2006) publish a new set of pollen diagrams, from Luci and Mohoş, which are more complex and are supported by ¹⁴C dates.

Also Magyari et al. (2006) publish a study about Holocene palaeohydrology and environmental history in the South Harghita Mountains which include a pollen analysis in sediments of Saint-Ana Lake.

Two sites are compared in this study: Mohoş and Luci peat bogs. The aim of this study is to reconstruct the Late Holocene vegetation history in Harghita Mountains, by comparing the pollen analysis realized in the two sites (Tanţău 2003, 2006, Tanţău et al., 2003). Both peat bogs are natural reservations for protection of relict plant like: *Empetrum nigrum*, *Drosera rotundifolia*, *D. obovata*, *Andromeda polifolia*.

2. Study area

The studied peat bogs occupy the bottom of two volcanic craters from the Harghita Mountains (Fig. 1). Harghita Mountains are the last massif of the Neogene eruptive chain Calimani-Gurghiu-Harghita. The altitude of bogs is 1079 m at Luci and 1050 m at Mohoş. Both of them are locally composed of *Sphagnum* peat. The local vegetation of these sites is similar, with forest of red pine (*Pinus sylvestris*), downy birch (*Betula pubescens*), black alder (*Alnus glutinosa*), and different species of willow (*Salix*).

Mohoş is located in the northeast of Saint Ana Lake, in the crater of the twin massive Puciosu (Ciomatu). The local vegetation type is assigned to the 'Vaccinio uliginosi – Pinetum silvestri' plant community, while the specific vegetation stage for this altitude (middle mountainous) is typically characterized by the 'Symphyto cordati–Fagetum' plant community (Coldea, 1991). From herbaceous plants specific on peat bogs the most abundant are: *Empetrum nigrum*, *Vaccinium vitis idaea*, *Vaccinium oxycoccos*, and *Andromeda polifolia*.

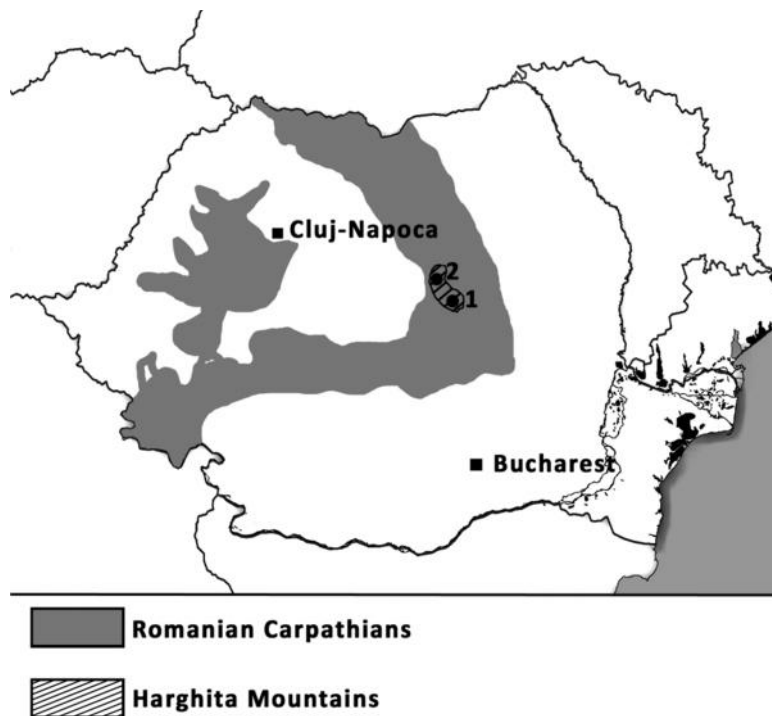


Figure 1. Romania map with the studied sites: 1 - Mohoş, 2 - Luci.

Luci peat bog is formed also by accumulation of peat into a crater lake. The peat is mainly formed by *Sphagnum* spp. Other species as *Andromeda polifolia*, *Drosera rotundifolia* and *Betula nana* are present. At the periphery of the bog in north and in south, vegetation is dominated by an association Sphagno - Caricetum rostratae Steffen, with *Viola epipsila*, relict species more abundant in the northern part of the peat bog. At the center of the bog, the association is Eriophoro vaginati - Sphagnetum recurvi Huek. In the middle and upper bog there is also the association Vaccinio - Pinetum sylvestris Klest with the sub-association Betuletosum nanae (Coldea and Plămadă, 1989; Coldea et al., 1997).

The region is characterized by a temperate-mountainous climate with an annual precipitation level above 1,000 mm. Precipitation reaches a maximum during summer and a minimum during winter. The mean annual temperature is 3°C and the mean summer temperature is 15°C.

3. Methodology

The pollen analyses of two sequences located in Harghita Mountains were compared (Tanțău et al., 2003; Tanțău, 2006). Only the upper part of the pollen diagrams (the Subboreal and Subatlantic periods) was used for this study. The chronology was established by radiocarbon data at the Laboratory of the Radiocarbon in Poznan (Poland).

4. Results

4.1. Chronology

Five AMS ^{14}C ages were used to obtain the chronology of the two sequences: three ages for Mohoș and two ages for Luci (Figs. 3-4) (Tanțău et al., 2006). The transition Subboreal-Subatlantic, which marked the beginning of the *Fagus* optimum, is well dated at Mohoș (2910 ± 90 years BP) than at Luci (only 2460 ± 40 years BP), where the transition is probably affected by a hiatus of sedimentation (Figs. 3-4).

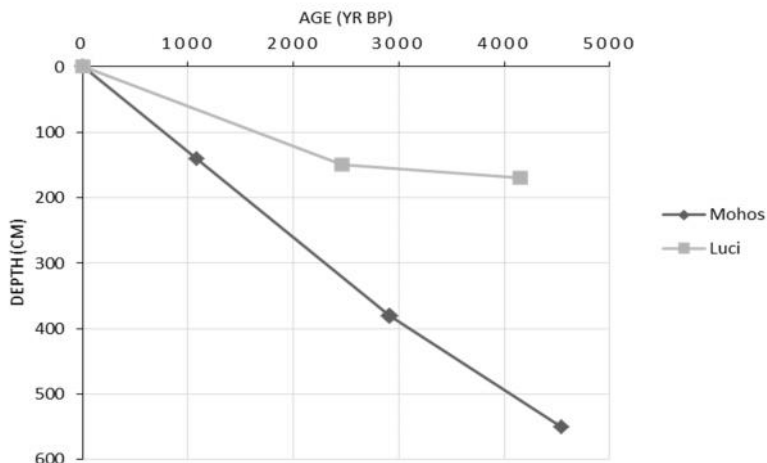


Figure 2. Age-depth model for Mohoș and Luci sequences.

The age-depth model was constructed based on linear interpolation of AMS ^{14}C ages (Fig. 2). Based on age–depth model there are some differences between Luci and Mohoş peat bogs, as the accumulation rates are concerned, being more uniform for the latter one. This diagram shows a higher sedimentation rate for the Mohoş peat bog (0.12 cm/year) than for Luci (only 0.05 cm/year).

4.2. Vegetation history

Four regional pollen zones are distinguished: the sequence Mohoş recorded all four zones while Luci includes only three local pollen zones (Figs. 3-4). Based on the main changes in the pollen percentages in these local zones the following points may be made:

- ❑ LPAZ 1 (ca. 4500-3500 years BP, depth: 550-430 cm at Mohoş): This zone corresponds to a maximum expansion of *Carpinus betulus*. The beginning of this zone is dated to about 4550 BP. The end of this *Carpinus* optimum expansion is dated between 2460 ± 170 years BP at Luci and $2,910 \pm 90$ years BP at Mohoş.
- ❑ LPAZ 2 (ca. 3500-2900 years BP, depth: 430-380 cm): In this zone, which is present only in Mohoş sequence, *Fagus sylvatica* replaces *Carpinus betulus*. *Picea abies* was also present in the studied zone. Percentages of *Ulmus* and *Fraxinus* decrease.
- ❑ LPAZ 3 (ca. 2900 years BP - historical times, depth: 380-50 cm): This zone is marked by the absolute dominance of *Fagus*, with values over 50%. At that time, *Fagus* extended over the whole periphery of the craters, gradually supplanting *Picea*, which could probably maintain itself on the summits only. *Abies alba*, represented by sporadic pollen occurrences, plays a modest role during the *Fagus* optimum. Herbs are not abundant in this zone, but human activity is attested by regular records of cereal pollen (*Secale*) and *Plantago lanceolata*.
- ❑ LPAZ 4 (modern times): In this modern zone, evidence is found for a peak in agricultural activities. Cereals pollen is present in all the pollen spectra of this zone. *Fagus* percentages fall abruptly to values below 20%. The increase in *Pinus* pollen percentages (modest at Mohoş) is due to an anthropogenic opening of forest environments.

5. Vegetation history and human impact

The pollen records illustrate the vegetation history and human impact during the Subboreal-Subatlantic periods (Figs. 3-4). The results are then correlated with the available data from other investigations in the Romanian Carpathians to give a general picture of the Late Holocene forest development in Romania. The start of Late Holocene is marked in Romania by the maximum expansion of *Carpinus betulus* (Tanţău, 2006).

5.1. Subboreal (ca. 4500 - 2900 years BP)

The bottom of the sequence is dated at 4550 ± 100 years BP in Mohoş and at 4150 ± 35 years BP in Luci, and begins with the *Carpinus betulus* maximum expansion. At that time vegetation around the craters was a *C. betulus* forest. *Picea* was probably present at the summits. *Corylus avellana*, *Betula*, *Quercus*, *Picea abies* and *Alnus* were also present in the region.

Herbaceous plants are few, but agricultural activities are confirmed by the first occurrences of cereals and *Plantago lanceolata* at ca. 4200 years BP.

The maximum expansion for *Carpinus betulus* was recorded in some other diagrams from Romanian Carpathians starting at 4800-5200 years BP (Farcas et al., 1999; Björkman et al., 2003; Bodnariuc et al., 2002; Tanțău et al., 2006, 2009, 2011). This optimum of *C. betulus* ends at about 3000 years BP with the *Fagus sylvatica* expansion (Fig. 3).

5.2. Subatlantic (ca. 2900 years BP - present)

The start of Subatlantic is marked by high percentages of *Fagus sylvatica* pollen, which is recorded earlier at Mohoș (ca. 3000 years BP) than at Luci (ca. 2500 years BP), where the transition is probably affected by a hiatus of sedimentation. During this period the pollen spectra are dominated by *F. sylvatica*, whose frequencies reach 50%, indicating its dominance in the local forests. It shares the territory with *Picea*, which probably occupies mainly the ridges.

The maximum expansion for *Fagus sylvatica* was recorded in some other diagrams from Romanian Carpathians starting at 2500-3500 years BP (Farcas et al., 1999; Bodnariuc et al., 2002; Feurdean and Willis 2008; Feurdean et al., 2009; Tanțău et al., 2009, 2011).

The moderate percentages of *Carpinus betulus* indicate the presence of this tree in the region. *Abies alba* pollen is recorded with fairly regular appearances and *Juglans* is also present in the area. First occurrences of *Juglans* are recorded at about 2000 years BP at Luci and only at about 600 years BP at Mohoș (Figs. 3-4). Other trees (*Betula*, *Quercus*, *Corylus avellana*, *Picea abies* and *Alnus*) are present in the region, but they display small percentages and fluctuating values, due to the episodic forest clearance.

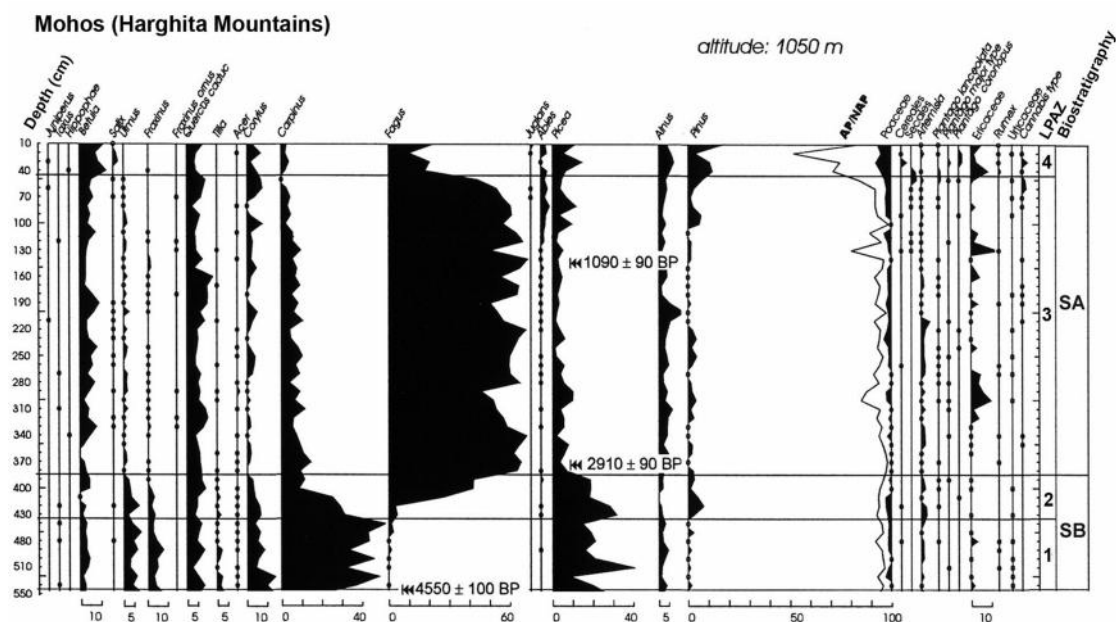


Figure 3. Simplified pollen diagram from Mohoș (after Tanțău et al., 2003, modified).

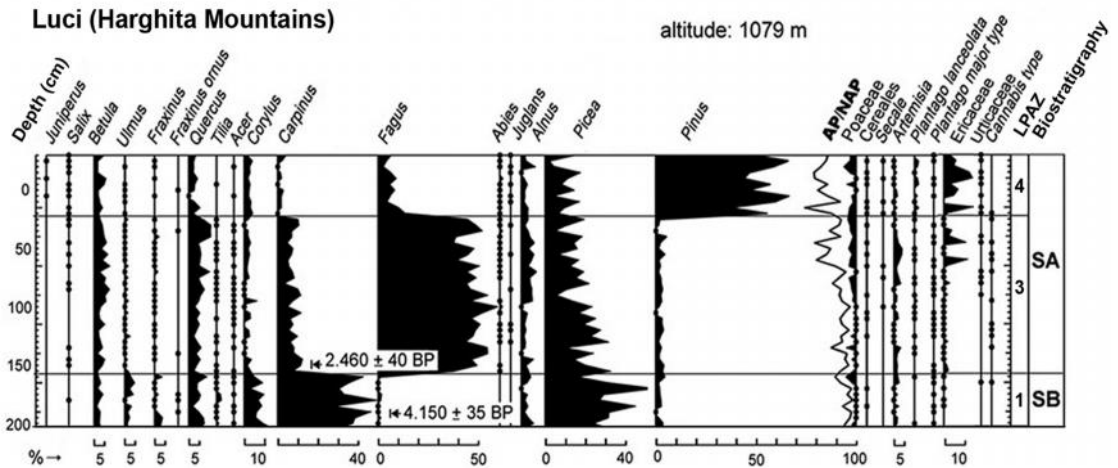


Figure 4. Simplified pollen diagram from Luci (after Tanțău, 2006, modified).

Human activity (especially agriculture and grazing) during this period is evidenced by the regular presence of the cereals pollen, *Secale* and *Plantago lanceolata*.

Towards the end of the interval (during the last centuries) we note the increase in pollen of anthropogenic indicators and this is associated to a change in the natural vegetation composition. The proportion of *Fagus* collapse suddenly and *Pinus* takes his place. The pollen of this pioneer opportunistic taxon reached percentages as high as 60%). *Carpinus* also records a decline at the same time with *Fagus*, maybe due to the deforestation.

Archaeological evidences about human occupation were found near the Mohoș crater: traces of Boian culture (middle Neolithic) dated to 5500-6000 years BP were found at Brăduț Turia (Székely, 1998); pottery of Cucuteni culture (5300-5600 years BP) were found at Malnaș-Băi (Laszlo, 1997), and settlements confined to Bronze Age (3500-4000 years BP) were found at Albiș and Peteni (Székely, 1980).

6. Conclusions

During the Late Holocene, the vegetation of Harghita Mountains was mainly dominated by *Carpinus* forests between 4500 and 3000 years BP and by *Fagus* forests between 3000 BP and about 200 years BP.

In modern times a strong regression of *Fagus* in the favor of *Pinus* took place due to the human impact. Also pollen from *Picea*, *Alnus*, *Betula* and *Quercus* is quite significant.

Carpinus records a decline at the same time with *Fagus*, sign of high human activity, suggesting deforestation.

Herbaceous plants are few, but agricultural activities are confirmed by presence of cereals since the Subboreal period. Cereals are recorded during the *Carpinus* optimum and throughout the *Fagus* phase, and they become more regular with the appearance of *Plantago lanceolata*, at ca. 2000 years BP.

During the last centuries the Poaceae progresses, sign of expansion of grasslands.

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