Palynological research into the peat bogs in the region of Chairski Lakes on the Trigrad Plateau (Central Rhodopes)

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Abstract. The results of the spore and pollen analysis of the peat bogs in the region of Chairski Lakes on the Trigrad Plateau (Central Rhodopes) are discussed. A reconstruction of the vegetation in the Late Holocene and up to the establishment of the contemporary plant communities has been made on the basis of data obtained from palynological research. The pollen diagrams reflect a period of well-developed coniferous forests in the region, as well as manifest anthropogenic pressure in the Late Holocene (Subatlantic).

Key words: Central Rhodopes, peat bogs, pollen analysis, Subatlantic, Trigrad Plateau, vegetation history

Introduction

The contemporary image of the broad coniferous belt, now existing in the Central Rhodopes, results from some long-standing and dynamic changes conditioned by various ecological factors, migration processes, competitive interrelations between the different plant species, and active anthropogenic pressure. Paleoecological investigations offer an opportunity for tracing out these processes in a retrospective.

On the basis of palynological data obtained from the research into the peat bogs in the region of Chairski Lakes on the Trigrad Plateau (1600 m) the trends in the Late Holocene dynamics of the vegetation have been traced out. Information on the vegetation history based on palynological data and radiocarbon dating in the last 2500 BP (Subatlantic) for the region of Cnetral Rhodopes has been so far reported for Mougla village (1350 m) (Lazarova 2003).

Contemporary vegetation

The relief of the Rhodopes acquired the image characteristic of its present morphological structure at the beginning of the Quarternary. The Central Rhodopes, and particularly their part enclosed between Vucha and Chepelarska Rivers, have a geomorphological image of their own. They stand out with a greater ruggedness of the relief, which facilitates the Mediterranean climatic influence (Velkov & al. 1998).

That part of the Rhodopes falls into the vastest in the area Chernatitsa Geobotanical Region, stretching from Vucha River in the east to Arda River and Zhulti divide. Spruce forests prevail, forming the most extensive massifs in Bulgaria. Forests of *Pinus sylvestris* L. are also widespread, but rather fragmentary. On the carbonate substrate of xerophytic habitats grow well-developed but scattered communities of *Pinus nigra* Arn. Fir forests are less distributed. In the eastern and partly in the northern part of the region there are vast beech massifs. There are extensive areas under *Quercus daleschampii* Ten., chiefly in the northwestern part of the region. Mixed forests, especially in the deep gorges, combine various species. Besides *Fagus sylvatica* L., *Carpinus betulus* L. and *Quercus daleschampii*, *Ostrya carpinifolia* Scop. also occurs there, occasionally dominating in the tree stands, as well as species of *Acer*, *Fraxinus excelsior* L., *F. ornus* L., etc. (Bondev 1997).

Material and methods

Description of the studied sites

Objects of this palynological investigation are some peaty stretches in the Chairite locality on the Trigrad Plateau (41° 36′ N, 24° 23′ E), around the four Chairski Lakes, situated in monodominant forests of *Picea abies* or mixed with *Pinus sylvestris*. Two corings were made in the region (Fig. 1):

1. **Trigrad-Chairite** (0–62 cm) – a peat bog situated around the highest Chairsko Lake. The slopes surrounding the lake to the east, west and south are densely covered with spruce forests, the northern ones are deforested. Single adult specimens of *Populus tremula* L. occur. The core was taken from a compact sphagnum mound, 30 cm high, with an area of 1 m^2, overgrown with *Carex echinata* Murr. and single specimens of *Molinia coerulea* (L.) Moench, *Eriophorum latifolium* Hoppe., with dominance of *Menyanthes trifoliata* L. In a wider range from the place of study, the vegetation cover consisted of *Typha latifolia* L., with *M. trifoliata* and patches of *Equisetum limosum* L. Around the place of coring there was a group of strongly dwarfed specimens of *P. sylvestris*, about 20–30 years old, and single individuals of *Picea abies* (L.) Karst. Wet alpine meadows stretch above the lake.

2. **Chairite-1** (0–95 cm) – a sphagnum peat bog lying in a spruce forest above Sinyoto Lake. The terrain is very stony, with many tree stumps buried on different depth under the peat. The core was taken at the periphery of the peat bog. Besides by *Sphagnum,* the surrounding vegetation is represented chiefly by *Poaceae* and *Carex*. There were representatives of *Trifolium*, *Campanula*, *Hypericum*, *Asteraceae, Apiaceae*, etc. Within the range of the studied terrain, there were shrubs of *Rosa* and *Populus*. A wet alpine meadow stretches between the first and the second lake.

The cores were taken with a manual Dachnowsky corer, with camera length 20 cm and diameter 2 cm. Laboratory processing of the samples for pollen analysis followed the standard method of Faegri & Iversen (1975). The pollen spectra were calculated on the basis of the total pollen sum, excluding the participation of aquatic, marsh and spore plants. Exclusion of local components from the total pollen sum ($\sum P = AP + NAP – L = 100\,\%$) is very important for the final results and their interpretation (Wright 1967). The results of the palynological research are presented in pollen diagrams (Figs 2, 3), on which the reconstruction of vegetation was based. Statistical processing of the data and plotting of pollen diagrams was made with the help of TILIA and TILIA-GRAPH software (Grimm 1991).

Results

The pollen diagrams divide into three local pollen zones (LPZ) differentiated on the basis of changes in the correlation of the main forest components in the pollen spectra (Figs 2, 3). Peat accumulated around the lakes at different speed, depending on the local uneven terrain and varying in thickness from 62 cm to 95 cm. Irrespective of the different depth of cores, their pollen spectra reflect one and the same time period. Owing to repetition of the results in the two cores, the pollen diagram of Trigrad-Cahirite (Fig. 2) is more detailed. Irrespective of the fact that the peat was only 62 cm deep, the pollen spectra of the cores, taken at every 2 cm, contain the same information as in the Chairite-1 profile (Fig. 3).

The pollen analysis has shown 138 pollen taxa altogether: 35 from AP (trees and shrubs) group, 88 from the herbaceous group (NAP) and 15 local pollen taxa (L) comprising aquatic, marsh and spore plants.

Local pollen zones

LPZ *TCH*-1 (62–44 cm)

This zone is characteristic with the highest percentage participation of pollen of the tree species (AP): between 60–69 % and a maximum of 79 %. Dominating participation in the pollen spectra was registered by *Pinus*, with about 30 % and two maximums of 37 % and 40 %, and by *Picea,* with about 20 % and a maximum of 30 %. The pollen of *Abies* was represented by 2–3 %, these being the maximum values for the entire profile. *Quercus* (3–7 % and a maximum of 10 %) and *Fagus* (3–7 %) were also represented by their maximum values. Of the herbaceous taxa, the highest values were shown by the representatives of *Poaceae* (7–16 %). The pollen of *Ranunculaceae*, *Brassicaceae* and *Rosaceae* also marked a significant participation. The pollen of *Triticum*/*Avena* registered a steady and prominent participation too. Of the local components, *Cyperaceae* manifested permanent participation with 3–5 % and a local maximum of 29 %. *Sphagnum* spores were registered with a maximum of 38 %.

Fig. 1. Map of the investigated regions and location of the cores.

– authors data

– literature data

LPZ *TCH* –2 (44–24 cm)

The summary curve of the tree species (AP) manifested a downslide, but fluctuated around 53 %. While that zone registered reduction in percentage for the values of *Picea* (with a maximum up to 13 %) and *Abies* (до 1 %), *Pinus* showed a permanent participation between 30–38 % (the maximum for the profile). The pollen of *Quercus* showed a downward trend towards the upper levels of the zone and a slight decrease in participation to the tune of 3–5 %. *Fagus* also marked a slight decrease (2–4 %). Irrespective of the fact that the pollen of tree species (AP) dominated over that of the herbaceous species (NAP), there was registered a maximum participation of the pollen of *Poaceae* for the profile, with 12–23 % in the zone. Higher participation was also observed of: *Plantago lanceolata*, *Rumex*, *Triticum*/*Avena*, *Chenopodiaceae*, *Rosaceae*, *Fabaceae*, etc. The pollen of *Colchicum* registered local maximums of 18 % and 20 %. The lower levels of the same zone manifested a permanently high participation of *Sphagnum* spores, between 12–23 %, and reduction to 3 % at the end of the zone. In spectra 11 and 12 *Sphagnum* marked a second peak of 20–23 %.

LPZ *TCH* -3 (24–0 cm)

The curve of tree species (AP) slid under 50 %. A drop was registered both in the participation of *Picea* (under 10 % and a maximum of 14 %) and of *Pinus* (average values about 27 % and a maximum of 35 %). *Quercus* retained permanent participation between 2–4 % and *Fagus* did not exceed 3 %. In that zone the curve of *Betula* marked an increase, with values up to 8–9 %. The participation of *Corylus*, *Carpinus orientalis*/*Ostrya* and *Fraxinus excelsior* also marked an increase. Pollen of *Poaceae* was registered in the zone, with values of 8–15 %.

Contemporary vegetation was reflected in the latest pollen spectra at the depth of 10–0 cm.

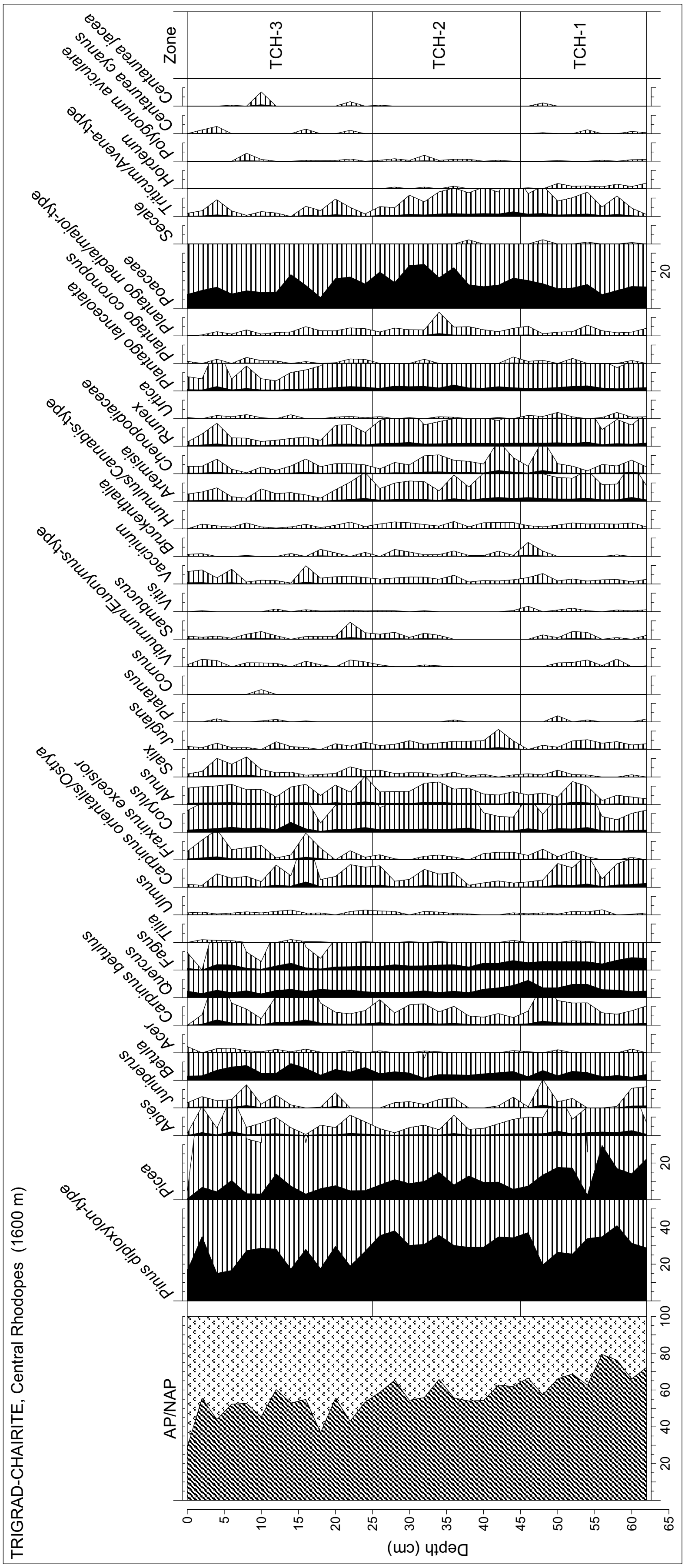

Fig. 2. Percentage pollen diagram of Trigrad – Chairite.

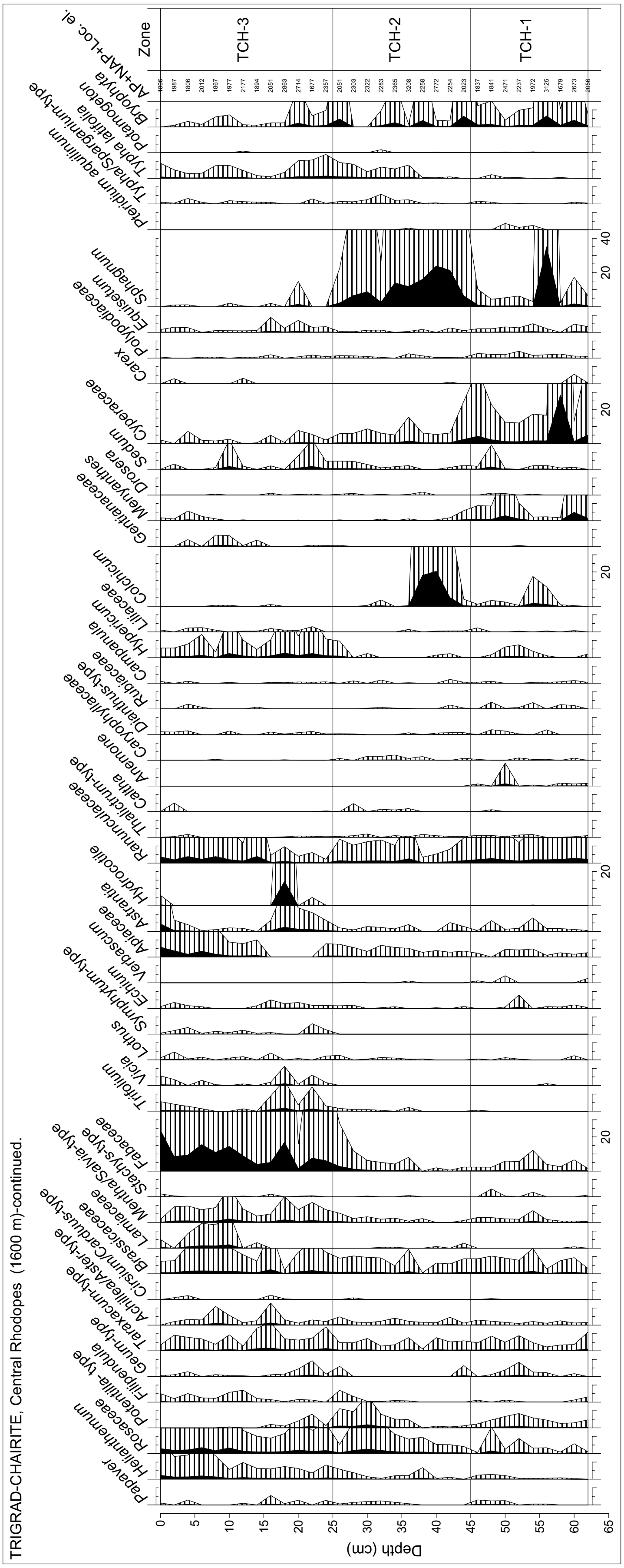

Fig. 2. Continuation

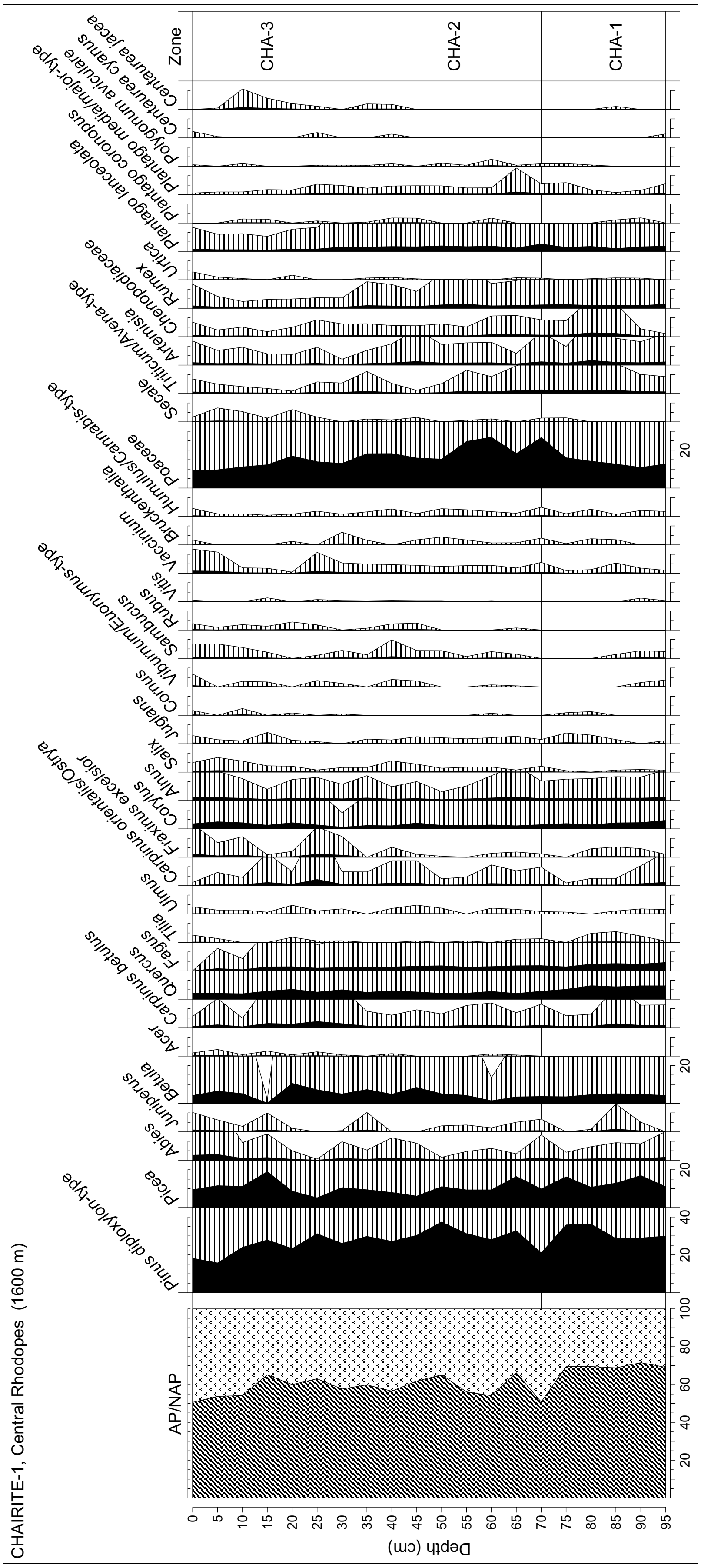

Fig. 3. Percentage pollen diagram of Chairite -1.

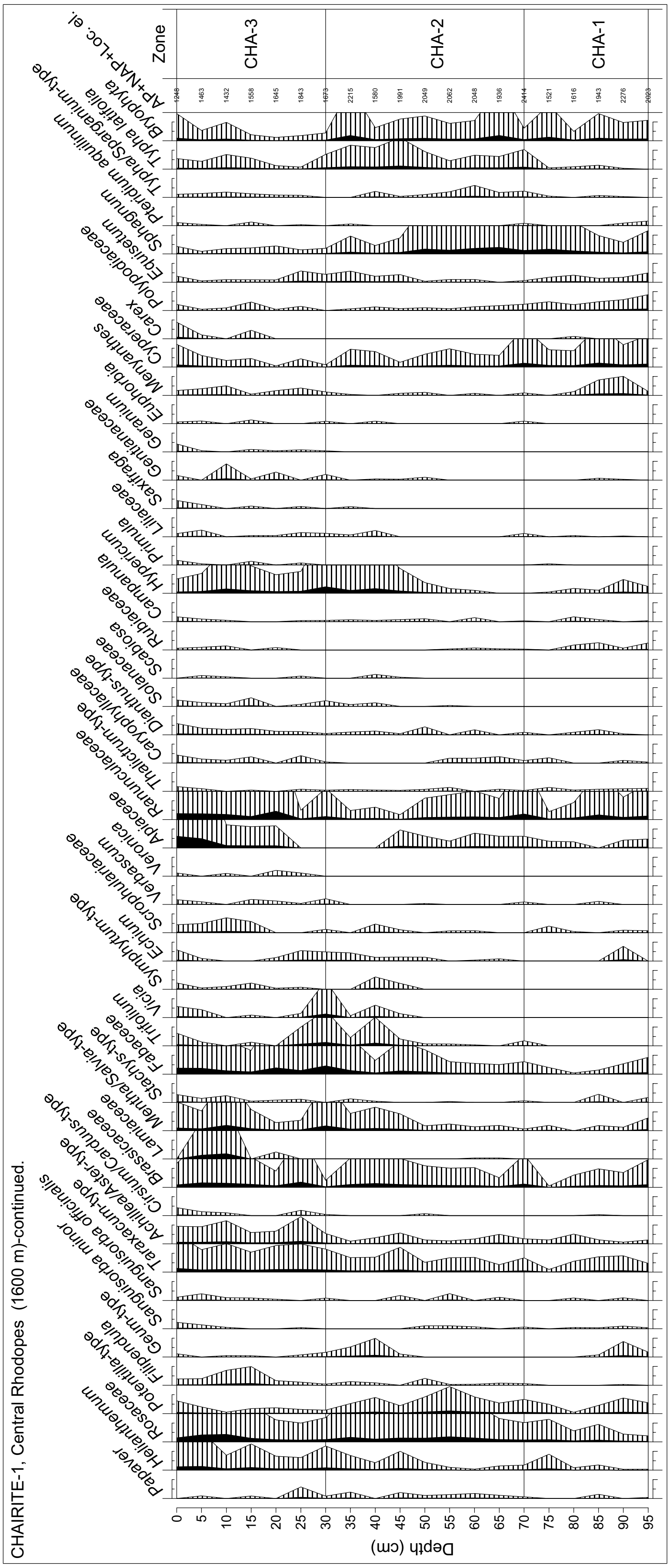

Fig. 3. Continuation

Discussion

The palynological results obtained from the studied peat bogs around Chairski Lakes on the Trigrad Plateau gave rise to the assumption that the age of the peat bogs was the Late Holocene (Subatlantic). The plant paleosuccession reflected in the pollen diagrams in that region resulted from the environmental changes during the period of peat accumulation and was strongly influenced by athropogenic activity, weather directly or indirectly.

Vegetation changes in that region reflect dominance of the coniferous forests of *Pinus* and *Picea* and correspond to the latest phase of development of the paleosuccession in the Western Rhodopes (Bozilova & al. 1989; Huttunen & al. 1992; Panovska & Bozilova 1994; Filipovitch 1995; Bozilova & al. 2000; Filipovitch & Lazarova 2001, 2003), as well as in the northern mountain regions of Greece (Athanasiadis & al. 1993; Gerasimidis & Athanasiadis 1995).

The earliest deposits in the zones ***TCH*-1** (Fig. 2) and ***CHA*-1** (Fig. 3) reflected in the pollen diagrams show the dominating role of coniferous forests in the region (AP up to 69 % and a maximum of 79 %), which used to form the forest upper timberline. The palynological study of the cores taken in the region of Chairski Lakes reflects a period of rapid expansion of *Pinus*. We have a radio-carbon dating of the Mougla-2 peat bog in the Central Rhodopes, at a depth of 170–175 cm, which registers the rapid expansion of *Pinus* at about 1670±60 BP (Lazarova 2003). Proximity of the sites gives rise to the assumption that the same dating could be valid for the expansion of *Pinus* and *Picea* already in the lower levels of zones ***TCH*-1** and ***CHA*-1**. Relatively close for a comparison with the studied area are also the palynological sites from the Western Rhodopes, where a similarly rapid expansion of *Pinus* and *Picea* was dated at about 1850±100 BP in the Sluncheva Polyana locality (Filipovitch 1995), and in Koupena II at 2070±100 BP (Hutunen & al. 1992). The slight differences in the three datings confirming the expansion of *Pinus* and *Picea* forests are probably due to the different altitudes. The contemporary coniferous belt in the Rhodopes, dominated by *Pinus* and *Picea* with insignificant mixes of other coniferous species, was formed at about 2000 BP, i.e. in the Subatlantic. The difference in percentage participation of the *Pinus diploxylon*-type and *Picea* is very small and calls for special attention to be devoted to their correlation in respect to the composition of adjacent forests. During interpretation of the pollen spectra, the excessive pollen productivity known from literature, as well as the better preservation capacity of the pollen of *Pinus* should be taken into consideration, as well as the possibility for effective air transportation (Andersen 1970, 1974; Faegri & Iversen 1975), against the lower pollen productivity of *Picea*. The results of the analysis confirm the well-known from literature and the established for the Balkan Range (Filipovitch & Lazarova 1997) and the Rhodopes (Filipovitch & Lazarova 1999) existence of spruce forests, whenever the percentage participation of *Picea* in the contemporary pollen spectra exceeds that of all other tree representatives taken singly. In this case only the *Pinus diploxylon*-type was represented by higher values. Applied to the concrete case, the correlation of the pollen of *Pinus* and *Picea* reflects the presence of spruce forests with the participation of *Pinus*. *Abies* participates as an admixture in these forests (Figs 2, 3).

Below the coniferous forests, communities of *Fagus*, *Carpinus betulus* and *Abies* were spread on the mountain slopes. During the Subatlantic, the optimum conditions were created for the distribution of *Fagus*, which gradually took a dominating place in the fur-and-hornbeam communities, limiting the spread of *Abies* and *Carpinus betulus* and forming its own belt (Filipovitch & Lazarova 2001). In these zones a permanent participation of *Fagus* was established, with maximum values for the profile (Figs 2, 3). The beech belt in the region is not reflected well in the diagrams owing to the followings facts: situation of the studied peat bog at higher altitudes, a dense filter of coniferous forests, and remoteness of the beech forests. For the Western Rhodopes, the increase of *Fagus* was dated at 2070 ± 100 BP in Koupena II (Huttunen & al. 1992). The expansion of *Fagus* in the Subatlantic is documented in the pollen spectra of the northern mountain parts of Greece (Athanasiadis & al. 1993; Gerasimidis & Athanasiadis 1995). The reasons for an enhanced role of *Fagus* are probably complex, combining both the climatic and the anthropogenic factor.

In the lower parts and at smaller altitudes the slopes were covered with mixed oak forests, dominated by various species of *Quercus* and with *Tilia* and *Ulmus* as subdominants. In these forests different species of *Acer* and *Fraxinus excelsior* took part, and in the undergrowth: *Corylus*, *Cornus*, *Viburnum*, *Euonymus, Ligustrum,* etc. *Alnus* and *Salix* used to grow in the gullies and in more humid habitats. The permanent participation of the pollen of *Juglans* could be explained by its supposed cultivation by man. The registered pollen of *Carpinus oriental-*

is/Ostrya is explained by the presence of representatives of both species now spread in the area of study. Of the low shrubs *Vaccinium* and *Bruckenthalia* (Figs 2, 3) took part in the ground floor in that period.

Vegetation in the peat bogs and around them constituted chiefly of representatives of *Poaceae*, *Ranunculaceae*, *Apiaceae*, *Brassicaceae*, etc. elements characteristic of herbage. The presence of pollen of *Chenopodiaceae*, *Artemisia*, *Plantago lanceolata, Rumex*, *Achillea/Aster, Taraxacum,* and *Urtica* (Figs 2, 3) testifies to human presence in the mountain and is regarded as an indicator of ruderal communities (Behre 1981). The registered *Triticum/Avena*, *Secale* and *Hordeum* (Figs 2, 3) give rise to the assumption that arable plots existed in the mountain.

The next pollen zones ***TCH*-2** (Fig. 2) and ***CHA*-2** (Fig. 3) reflect a reduction in the participation of the tree species (AP) in general, but with values varying about 53 % and with a maximum up to 65 %. That zone registered a slight reduction of the *Picea* and *Abies* communities, while these of *Pinus* retained an almost permanent maximum participation. The presence of *Betula* showed a slight increase as compared to the previous zone. In the lower part of the mountain the mixed deciduous forests had undergone some significant changes. There was a slight drop in the values of *Quercus* and *Fagus,* which could be explained by the reduction of the beech and mixed deciduous forests in the region resulting from human interference, or to the existing coniferous filter. The participation of *Ulmus*, *Tilia* and the other components of deciduous forests was minimal (Figs 2, 3). Parallel to this, the herbaceous species (NAP) increased their presence both quantitatively and in terms of species diversity. The widest spread and maximum participation was claimed by the communities of the representatives of *Poaceae*. The presence of indicators of human presence in the mountain, such as *Chenopodiaceae*, *Artemisia*, *Plantago lanceolata, Plantago media/major, Rumex*, *Achillea/Aster, Taraxacum, Urtica,* and *Brassicaceae* showed a permanent participation in numbers. The *Triticum/Avena*-type, registered the highest values there, which presumably means an increase of the arable plots in the region. Mention deserves the unusually high percentage participation of *Colchicum,* expressed as a local maximum in the lower levels of zone ***TCH*-2** (Fig. 2). Of the local elements, in the Trigrad-Chairite peat bog a permanently high participation and maximum values in the lower levels were registered by the spores of *Sphagnum*, which corroborated the fact that the peat bog had entered a sphagnum stage of development. A notable decrease of *Cyperaceae* was registered too (***TCH*-2,** Fig. 2).

The latest pollen zones ***TCH*-3** (Fig. 2) and ***CHA*-3** (Fig. 3) reflect the latest stage of development of the vegetation pertaining to the formation of contemporary plant relations in the area of study. A drop in the participation of the tree species (AP) was marked, the pollen curve showing downslide in the upper levels and minimum values for the profile (Figs 2, 3). A general trend towards reduction of the *Pinus* and *Picea* communities in general was registered too, with the exception of a local maximum for *Picea* in the zone (***CHA*-3,** Fig. 3). The correlation of the two taxa and the above-mentioned objective laws give rise to the assumption that spruce forests prevailed in the region, which also corresponds to the contemporary situation. *Quercus*, *Carpinus betulus*, *Fagus*, *Carpinus orientalis/Ostrya*, and *Fraxinus excelsior* marked a slight increase in presence, as compared to that in the preceding zone. The increase is even more distinct for *Betula* and *Corylus* represented by their maximum values in these zones. Such an increased participation was probably due to the limited forest filter, following the reduction of coniferous forests in the region. The participation of *Corylus* could be also explained by the reduced forest filter, or by the invasion of hazel-bush in the freed terrains. The permanent presence of *Juglans* was probably related to its cultivation by man, who was very active in the Iron Age and during Roman times. The species diversity of herbaceous vegetation had strongly increased. Components typical of the composition of herb meadows prevailed. The representatives of *Fabaceae*, *Rosaceae*, *Apiaceae*, *Brassicaceae*, *Ranunculaceae*, *Lamiaceae*, *Menta, Salvia*, *Helianthemum*, *Hypericum,* etc. registered maximum participation in the zones, including *Poaceae*, which showed a slightly lower participation as compared to the preceding zones. The increase of herbaceous species was probably due to the destruction of a large part of the forests, in order to meet the economic needs of the population, to expand pasturelands and arable land in the region (Figs 2, 3).

The present palynological research has made possible the following of the impact of human activities on the vegetation in the region of the studied sites in the Late Holocene (Subatlantic). The economic activity of the population of Central Rhodopes differed in the different epochs. It mainly included destruction of forests by cutting or firing, cultivation of farm crops and rearing of domestic animals. On the more level parts vast areas were set for cattle breeding, while coniferous wood was favoured for building and as firewood. All that led to changes in natural vegetation and, hence, to changes in the deposited pollen registered and reflected in the pollen spectra.

Data from the palynological studies give rise to the assumption that the changes in forest vegetation in that region affected the coniferous and beech belts in the higher parts of the mountain. The general trend to reduction of the tree species (AP) and the higher values of the herbaceous species (NAP) in the upper levels of the diagrams, including the indicators of anthropogenic impact, could be commented on as a result of the enhanced economic activities of man (Figs 2, 3). The enhancing role of human activities in the Late Holocene (the Iron Age and the Roman times) had brought about dominance of the anthropogenic factor as a major factor in the formation of the contemporary plant communities. That anthropogenic impact is registered by the frequent fluctuations of the AP curve, owing to sharp changes in the percentage participation of the tree representatives. Parallel with this, the presence of pollen of *Triticum/Avena*-type and *Secale* was registered in most of the samples (Figs 2, 3). The presence of the pollen of *Secale* already in the lower levels of the diagram gives rise to assumptions that a developed farming already existed in the region, considering the fact that the cultivation of *Secale* in Bulgaria was related to the latest stages of development of farming. The participation of pollen of the cultivated grasses in the pollen spectra during the Iron Age and Roman times presumes the existence of farming in the mountain, greatly facilitated by the advent of iron instruments of work.

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