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Late Miocene vegetation and climate reconstruction based on pollen data from the Sofia Basin (West Bulgaria)

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Abstract

The analysis of fossil palynomorh assemblages in the Late Miocene freshwater sediments of the Sofia Basin (West Bulgaria) was done to collect data on the vegetation and climate dynamics during the Late Miocene. On the basis of pollen data, we described the main palaeocomunities developed in the region. The mixed mesophytic forests dominated the vegetation in which species of *Quercus*, *Ulmus*, *Zelkova*, *Fagus*, *Carpinus*, *Betula*, *Castanea*, *Corylus*, *Pterocarya*, *Carya*, *Juglans*, and *Eucommia* played important roles. Swamp forests were also recorded, including Taxodiaceae, *Alnus*, *Glyptostrobus*, *Nyssa*, and *Myrica*. Herbaceous vegetation was distributed in the middle part of the section, with a maximum of 35.5%. The vegetation dynamic passes through several phases, which were associated with changes in paleoclimate and palaeoecological conditions. Coexistence Approach (CA) was applied to palynological data to calculate four climatic parameters. The values of coexistence intervals for mean annual temperatures are 13.6–16.6 °C, with winter temperatures being 3.7–6.6 °C and summer temperatures being 23.6–27.8 °C. Mean annual precipitation ranged most frequently between 828 and 1308 mm. The palaeoclimatic reconstruction illustrates existence of a warm-temperate and relatively humid climate with higher mean annual temperature than the present day climate.

Keywords: Palynology; Palaeoclimate; Bulgaria; Late Miocene–Early Pliocene; Vegetation; Coexistence Approach

1. Introduction

Bulgaria is situated in a border area between the Mediterranean and Central Europe. From the palaeogeographic point of view its position offers a good opportunity for understanding the evolution of modern flora and distribution of the herbaceous vegetation as well as the climatic influence on vegetation dynamics. In the vegetation during the Late Miocene (Pontian)–Early Pliocene (Dacian) in Bulgarian flora the arctotertiary floristic elements played a dominant role and the observed trend of reduction of palaeotropical elements that had begun during the Middle Miocene still continued (Bozukov et al., 2009). These processes are well documented in the Late Miocene sediments of freshwater basins in South-West Bulgaria. The present study focuses on the Sofia Basin, in which the sediments reveal detailed information about the composition and evolution of the Bulgarian and European floras. The basin belonged to the system of lake-marsh sedimentary complexes of the Balkan Peninsula existed during the Late Miocene. Its development has a direct impact on the proximity of Beli Breg, Staniantsi, and other basins within the Sofia lake complex.

The fossil macroflora from the Sofia Basin has previously been described in several studies (Stojanoff and Stefanoff, 1929; Stefanov and Jordanov, 1935; Kitanov and Nikolova, 1956; Kitanov, 1982). Pollen analysis of the sediments was carried mainly for the biostratigraphic purposes (Kamenov and Kojumdjieva, 1983). The character and composition of the flora were discussed on the basis of macro- and microfloristic data by Drivaliari (1992), Drivaliari et al. (1999), and Palamarev et al. (1999, 2002). Pollen flora from the Sofia Basin was analysed and compared to other late Miocene floras by Jiménez-Moreno et al. (2007) based on the data from drilling materials from southeastern part of the basin (Ravno pole). In the present study we quantitatively analysed palynological data from core Katina

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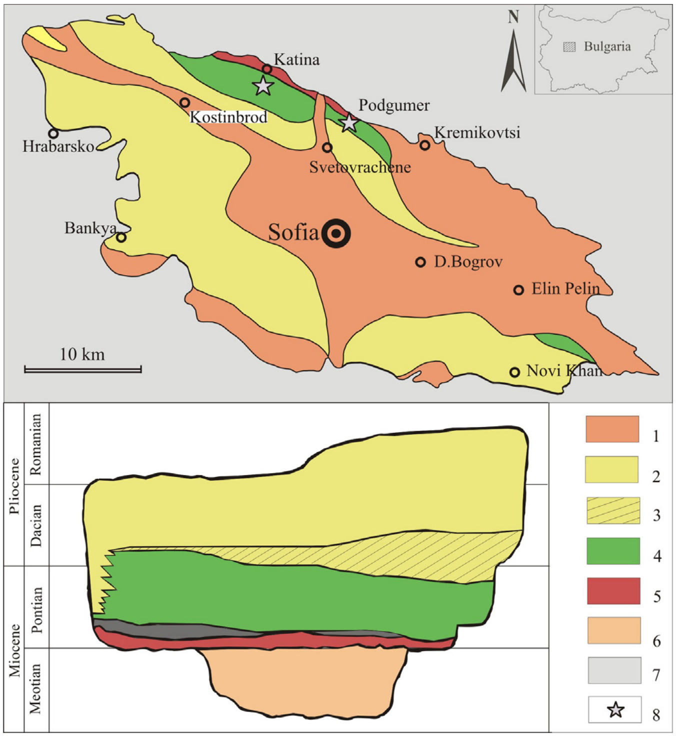

Fig. 1. The Sofia Basin — geological map and general stratigraphic section. Legend: 1, Quaternary; 2, Lozenets Formation; 3, Novi Han Member of Lozenets Formation; 4, Novi Iskar Formation; 5, Gnilyane Formation; 6, Variegated Terrigenous Formation; 7, pre-Neogene rocks; 8, location of core C-14 and outcrop PG-1 (redrawn after Kamenov and Kojumdjieva, 1983).

C-14 aiming to obtain new data for climate dynamics during the sedimentation process in West Bulgaria. This study is a part of a series of investigations into the flora, vegetation, and climate reconstruction of Southwest Bulgaria during the Neogene period (Hristova and Ivanov, 2009a,b,c, 2012; Ivanov et al., 2007a, 2008, 2012).

2. Geological settings

The Sofia Neogene Basin was formed during the Late Miocene as a large graben structure. It is situated to the south of the Stara Planina Mountain, surrounded by the Vitosha and Lulin Mountains; it is more than 80 km long and 20 km wide (Nakov et al., 2001). The substrate and shoreline of the basin are composed of Paleozoic, Mesozoic, and Paleogene rocks (Kortenski and Zdravkov, 2007; Stefanova et al., 2012). The basin is filled with Neogene sediments, lithostratigraphically devided into four subdivisions (from bottom to top): Variegated Terrigenous Formation, Gnilyane, Novi Iskar and Lozenets formations. The last three formations have been folded together into the Sofia Group (Kamenov and Kojumdjieva, 1983) (Fig. 1).

The Novi Iskar Formation extends as a broken strip along the northern rim of the basin near villages Novi Iskar, Podgumer, Dragovishtitsa, and Balsha (Fig. 1). The thickness of the formation ranges from 100 m to 350–400 m in the southern parts of the basin. It is formed of lake sediments that consisted of grey clays, diatomaceous clays, and silty clays. Based on mollusc and mammal fossil finds, the age was determinated as the Middle and Late Pontian in the southern and central parts of the basin up to the Early Dacian in the northern parts (Kamenov and Kojumdjieva, 1983; Nikolov, 1985; Angelova and Yaneva, 1998; Spassov, 2002; Kortenski and Zdravkov, 2007). The age was also confirmed by the diatom analysis (Ognjanova and Popova, 1991; Ognjanova-Rumenova et al., 2008).

3. Materials and methods

A total of 111 samples from the Late Miocene sediments of the Sofia Basin (West Bulgaria) were investigated. Seventy-five samples from borehole C-14 near the village of Katina (42°50′43″N, 23°19′10″E) and thirty-six samples from outcrop PG-1 near the village of Podgumer (42°48′77″N, 23°24′03″E) were processed and analysed. The studied sediments belong to the Novi Iskar Formation. The lithological composition of the sediments is sands, sandy clays, silty clays, diatomaceous clays, lignite, and limestone (Fig. 2).

Two samples from C-14 have a poor content of fossil pollen grains and spores (№ 69 at 260.00 m; № 70 at 262.40 m) and they were not included in the analysis. The remaining samples contain well-preserved pollen grains and spores, and reflect a varied and rich flora.

Studied materials were processed by standard methods for disintegration of Tertiary sediments (Erdtman, 1966; Faegri and Iversen, 1975). Taxonomic identifications of the fossil pollen grains and spores were based on published pollen keys and atlases with morphological information (Faegri and Iversen, 1975; Moore et al., 1991; Kohlman-Adamska et al., 2004; Punt et al., 2007; Stuchlik et al., 2001, 2002; Willard et al., 2004), and by using recent materials of the palynological collection of the section “Palaeobotany and Palynology”, Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences. The frequency of occurrence of different pollen and spores are calculated and presented in a percentage from the total pollen sum, which include the amount of arborael and nonarboreal taxa. The estimated pollen sums were based on more than 100 defined grains (Figs. 3–6). The results of the pollen analysis were plotted in spore-pollen diagrams constructed with the software TILIA 2.0.b.4 (Grimm, 1991) and TGView 2.0.2 (Grimm, 2004) (Figs. 3–6). Mathematical processing and cluster analysis were performed with CONISS (Grimm, 1987). A palynological zonation of the Late Miocne sediments of the Sofia Basin and detailed description on the basis of the most characteristic changes in the percentage abundance of the basic pollen types in the pollen spectra followed Hristova and Ivanov (2009b). Paleoclimate reconstructions are based on the Coexistence Approach method (Mosbrugger and Utescher, 1997). The number of taxa included in the analysis reached to 34. The coexistence intervals for each climatic parameter were calculated using the software ClimStat 1.02 (Heinemann, 1998–1999) and Palaeoflora Database (Utescher and Mosbrugger, 1990–2007). The analysis of pollen spectra used four main climatic parameters — mean annual temperature (MAT), mean temperature of the coldest month (CMT), mean temperature of the warmest month (WMT), and mean annual precipitation (MAP).