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Middle Miocene (Badenian) vegetation and climate dynamics in Bulgaria and Poland based on pollen data

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ABSTRACT

The Miocene represents a time in Eurasia when evergreen and thermophilous dominated Paleogene vegetation was replaced by deciduous and temperate plants. Climatically, it is the transition from a greenhouse to an icehouse world, with the middle Miocene Climatic Optimum as the last warm episode of Earth history. Processes of plant evolution, transformation of vegetation and coenotic structure were significantly forced by both, changes in the global climate system, and also by significant palaeogeographic reorganizations. To give new insight in the middle Miocene evolution of European ecosystems and climate dynamics, we compared plant assemblages from northern Bulgaria and southern Poland (southern Paratethyan and Polish Lowlands realms).
Based on palaeoecological analysis the main palaeocommunities are distinguished in hygro–hydrophytic herbaceous palaeocoenoses (reed marshes), hygrophytic forest palaeocoenoses (swamp forest and bush swamp), riparian forests, and mixed mesophytic forests. Despite some differences in taxonomic composition of these fossil floras and the proportion of individual taxa the vegetation shows similar composition and trends through time. The main trend in the vegetation dynamics is a general decrease in the abundance of palaeotropic and thermophilous elements of semi-evergreen forests. Together with these changes is a corresponding increase in the role of arctotertiary species in plant communities, and these plants became dominant in the mesophytic forests. Changes in swamp vegetation are climatically related too, but these reflect mainly local environmental dynamics and changes in inundation of the basin. Climate data from Bulgaria and Poland lack significant latitudinal climate gradient, thus confirming more or less homogenous climatic conditions within Europe in the middle Miocene.

1. Introduction

During the Miocene Palaeogene vegetation dominated by thermophilous and evergreen plants was replaced by a vegetation comprising mainly deciduous and temperate ones (Mai, 1995). The early to middle Miocene is known as the last warm episode in Earth history, prior to the transition from a greenhouse to an icehouse world. The processes of plant evolution and transformation of vegetation and coenotic structures were significantly forced both by these changes in the Earth climate and palaeogeographic reorganizations. Remarkable global and regional climatic and environmental changes took place during the particularly warm middle Miocene (17 to 15 Ma), known as the climatic optimum (MMCO), which was followed by a period with declining temperatures, evident both from the analysis of stable isotopes (e.g. Zachos et al., 2001) and palaeontological data (Böhme, 2003; Utescher et al., 2015).

The Miocene in Central and Eastern Europe was characterized by large-scale palaeogeographic changes. The collision of the Eurasian and Afro-Arabian tectonic plates resulted in the closure of the Tethys Sea in the late Eocene (Allen and Armstrong, 2008), leading to plate reorganization and oceanographic changes. The active Alpine tectonics forced the uplift of the Dinarides and Rhodope massif, Balkan and Carpathian chain, and the Caucasus (Meulenkamp and Sissingh, 2003). These new mountain chains and valleys in the context of global climatic change caused impulses of regressions and transgressions and the appearance and disappearance of lakes and swamps (Kojumdgieva and Popov, 1989; Meulenkamp et al., 1996; Rögl, 1998, 1999, 2001; Meulenkamp and Sissingh, 2003; Ilyina et al., 2004; Harzhauser and Piller, 2007; Harzhauser et al., 2007; Harzhauser and Mandic, 2008).

To give a new insight into the middle Miocene evolution of Eastern European ecosystems and climate dynamics, we compared plant assemblages from Bulgaria and Poland. From palaeogeographical point of view, the studied areas belong to the Forecarpathian and Euxinian Basins (Eastern Paratethys) and Polish Lowlands. Sections of middle Miocene (regional Badenian stage = Langhian to lower Serravalian, see Fig. 2) age from this area were analysed, comparing new information with already published data.

The geographical position of the studied sections is of great interest because these compare the north of the Central Paratethys with the

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southern part of Central/Eastern Paratethys allowing a discussion of the latitudinal differences in vegetation and climate throughout the middle Miocene.

2. Geological settings and middle Miocene basin configuration

2.1. Eastern Paratethyan domain: Forecarpathian (Dacian) and Euxinian Basins

The following summary of the palaeogeographic evolution of the Forecarpathian Basin is largely based on data presented by Kojumdgieva et al. (1989) and Ivanov et al. (2002). During the early Miocene northwest Bulgaria was a continental area and no sediments are known from this time period. The beginning of the middle Miocene is characterized by a large marine transgression flooding most of northwest Bulgaria representing the oldest Neogene deposits in the Forecarpathian Basin. During this stage, the flooding of the Forecarpathian Basin had a maximum extension (Fig. 1), covering the territory of northwestern Bulgaria to the south (the so-called Dacian Gulf of Forecarpathian Basin) (Kojumdgieva and Popov, 1989; Rögl, 1998; Ivanov et al., 2002). Furthermore, the basin continued to the west through the territory of Serbia, thus providing a marine connection between the Vienna–Pannonian Basin and the Central Paratethys (Fig. 1). Due to the existing seaway between the Forecarpathian and Pannonian Basins at this time (Rögl, 1998) facies and fossil content of the sediments of both basins are quite similar. Hence, the stratigraphic scheme of the Pannonian basins can also be used in the Forecarpathian study area (Kojumdgieva and Popov, 1986). Regression and isolation of the basin took place at the end of the Badenian stage, caused by the uplift of the Carpathian Mountains, which coincided with a retreat of the sea from the territory of NW Bulgaria before the end of the Badenian.

The Neogene sediments of the Varna–Dobrogea Bay of the Euxinian Basin in NE Bulgaria, their palaeogeography and evolution of the basin during the Miocene are relatively well known (see Ivanov et al., 2007 and references therein). The Euxinian Basin played an important role in connecting basins during the Miocene, providing seaways between the eastern and central parts of the Paratethys (Fig. 1) throughout the Black Sea Basin (Rögl, 1998). The brief description of the geology and palaeogeographic evolution of the area presented here is based on data published by Kojumdgieva (1983), and Kojumdgieva et al. (1989). During the early Miocene, NE Bulgaria, similarly as the northwestern area, was exposed, and no sediments are known from that time. A tectonics-controlled reorganization at the end of early and earliest middle Miocene in the Eastern Paratethys resulted in the emergence of the Greater Caucasian archipelago (Meulenkamp and Sissingh, 2003), followed by a transgression in the territories west of the Black Sea, reaching the Varna–Balchik area. At the beginning of the Tshokrakian time (~15 Ma) a regression caused a separation of the Ponto-Caspian area from the open oceans (Rögl, 2001), thus leading to the appearance of brackish conditions. A new transgression took place in the Karaganian (=latest Langhian–earliest Serravallian), when marginal areas were flooded, indicated by sandy and calcareous sediments.

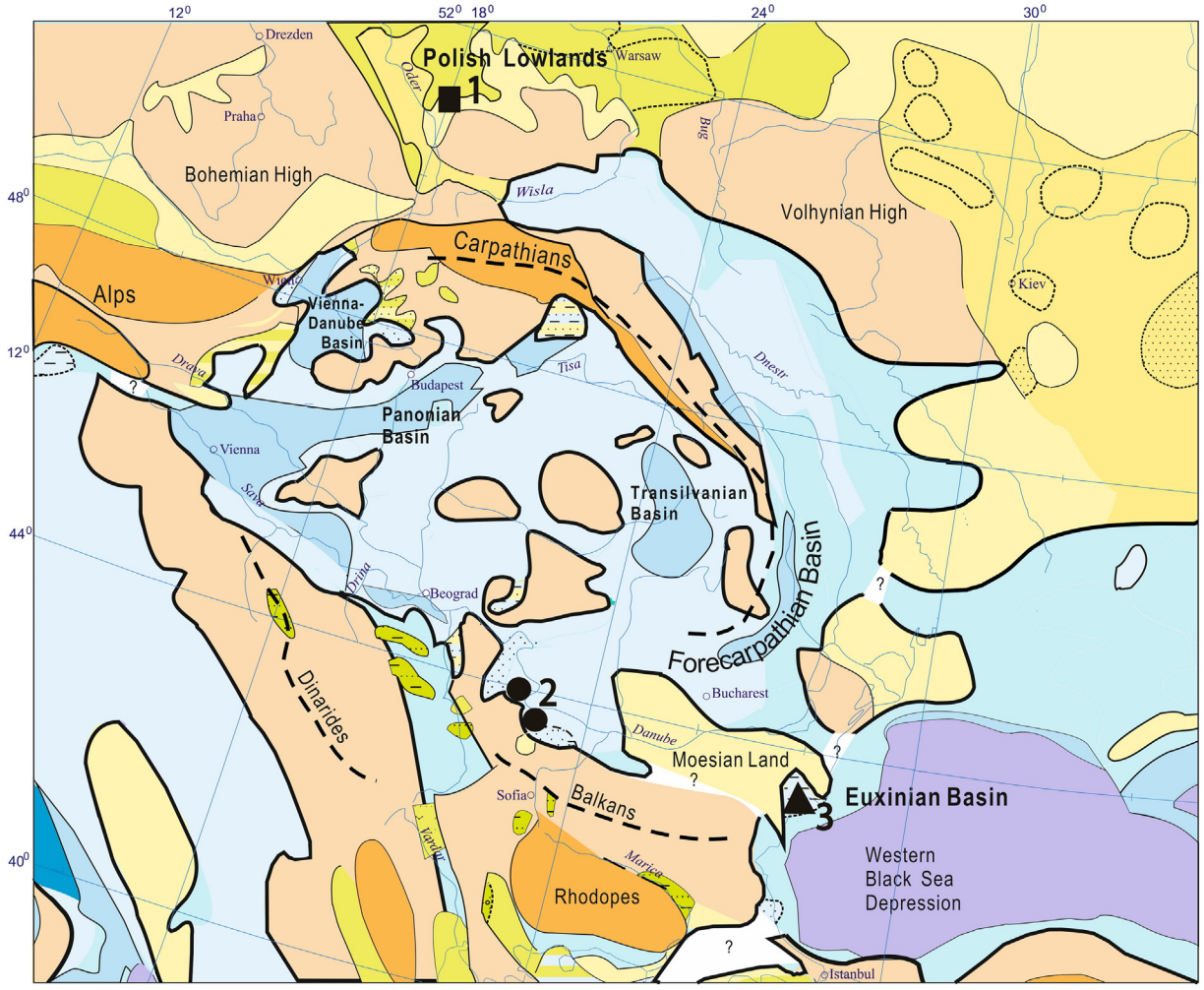

Fig. 1. Palaeogeographic map of the studied area for the middle Miocene and location of the sites: 1. Poland: Legnica; 2. Bulgaria: Forecarpathian Basin; 3. Bulgaria: Euxinian Basin. Redrawn from Ilyina et al. (2004), simplified.

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