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Research paper

A 30,000-year pollen record from Mire Kupena, Western Rhodopes Mountains (south Bulgaria)

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ABSTRACT

A palynological study was performed on a 2 m thick sediment sequence recovered from Mire Kupena (1356 m), a former lake in the Western Rhodopes Mountains (south Bulgaria) and supported by radiocarbon dating. The record extends back to ca. 30,000 cal. yrs. BP (Middle Pleniglacial) when the study area was occupied by wooded steppe composed of *Pinus* sp., *Pinus peuce*, some *Betula*, *Juniperus*, and cold-tolerant herb vegetation dominated by *Artemisia* and Chenopodiaceae. In addition, the almost continuous presence of deciduous *Quercus*, *Tilia*, *Corylus*, *Abies*, *Picea*, *Fagus*, *Alnus*, and *Carpinus betulus* pollen suggests interstadial conditions and this area could be recognized as a montane refugial place. A reconstruction of the interval between ca. 24,000 and 15,000 cal. yrs. BP was not possible due to an extremely low sediment accumulation rates or, more likely, a hiatus. The lateglacial landscape was dominated by mountain-herb steppe vegetation with isolated stands of *Pinus*, *Betula* and shrubland of *Juniperus*. The afforestation in the Early Holocene started with broad-leaved forests composed of *Quercus* with *C. betulus*, *Carpinus orientalis*/*Ostrya*, *Ulmus*, *Tilia* and *Corylus* and minor amounts of *Pinus*, *Betula* and *Abies*. In the Late Holocene (<ca. 4700 cal. yrs. BP) *Fagus* began to gain importance chiefly at the expense of the mixed oak forests, while after ca. 2000 cal. yrs. BP forests of *Pinus sylvestris* with some *P. peuce* quickly expanded around the mire. A comparison with other long palynological records from the mountains and lowlands of Bulgaria and in northern Greece reveals not only common trends in the vegetation development that are a reflection of the climate changes, but also site-specific features related to the location and topography of each site.

1. Introduction

The location of Bulgaria in the middle part of the Balkan peninsula creates a high diversity of modern vegetation, topography and climate conditions, and provides encouraging possibilities for investigations of past changes in vegetation and climate and the impact of humans. In recent years abundant paleoecological information since the termination of the last glaciation has been collected from terrestrial sites with relatively consistent chronological control in the Rila (Bozilova and Tonkov, 2000, 2011; Tonkov et al., 2008, 2011, 2013a) and northern Pirin mountains (Tonkov et al., 2002; Stefanova and Ammann, 2003; Stefanova et al., 2006a,b; Marinova and Tonkov, 2012), and the Thracian lowlands (Magyari et al., 2008; Connor et al., 2013). These studies revealed the basic stages and trends in vegetation development, climate fluctuations, possible location of refugia, tree migrations, and patterns of human impact and they have also enriched our knowledge about the important role of the Balkans as one of the key areas for the postglacial plant recolonization of Europe (Lang, 1994; Willis, 1994; Bozilova et al., 1996; Tzedakis, 2004; Jalut et al., 2005; Magri et al., 2006; Tzedakis, 2009; Fletcher et al., 2010; Tzedakis et al., 2013).

In the context of the above-mentioned palynological and paleoecological studies in Bulgaria a particular role is assigned to the Rhodopes Mountains, a vast massif located in the southern part of the country, with an extension to northern Greece. It is thought that this area was not glaciated during the Quaternary (Vlaskov, 2002) where a number of plant species have survived the northern hemisphere glacials. Until now, indications in support of this hypothesis were obtained from continuous pollen profiles of lateglacial age collected from mires and peatbogs in the Biosphere Reserve Kupena (Bozilova et al., 1989; Huttunen et al., 1992) and the Shiroka Polyana locality (Filipovitch and Lazarova, 2003; Stefanova et al., 2006a). The influence of the periglacial climate with low temperatures and insufficient precipitation resulted in the distribution of herb mountain-steppe vegetation dominated by *Artemisia*–Chenopodiaceae–Poaceae and other cold/dry-tolerant species at altitudes between 1000 and 1300 m, and stands of *Pinus*, *Betula* with

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shrubland of *Juniperus–Ephedra*. The results suggest that during the Lateglacial these areas sheltered a number of deciduous (*Quercus*, *Carpinus betulus*, *Acer*, *Fagus*, *Corylus*, etc.) and coniferous (*Pinus*, *Abies*, *Picea*) trees in places where the local microclimatic conditions favored their growth and reproduction (Bozilova et al., 2011).

In an attempt to extend the paleoecological evidence from the Rhodopes Mountains beyond the Lateglacial a new sediment core from Mire Kupena was collected and the preliminary palynological information indicated Middle Pleniglacial age (Tonkov et al., 2013b). This paper presents in more detail the development of the vegetation and climate changes in the study area during the last ca. 30,000 years and compares the results with other long pollen profiles from sites in Bulgaria and northern Greece that are supported by reliable chronological frameworks.

2. The study area

2.1. Physico-geographical characteristics and modern vegetation

The Rhodopes Mountains are a large massif, approximately 240 km W–E and 100 km N–S, which occupy 14,730 km^2 in South Bulgaria and 3270 km^2 in Northern Greece. It is divided into the Western Rhodopes (8732.1 km^2), with the highest peak Goljam Perelik (2191 m), which is characterized by vast level stretches that are most prominent in the interior parts at 1500 m a.s.l., and the Eastern Rhodopes (1463 m), which is characterized by wide valleys and short ravines. The slightly inclined, typical wide valleys are crossed by meandering rivers and streams. Geologically, the core of the mountains is a large granite pluton covered by metamorphic rocks (gneisses, schists and marble) of Paleozoic and pre-Paleozoic ages. The contemporary relief of the Western Rhodopes was shaped during the Neogene–Quaternary when the rising vault was broken into large blocks by numerous faults. Some of these blocks subsided and formed intermontane structural basins (Galabov et al., 1977). During the Quaternary the highest parts above 2000 m were under the influence of periglacial processes (Vlaskov, 2002).

The climate of the Western Rhodopes is a montane variant of the Transitional Continental type. The mean annual air temperature is 5 °C–10 °C at 1000 m a.s.l. with mean January temperatures below 0 °C, while the mean July temperature depends on the altitude. The mean annual precipitation is 600–800 mm with a maximum in May–June and a minimum in August–September. A Mediterranean influence is more clearly expressed in the southern parts. The northern slopes of the mountains are in a precipitation shadow and the amount of annual precipitation is less than in the interior parts (Velev, 2002). The basic soil types are brown forest (60%) up to 1700–1900 m, cinnamomic-forest (up to 800 m), humic-carbonate and mountain-meadow on the highest parts (Ninov, 1997).

According to the most recent geobotanical division of the country the Western Rhodopes Mountains are recognized as a separate region characterized by vast distribution of coniferous forests dominated by *Picea abies* (L.) Karst. and *Pinus sylvestris* L. (Bondev, 2002). The deciduous forests occupy areas at lower altitudes predominantly in the eastern and northern parts. They are composed mainly of *Quercus dalechampii* Ten. with occasional presence of *Quercus frainetto* Ten. and *Quercus cerris* L. on south-facing slopes. Mixed forests of *Q. dalechampii*, *Fagus sylvatica* L., *Carpinus betulus* L. with participation of *Ostrya carpinifolia* Scop. occur in the valleys. Quite often mixed coniferous–deciduous communities are also found. The present-day vegetation composition has, in many places, been influenced by grazing herbivores, cultivation of potatoes and crops, timber production and more recently an increase in the intensity of touristic activities.

2.2. Study site

Mire Kupena is a former lake (41° 59′ 07.5″ N, 24° 19′ 05.1″ E; 1356 m a.s.l.) found on the territory of the Biosphere Reserve Kupena in the Western Rhodopes Mountains (Fig. 1). The reserve is located between 600 and 1400 m a.s.l. on a north-facing slope and occupies an area of 1086.4 ha. Its present vegetation is rather diverse. The lower parts are dominated by plant communities of *Quercus dalechampii* mixed in some places with *Carpinus betulus*, *Fagus sylvatica*, *Pinus nigra* Arn. and *Pinus sylvestris*. Higher up, plant communities of *F. sylvatica* dominate, followed by those of *P. sylvestris* with some *Abies alba* Mill and *Picea abies*. Stands of *P. abies* are also found. The mire formed in a depression and covers an area of 6 ha, fed by precipitation and surface runoff. During spring the water depth can increase to 50 cm due to rapid snow melt. The mire is surrounded by an almost pure forest of *P. sylvestris* with an admixture of *P. abies*, *A. alba*, *F. sylvatica*, *Betula pendula* Roth., *Sorbus aucuparia* L., *Q. dalechampii* and an undergrowth of *Juniperus communis* L., *Vaccinium myrtillus* L. and *Vaccinium vitis idaea* L. The mire vegetation is represented by sparse moss cover of *Sphagnum angustifolium* (C. Jens. ex Russ.) C. Jens., *Sphagnum platyphyllum* (Lindb. ex Braithw.) Sull. ex Warnst., *Sphagnum subsecundum* Nees in Sturm and herbs like *Carex riparia* Curt., *Carex nigra* (L). Rchb., *Carex acuta* L., *Carex echinata* Murr., *Eriophorum angustifolium* Honck., *Galium palustre* L., *Juncus effusus* L., *Juncus conglomeratus* L., *Potentilla erecta* (L.) Rausch., *Potentilla palustris* (L.) Scop., *Ranunculus repens* L., etc. During the last two decades most of the mire hummocks have been overgrown by pine trees (Huttunen et al., 1992; Tonkov et al., 2013b) (Fig. 2).

3. Material and methods

3.1. Sediment core and lithology

The new core Kupena-3 was collected with a Dachnowsky hand corer from the peripheral open northeastern part of the mire in 2009 (Fig. 2). The coring was aborted at a depth of 200 cm because it was not possible to penetrate the underlying strata. The lithology of the sediments of all three cores from this site is presented in Table 1. The cores Kupena-1 and Kupena-2 were retrieved from the central part of the mire about 50 m from each other (Huttunen et al., 1992).

3.2. Pollen analysis

Sampling for pollen analysis was carried out at 5 cm intervals. The laboratory treatment of the samples followed the standard acetolysis procedure (Faegri and Iversen, 1989) after removal of siliceous material with HF acid (Birks and Birks, 1980). The pollen sum (PS) used for percentage calculations was based on AP (arboreal pollen) + NAP (non-arboreal pollen), excluding spores of mosses and pteridophytes, and pollen of aquatics and Cyperaceae. Their presence was expressed as percentages of the PS. The average number of pollen grains (PS) counted per sample from the clay/sandy clay sediments (70–200 cm) was 400–520 and 900–1100 from the uppermost 70 cm of peat and clay. The identifications of spores and pollen were made using reference collections, the keys in Beug (2004), Faegri and Iversen (1989) and Moore et al. (1991). For calculations and construction of the pollen diagram (Fig. 3a and b) the program TGView version 2.0.2 was applied (Grimm, 2004). The delimitation of the boundaries of the local pollen assemblage zones (LPAZ) was promoted by CONISS (Grimm, 1987) in an attempt to correlate the zones with those identified in a previously studied core from this site, Kupena-2 (Huttunen et al., 1992) (Fig. 4).

3.3. Radiocarbon dating

The radiocarbon age of 6 bulk sediment samples was determined in the Radiocarbon Dating Laboratory at the University of Lund, Sweden. The calibration (95.4% probability) was performed with the OxCal v4.1 program (Bronk Ramsey, 2011) and the IntCal13 calibration data (Reimer et al., 2013). The results and the mean values are shown in Table 2. The radiocarbon dates from the cores Kupena-1 and Kupena-2