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A 9000 year record of cyclic vegetation changes identified in a montane peatland deposit located in the Eastern Carpathians (Central-Eastern Europe): Autogenic succession or regional climatic influences?

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ABSTRACT

We present a high-resolution, continuous plant macrofossil remains record complemented by a pollen sequence from Tăul Muced bog, in the Eastern Carpathian Mountains (Romania). The record spans the last 9000 years and we test whether peatland development in the Eastern Carpathians is linked to climate change or to autogenic succession. We find that *Sphagnum magellanicum* was the dominant peat-forming species for ca. 8000 years but we also identify ten phases of increased representation of *Eriophorum vaginatum* at approximately 8100, 7550, 6850, 6650, 5900, 4650, 3150, 1950, 1450, and 750 cal yr BP. Visual inspection and wavelet analysis show that the episodic increases in the relative abundances of *Eriophorum vaginatum* were simultaneous with decreased abundances of *Sphagnum magellanicum* and *Sphagnum angustifolium*. Comparison with published palaeoclimatic records in this region suggests that these cyclical successions of *S. magellanicum* and *E. vaginatum* appear to be primarily a result of climate changes, with *E. vaginatum* developing mainly during dry phases and *S. magellanicum* during wetter periods. We therefore suggest that the development of this peatland was largely influenced by changing climatic conditions, although the role of autogenic plant succession cannot be excluded. Our results show the value of ombrotrophic peat deposits as archives of past climate change.

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1. Introduction

Ombrotrophic peatlands (peatlands fed entirely by precipitation) are habitats for a range of rare species and play an important role in the maintenance of biodiversity. Many of these peatlands are designated as protected areas, but knowledge of the rate and nature of their long-term development, and their response to past climate change is often limited. Pristine ombrotrophic montane peatlands exist in the Eastern Carpathians, and because these peatlands have not been subjected to drainage, forest clearance, and peat exploitation, they represent reliable archives for the history of local vegetation development and peat accumulation. This is of particular significance for the reconstruction of local vegetation development and its response to climate changes, given that in many areas of the world natural peat dynamics has been profoundly affected by anthropogenic influences. Two main hypotheses are used to explain the causes of vegetation changes on peatlands: i) local vegetation dynamics resulting from regional climate changes (Barber, 1981; Mauquoy and Barber, 1999; Barber et al., 2004; Schoning et al., 2005; Charman et al., 2006) and ii) local vegetation changes related to autogenic vegetation successions within the peatland (Osvald, 1923; Kulczyński, 1949). However, paleoecological studies from North-western and Northern Europe, and in Patagonia showed that peatland development cannot be fully explained by either of these hypotheses (Loisel and Yu, 2013; Swindles et al., 2012; Tuittila et al., 2007), especially when detailed stratigraphic studies have been conducted (Walker and Walker, 1961). High-resolution plant macrofossil remains analyses of peat sequences in mountain areas were also performed in the Swiss Alps (van der Knaap et al., 2011) and the Schwarzwald, SW Germany (Hölzer, 2010); however, only the most recent peat layers (the last ca. 1000 years) were analysed. Multi-proxy studies of montane raised peat bog deposits (pollen, macrofossils, testate amoebae, and peat characteristics) were conducted in

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the Krkonoše Mountains (Speranza et al., 2000) and Hrubý Jeseník Mountains, Czech Republic (Dudová et al., 2012). At these sites, *Sphagnum* species such as *S. magellanicum*, *S. russowii* and *S. fuscum*, and *Eriophorum vaginatum* played a dominant role during local plant succession.

Despite their excellent preservation, the Eastern Carpathian ombrotrophic bogs have not yet been used for the reconstruction of local vegetation development or for understanding the processes leading to their formation. To fill this gap, we reconstruct for the first time the local vegetation dynamics of a mountain-raised bog in the Eastern Carpathians based on contiguous, high-resolution plant macrofossil remains analyses. We evaluate if regional climate changes had a stronger influence on the development of small ombrotrophic mountain peatlands in this region or if the local autogenic succession was more important. Our temporal perspective and high- resolution, contiguous sampling approach allows the identification of the time of the appearance, expansion, and retraction of local plant taxa. Furthermore, our results have implications for understanding the response of mires to past hydroclimate changes and demonstrate the potential of peat records as valuable proxies of past climates.

1.1. Study site

The study site is located in the Rodna National Park and Biosphere Reserve, in the Rodna Mountains, Eastern Carpathians, Romania (Fig. 1). The study area has a moderate, temperate continental climate with Atlantic and Baltic influences (Donita, 2005). Mean annual temperature is ca. 5 °C and annual precipitation is ca. 1400 mm, with the highest rainfall in the summer and the lowest in winter. The regional vegetation is composed of Norway spruce (*Picea abies*) forest (Feurdean et al. 2015). Marked deforestation is ongoing in the region, but not in the immediate vicinity of the bog. The study site, Tăul Muced (47°34′26″N, 24°32′42″E; 1360 m a.s.l.; 2 ha) is an ombrotrophic raised bog, and 0.5 ha of its total surface has the status of scientific reserve category Ia IUCN (Management Plan of Rodna Mountains National Park). The site is surrounded by almost mono-dominant *Picea abies* forest, which also covered the bog itself alongside with patches of dwarf pine (*Pinus mugo*). The moss communities in the central part of the cored peatland are dominated by *Sphagnum russowii* and *S. magellanicum*, whereas *S. girgensohnii* and *Vaccinium myrtillus* are dominant on the hillsides. There are no distinctive hummocks and hollows at the coring point.

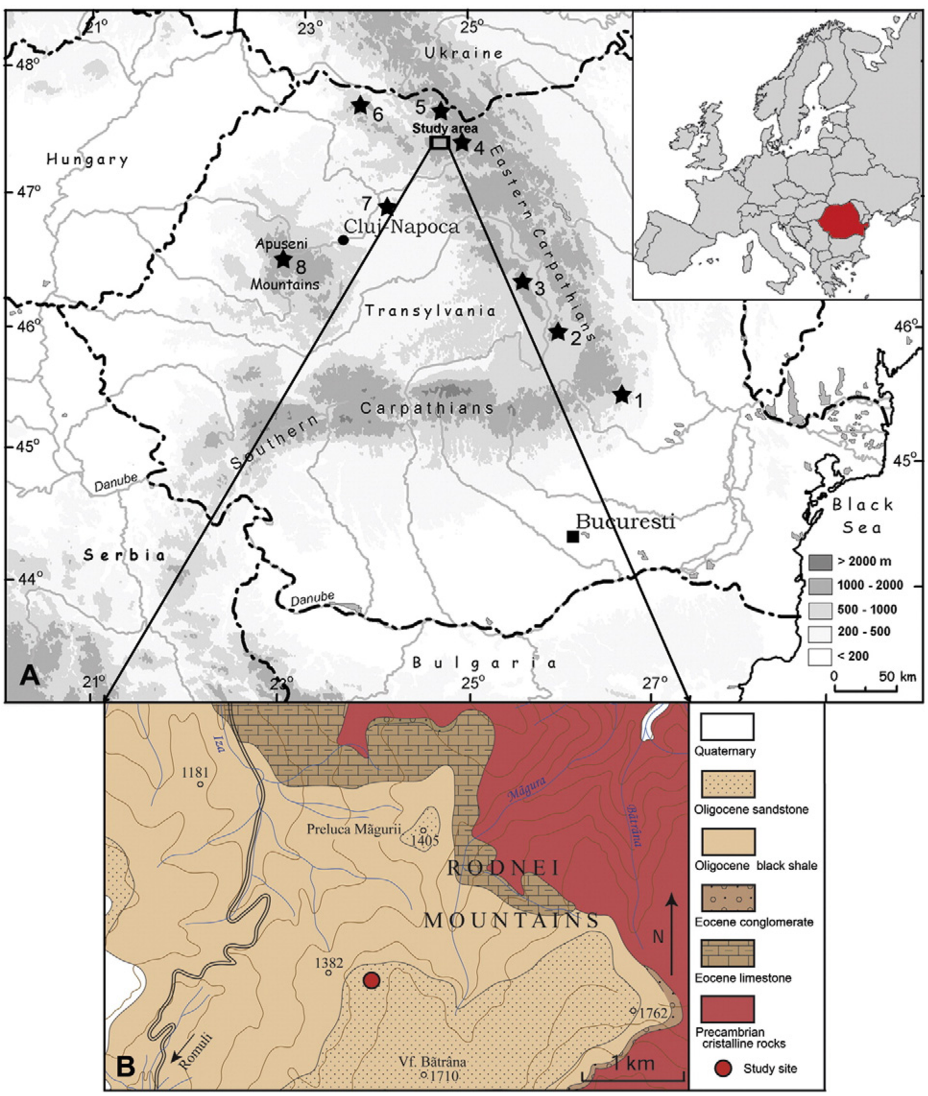

Fig. 1. A. Location map of the study site in the Romanian Carpathians and of the most relevant sites used for comparison: 1) Bisoca (Tanţău et al., 2009); 2) Sfanta Ana (Magyari et al., 2009); 3) Luci (Tanţău et al., 2014b); 4) Gărgălău (Tanţău et al., 2014a) and Poiana Ştiol (Tanţău et al., 2011; Feurdean et al., 2016); 5) Fenyves-tetö (Schnitchen et al., 2006); 6) Steregoiu (Björkman et al., 2003) and Preluca Tiganului (Feurdean 2005); 7) Lake Stiucii (Feurdean et al., 2013); and 8) Ic Ponor (Grindean et al., 2015) Molhasul Mare and Calineasa (Feurdean et al., 2009). B. Location map of the studied site in the western part of Rodnei Mountains (Sahy et al., 2008).

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