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Research paper

Erosion or plant succession — How to interpret the presence of arbuscular mycorrhizal fungi (Glomeromycota) spores in pollen profiles collected from mires

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ABSTRACT

The spores of arbuscular mycorrhizal fungi (AMF), microorganisms which occur belowground, are recognized as important indicators of erosion in palaeoecological reconstructions. In this study, the indicative value of the AMF was examined in peat deposits. A combination of palaeoecological methods, involving loss on ignition (LOI) and palynological analysis, and mycological techniques, including the assessment of AMF colonization of roots and AMF trap cultures, was used. A layer with abundant AMF spores parallel to other erosion indicators was thereby examined. The results clearly proved that the application of AMF spores as erosion indicators in peat deposits is highly questionable because the spores may have been produced by mycorrhizal mycelia related to AMF host plants whose roots have grown into the layer where the deposits lie. Nonetheless, AMF should still be considered as important markers of episodes of higher downwash in continuous lacustrine sediments.

1. Introduction

Fossil fungal spores and other non-pollen palynomorphs (NPPs) that are commonly found in pollen preparations are powerful environmental proxies in palaeoecological investigations, even if their potential has not yet been fully explored (van Geel et al., 2011). Among fungi important for palaeoecological reconstructions are arbuscular mycorrhizal fungi (AMF), known in palynological nomenclature as type HdV-207 (van Geel, 1986; van Geel et al., 1989), type HdV-1103, type UG-1291 (East African types; Gelorini et al., 2011; van Geel et al., 2011), *Glomus* cf. *fasciculatum* (Anderson et al., 1984; Mauquoy and van Geel, 2007) or *Glomus* sp. (van Geel et al., 1989; Ejarque et al., 2009; Gelorini et al., 2011). The fact that AMF sporulate below the ground has made them an important indicator of soil erosion, especially when their spores (chlamydospores) are present in lacustrine deposits (e.g. Anderson et al., 1984; van Geel, 1986; van Geel et al., 1989; Bos et al., 2005; Argant et al., 2006; Marinova and Atanassova, 2006; Kramer et al., 2009; Di Rita et al., 2010; Gauthier et al., 2010; López-Merino et al., 2010; Gelorini et al., 2011; van Geel et al., 2011) or to a lesser degree in coastal marsh (Kouli, 2012) and fen peat (Ejarque et al., 2010; Wieckowska et al., 2012). However, the presence of AMF in non-lacustrine deposits seems to be more complicated because there is the possibility of the local occurrence of AMF host plants and thus the production of spores by the mycorrhizal mycelia may occur. Mauquoy and van Geel (2007) reported that *Glomus* spores might be common in various types of (non-oligotrophic) peat deposits. Chmura et al. (2006) considered them as indicative for a low water table in Everglades ecosystems. Similarly, Ejarque et al. (2009) linked the presence of *Glomus* sp. with a low water table during peat deposition in a layer spanning the medieval period in the Pradell fen in eastern Pre-Pyrenees. The presence of higher values of *Glomus* sp. in other fens, in the eastern Pyrenees, was also interpreted as an effect of increasing soil erosion (Ejarque et al., 2010). This is where interpretational difficulties may appear when terrestrial or telmatic deposits (i.e. these from rich fens) are analyzed, because a parallel strong inflow of allochthonous matter is recorded. In this study, we carried out experimental research, aimed at examining the origin of AMF spores preserved in peat sequences from sites affected by inwashed inorganic material. Our hypothesis states that the presence of AMF spores is mainly a result of the sporulation of modern fungi which live in symbiosis with plants overgrowing the mire. To examine this hypothesis, conventional palaeoecological methods were used. These include loss on ignition (LOI) as an indicator of the input of inorganic material during peat deposition (e.g. Speranza et al., 2000), along with palynological analysis as a method for assessing the frequency and concentration of spores. These methods were combined with mycological techniques. Firstly, the assessment of the AMF colonization of roots was used as a method for detecting the presence of AMF in the fen. Secondly, AMF trap cultures were carried out to detect viable AMF

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propagules and to multiply the fungal spores to facilitate species identification (Smith and Read, 2008).

2. Materials and methods

2.1. Site description

Our study was undertaken in a small rich fen measuring <1 ha (40 m long and 24 m wide), which developed in a depression formed at the foot of a landslide head scarp in the Beskid Sądecki Mts. (Western Outer Carpathians, Fig. 1). This mountain range is built of flysch rock of the Magura Unit (Nappe) (Chrząstowski et al., 1995). The landslide was formed in the upper segment of the Łomnicka stream valley, in thick bedded Magura sandstones, and this process was successively stimulated by erosion of the Łomnicka stream (Margielewski, 1997; Margielewski et al., 2011). The mire is situated within the Jesionowa pasture–hamlet in a beech–fir (*Fagus–Abies*) forest belt, consisting of common beech (*Fagus sylvatica* L.) slightly combined with silver fir (*Abies alba* Mill.). There is also a small *Betula pendula* Roth woodland and a vast forest clearing adjacent to the site. Wetter sections of the fen surface are overgrown by *Scirpus sylvaticus* L., *Eriophorum angustifolium* Honck., *Carex flava* L., *Typha latifolia* L., *Juncus bufonius* L., *Juncus articulatus* L. em. K. Richt., *Caltha palustris* L. and *Equisetum fluviatile* L. In drier sections of the mire there are also species characteristic of mown meadows and/or pasturelands e.g. *Ranunculus repens* L., *Briza media* L., *Potentilla erecta* (L.) Hampe, *Luzula luzuloides* (Lam.) Dandy & Wilmott, *Mentha arvensis* L., *Lychnis flos-cuculi* L., *Lysimachia nummularia* L., *Lathyrus* sp. and *Alchemilla* sp. The top sections of the fen are overgrown by *Epipactis palustris* (L.) Crantz and *Mentha longifolia* (L.) L. The latter species forms a homogenous patch close to the place of drilling (Margielewski et al., 2011). Plant nomenclature follows Mirek et al. (2002).

2.2. Fieldwork

The cores were collected in September 2009 from the sector previously identified as the place where the bedrock was located deepest (49°28′614″N, 20°44′944″E; 866 masl, Fig. 1). Both sequences were retrieved using an INSTORF sampler (Russian type), and labeled Jesionowa 1a (diameter 5 cm) and Jesionowa 1b (diameter 7 cm). The distance between both coring points did not exceed 40 cm.

The plant material selected to analyze the colonization by arbuscular mycorrhizal fungi (AMF) of the vascular plant roots which overgrow the fen was collected in October 2011. Three species of the families and genera that usually form arbuscular mycorrhiza (AM) (Wang and Qiu, 2006; Dickson et al., 2007; Zubek et al., 2008, 2011a,b, 2012; Zubek and Błaszkowski, 2009) were selected for the study: *Lysimachia nummularia* (Primulaceae), *Mentha longifolia* (Lamiaceae) and *Ranunculus repens* (Ranunculaceae). Root systems were excavated intact, up to a depth of 30 cm, in the near-vicinity (up to 1 m) of the coring location. From each plant species, five replicate samples were collected. The roots were placed in 50% ethanol and transported to the laboratory.

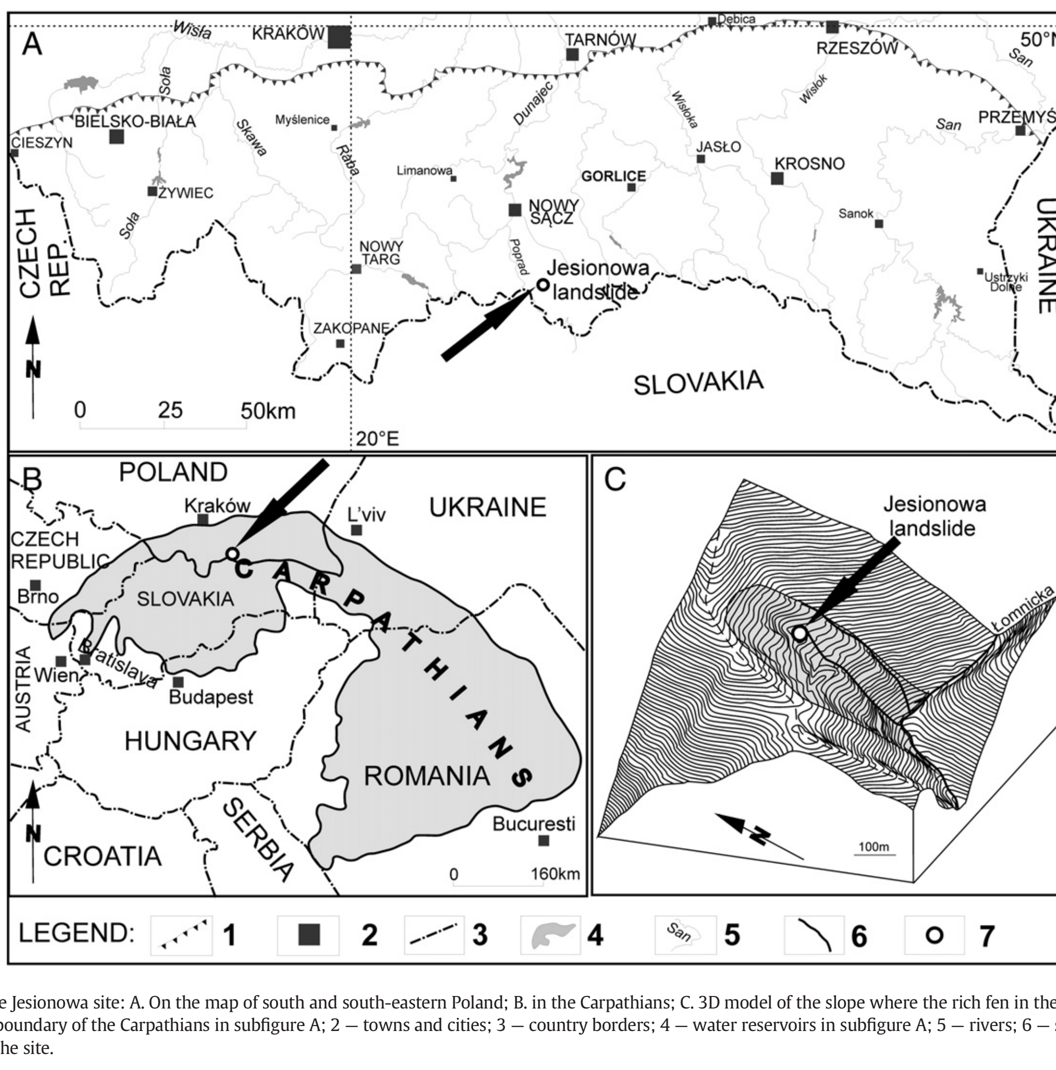

Fig. 1. Location of the Jesionowa site: A. On the map of south and south-eastern Poland; B. in the Carpathians; C. 3D model of the slope where the rich fen in the Jesionowa landslide is situated: 1 — north boundary of the Carpathians in subfigure A; 2 — towns and cities; 3 — country borders; 4 — water reservoirs in subfigure A; 5 — rivers; 6 — streams in subfigure C; and 7 — location of the site.