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SIMPLE GEOCHEMICAL CHARACTERISTICS OF PEAT IN RECONSTRUCTING PEATLAND HISTORY

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SUMMARY

Thanks to their unique physical, chemical and biological properties, peat deposits are considered archives of past hydrological and vegetational changes on the peatland and in its surroundings. To infer about such changes palynomorphs and macrofossils are frequently used as biomarkers. Yet there are several drawbacks of this approach, making easy to obtain geochemical parameters of peats a worthy alternative. Results obtained with geochemical parameters used in this study were in good agreement with macro- and microfossil record. Therefore, even such simple features of peat can be potentially used as markers of paleoenvironmental changes.

KEY WORDS :peat, geochemistry, paleoenvironment

INTRODUCTION

Paleoecological archives, name frequently used for peat deposits, seems to be well deserved. These quaternary sedminets can register and store information on events and proccesses that took place on the peatland or in its surroundings. Moreover, peats provide records of vegetation changes and water regime modifications, which in turn can be results of plant succession, drainage system alterations or even climate changes (Tobolski, 2000, 2004 and 2007; Blackford, 2000; Blackford and Payne, 2008). Undisturbed peat deposit is characterised by chronological order of layers, which consist of plant biomass of autogenous origin. These features enable determination of younger and older layers and reconstruction of subfossil plant communities. Plants are recognised on the basis of their macrofossil remains, which thanks to unique properties of peat are ussually well preserved. High saturation with water and low condensation of oxygen combined with low pH value, occurrence of tannins and poorly developed microflora and mesofauna, make peat deposits ideal media for storing organic remains of various organisms. Besides plant macrofossils, which constitute main part of the sediment, peat comprises also micorfossils, such as palinomorphs (pollen and spores), used in reconstruction of vegetation history and sediment dating, remains of protists, fungi and animals, e.g. testate amoebes, desmids or copepods (Tobolski, 2000; Blackoford, 2000). However, proper identification of fossilized material is laborious and can be performed only by a specialist. Furthermore, some of the species used as markers have quite broad ranges of ecological tolerance, which makes them very rough indicators of habitat transformation (Hugues *et al*., 2006). Last but not least, in many cases correct identification of plant remains is impossible due to high decomposition degree of peats. Considering these facts, additional markers are needed, and as such geochemical parameters describing decomposition and humification degree and lipid profile of peat become nowadays more frequently used. The aim of this study was to check the applicability of simple, easy to analyse geochemical features of peat to reconstruct past climatic changes.

MATERIALS AND METHODS

From six peatlands of different origin peat cores were taken with the use of an Instorf sampler. Samples from each distinct layer were collected and analysed. Organic matter properties of the samples were examined by measuring decomposition degree (Okruszko, 1974), humic substances content, including humic and fulvic acids content and $E_{4/6}$ ratio(humic substances absorbance at 465 λ to their absorbance at 665 λ) (Kononova 1968, Baran, 2002), total lipids content, non-hydrolysable lipids content and by conducting standard geochemical analyses - pH value, ash content, total nitrogen content (Ostrowska et al., 1991; Sapek and Sapek, 1997). Acquired data were compared with literature presenting complex information on palinological and macrofossil analyses. For purposes of comparison, peat cores were synchronized according to layers which occur uniformly through whole cross-section of peatland.

RESULTS

In this article results are presented on an example of a raised bog which developed in a valley of a mountain stream in the Western Sudetes, south-west Poland. Surface of the bog is covered with *Sphagnum* moss, tussock cottongrass and plants from *Ericaceae* family. It is encircled with a belt of dense dwarf pine thickets. The bog formed through paludification at the end of the Boreal period. High water level was maintained by the inflow of waters of a nearby stream, which additionally deposited there mineral sediments.

Tab.1 Stratigraphy of the raised bog nad Jagnięcym Potokiem, the Western Sudetes, Poland.

Bog	Depth (cm)	Layer	Peat species
nad Jagnięcym Potokiem	0-10	0	remains of *Sphagnum*, cottongrass and *Ericaceae* plants
	10-60	1st	hummock *Sphagnum* peat
	150-200	2nd	hummock *Sphagnum* peat
	270-320	3rd	hollow *Sphagnum* peat
	350-400	4th	cottongrass – *Sphagnum* peat
	400-450	5th	*Scheuchzeria* peat

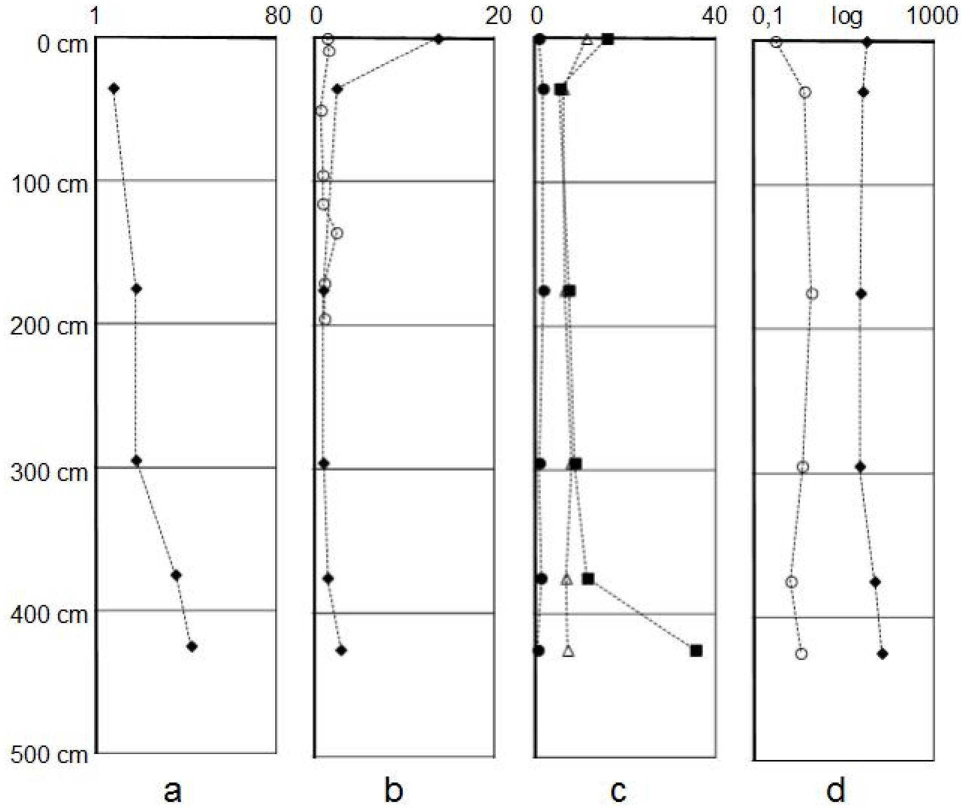

Fig.1 Changes in geochemical features of peats in the profile from the raised bog nad Jagnięcym Potokiem in the Western Sudetes. a. degree of decomposition; b. percentage ash content (circles) and total nitrogen content (diamonds); c. percentage humic substances content (squares), $E_{4/6}$ ratio (triangles), ratio of humic acids content to fulvic acids content (circles); d. total lipid content (diamonds) and non-hydrolysable lipid content (circles) in mg/g d.m.

Initially, fed by fertile surface waters, transition bog established (Tomaszewska, 2004). During this stage in the bog development the 5th layer from the profile accumulated, consisting of *Sphagnum*-*Carex* peat with cottongrass and wood remains (Tab.1). This layer is characterized by high degree of decomposition, high amount of humic substances, mostly fulvic acids, and high concentration of total nitrogen (Fig.1). The occurence of *Sphagnum* peat combined with significantly smaller amount of total nitrogen and of humic substances in the 4th layer (Tab.1, Fig.1), indicates that the water level lowered and the process of oligotrophication had begun. According to Tomaszewska (2004), sedge community, characteristic for transition bog, was gradually substituted by cottongrass and *Ericaceae* plants. Due to low pH value on the bog, plant succession processes led to formation of the typical raised bog communities. This stage of development was ended in the flooding of the bog and deposition of stream sediments on its surface. Newly formed oligotrophic substrate was colonised by *Sphagnum* species from *Cuspidata* section (Tomaszewska, 2004). The 3rd layer from the profile was accumulated under this conditions (Tab.1, Fig.1). After subsequent floodings and changes in *Sphagnum* species composition, the hummock-hollow structure developed on the surface of the bog (Tomaszewska, 2004). During this phase the 1st and 2nd layers were formed (Tab.1). In the samples from all the layers formed under strictly oligotrophic conditions (1st, 2nd, 3rd) the amount of total nitrogen and total lipids was significantly lower than in the samples from the layers of minerotrophic origin (Fig.1). The content of humic substances was also lower, however in the oligotrophic layers humic acids prevailed over fulvic acids (Fig.1).

DISCUSSION

All geochemical features of peat chosen for paleoenvironment reconstruction were markers of organic matter changes, which in turn were directly connected with alterations of habitat conditions. The most widely used marker of organic matter changes is, of course, degree of decomposition, measured as a ratio of decomposed amorphic matter to undecomposed peat. The key driver of decomposition processes on peatlands are changes of water regime, which are often an outcome of large scale climatic events. It is commonly assumed that under cool and moist climatic conditions carbon sequestration is favoured over mineralization of organic matter, while warm and dry climate intensifies oxic degradation of peat deposits (Wieder, 1994; Weltzin *et al*., 2000; Dorrepaal, 2004; Novak *et al*., 2008). All the studied cases followed this rule – each decrease in water level during the development of examined peatlands was marked by accumulation of highly decomposed layer of peat. Peats formed under drier conditions were also richer in total humic substances, however their degree of humification (measured as ratio of humic acids content to fulvic acids content, HA/FA, and by ratio of aromatic compounds content to aliphatic compounds content, $E_{4/6}$) was quite low. Apart from being a marker of hydrologic changes, degree of humification is highly influenced by botanical composition of peat and methods of humic substances extraction (Yeloff and Mauquoy, 2006; Klavins *et al*., 2008).

Both ash and nitrogen content in peats can be also used as simple markers of peatland development stages, with high levels resulting usually from the fast rate of decomposition. Moreover, sudden increase in mineral parts, including mineral forms of nitrogen, may be an effect of water regime changes from ombrotrophic to minerotrophic system. Such alternations may be caused by plant succession (autogenous changes) or by climatic changes (allochthonous changes). Under moist and cool conditions with restricted evaporation rate, bottom-up water flow typical for minerotrophic bogs and fens can be substituted by up-bottom system, characteristic for raised bogs (Robichaud and Begin, 2009). However, in all but one studied cases water regime changes were autogenous and the exception was caused by human activity (Tomaszewska, 2004).

Detailed analyses of lipid content in peats are used nowadays to study succession of subfossil plant communities (Pancost *et al*., 2002). In this research total lipid content and non-hydrolysable lipid content were used as geochemical markers. The first one corresponded strictly to botanical composition of peats rather than to development stages of peatlands, with highest amounts in cottongrass peats. On the contrary, non-hydrolysable lipids were connected with decomposition degree and the highest levels were observed in the least decomposited peats. Therefore, non-hydrolysable lipids may prove a good indicator of organic matter degradation.

Summarizing, changes in simple geochemical characteristics of peats can be used as markers of past transformations of habitat and, in case of ombrotrophic bogs, of paleoclimate.

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