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"Stump Horizon" in the Bílina Mine (Most Basin, Czech Republic) — GC–MS, optical and electron microscopy in identification of wood biological origin

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ABSTRACT

Numerous coalified tree stumps remained preserved *in-situ* in the so-called "Stump Horizon" (the palaeontologic horizon No. 31), which represents clayey overburden of the main coal seam in the Bílina open cast mine in the Most Basin (Czech Republic). The petrological and chemical composition, palaeobotanical origin and preservation of 24 selected tree stumps were studied by optical and scanning electron microscopy and gas chromatography–mass spectrometry (GC–MS). Composition of the fossil wood is dominated by ulminite, particularly texto-ulminite B. Textinite forms up to 38 vol.% in the decomposed tree stumps. Corpohuminite dominates in bark and root tissues. Partly gelified and deformed woody tissues contain both corpohuminite and resinite fillings. Random reflectance of ulminite ranges from 0.33% to 0.39% and carbon content from 49 wt.% to 78 wt.%. Samples represent pure woody material with small admixtures of clay minerals, siderite, and very rare pyrite. Observations by scanning electron microscopy revealed various levels of deformed secondary xylem with more or less swollen cell walls, conspicuous tracheids, uniseriate rays of a different height, and round or cylinder-like resin or corpohuminite bodies. According to our results and other published data the wood might belong to *Glyptostroboxylon* and *Taxodioxylon* genera that are supposed to belong to *Glyptostrobus* and *Quasisequoia* plants respectively, representatives of the coniferous family Cupressaceae. The biomarker composition in the extracts of the fossil wood includes sesquiterpenoids (α-cedrane, drimane, eudesmane), diterpenoids (abietane, fichtelite, 16α(H)-phyllocladane) and their degraded compounds. The terpenoids are derived from precursors produced by the source plants and microorganisms. The terpenoid signatures support a relationship to the Cupressaceae family with input of microbial species. These characteristics were identical for all studied samples. Significant variations have been observed in sesquiterpenoid α-cedrane and diterpenoid 16α(H)-phyllocladane contents.

1. Introduction

Fossil woods are common constituents in sedimentary sequences worldwide and in the calcified, silicified or charred forms may exhibit a high degree of anatomical preservation. These materials represent an important archive of data for palaeoenvironmental reconstructions (Falcon-Lang, 2005; Figueiral et al., 1999; Jeong et al., 2009; Kunzmann et al., 2009; Teodoridis and Sakala, 2008; Visscher and Jagels, 2003; Witke et al., 2004; Yoon and Kim, 2008). Part of fossil wood forms mummified, humified and gelified wood with variable preserved cell tissue structure, which is problematic for palaeoecological studies (Figueiral et al., 1999; Sweeney et al., 2009). Relationship between gelification, coalification, microscopic appearance, and chemical composition and structure of wood has been described in many Tertiary deposits, *e.g.*, Victorian brown coal in Australia (Russel, 1984; Russel and Barron, 1984), Greece (Kalaitzidis et al., 2004), Poland (Drobniak and Mastalerz, 2006; Wagner, 1982), Canada (Sykes, 1994), and Hungary (Erdei et al., 2009; Hámor-Vidó et al., 2010). Coalified fossil woods are usually deformed by the hydrostatic pressure of buried sediments, whereas petrified cherts and siderite coal balls preserve the original geometry of fossilized plant tissues (Hámor-Vidó et al., 2010; Sweeney et al., 2009).

The deformation and homogenization of gelified cellular structure caused a problem in the study of wood anatomy and identification of botanical affinity of coalified fossil wood. An effective technique in identification of plant tissue types is the old technique of etching of polished surfaces with oxidizing agents as summarized by Stach et al. (1982) and Taylor et al. (1998). Vassio et al. (2008) or Gryc and Sakala (2010) used a method based on boiling of wood in water for several hours to soften it before preparation of thin sections for a microscopical study in transmitted light. Figueiral et al. (2002) used

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laboratory charring of wood specimens followed by taxonomy identification by reflected light microscopy. The botanical affiliation of the fossil wood can be also determined based on the molecular composition of terpenoid hydrocarbons. Chemotaxonomical classification of fossil fragments is based on majority of terpenoids in agreement with pollen elements representing a forest swamp environment (Bechtel et al., 2007; Otto and Wilde, 2001; Stefanova et al., 2005; Zdravkov et al., 2011).

Previous research on coalified fossil wood has largely focused on the chemical and petrographical characterization of organic matter, its deformation, degradation, mineralization, and determination of botanical affiliation of woody materials from the fossil forests or tree stumps and trunks in coal seams (Bechtel et al., 2007, 2008; Hámor-Vidó et al., 2010; Sweeney et al., 2009; Sykes, 1994; Vassio et al., 2008).

This study has investigated petrological and chemical properties of selected coalified woods from the Miocene "Stump Horizon" in the Bílina open pit mine in the Most Basin. The attention was also paid to determination of the palaeobotanical origin and the way of preservation of selected tree stumps using optical and scanning electron microscopy (SEM) and gas chromatography–mass spectrometry (GC–MS) analysis of extracts.

2. Geological settings

Since the opening of the Bílina open cast mine (exploiting 9 million tonnes of brown coal per year) on the top of coal seam 2–5 m thick uniform layer of clay rich in coalified remains of *in-situ* growing trees has been documented. Numerous coalified tree stumps remained preserved *in-situ* in clay overburden up to 5 m thickness of the main coal seam in the Bílina open cast mine in the Most Basin, Czech Republic (Fig. 1). This so called "Stump Horizon" is a clastic time equivalent of the lower half of the upper bench of the main coal seam within the Holešice Member of the Miocene age (Fig. 2). It consists of 2–4 distinguished horizons of stumps. Laterally this layer gradually turns to a clear coal bench. Vertically it gradually changes into prodeltaic laminated clays and a 100 m thick lacustrine deltaic system. This layer covers an area

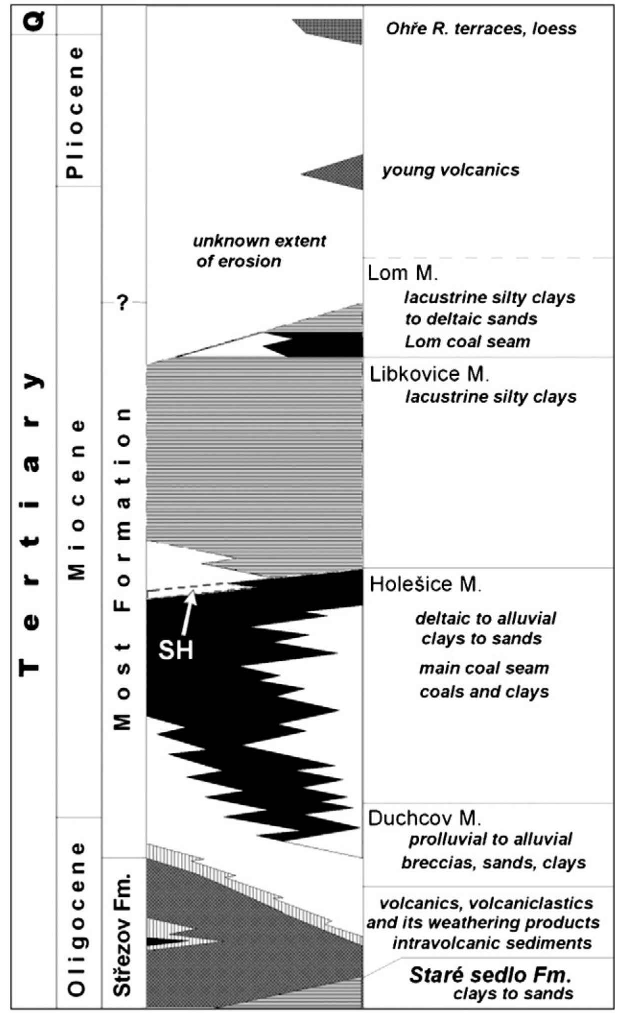

Fig. 2. Stratigraphy of the Most Basin fill. SH – "Stump Horizon" in the Bílina open pit mine.

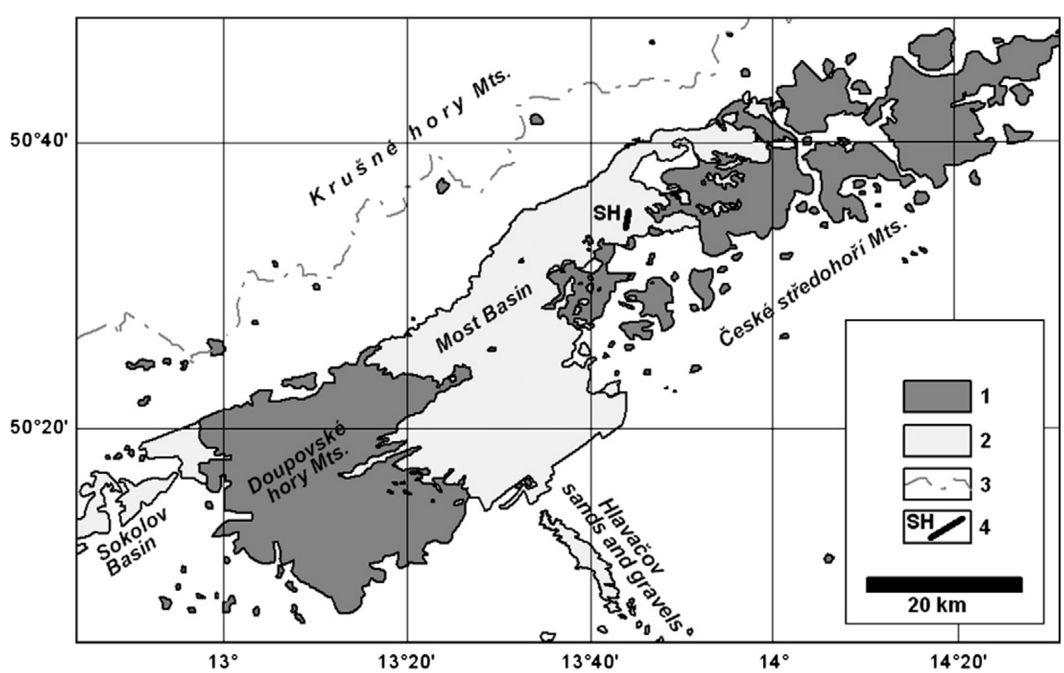

Fig. 1. Sketch map of the Most Basin. 1 – Oligocene volcanics (alkalic basalts, trachytes, phonolites) and its volcanoclastic equivalents; 2 – Lower Miocene sedimentary fill of the Most Basin (sands, clays, coal seam); 3 – state border; 4 – SH - area of "Stump horizon" sampling.