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Depositional environments of overbank sedimentation in the lignite-bearing Grey Clays Member: New evidence from Middle Miocene deposits of central Poland

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ABSTRACT

A detailed sedimentological study of Polish lignite-bearing successions has not previously been undertaken. This contribution focuses on the lignite lithotypes and lake and crevasse splay lithofacies that together constitute the Grey Clays Member. This lithostratigraphic unit strictly refers to the Middle Miocene overbank fluvial environments in central Poland. It mostly consists of the First Mid-Polish Lignite Seam (MPLS-1) in the Tomisławice lignite opencast mine. This lignite seam, containing four lithotypes, is interbedded by sandy and silty-clayey lithofacies. The lithotype associations are characteristic of the low-lying mires representing: fen or open water (<2 m deep), bush moor and wet-forest swamp. Thus, during their formation the water table was close to the depositional surface. On the other hand, the occurrence of a muddy association composed of clayey-silty (fines) lithofacies both within and on top of the lignite seam corresponds to the presence of small and deep (>2 m) lakes in the mire area. This is additional evidence of the relatively long-lasting and slow sedimentation of these very fine-grained clastics from suspension in standing lake water. Conversely, the sandy lithofacies associations, representing crevasse splays, were deposited suddenly during overbank flooding. Crevasse splay deposits are typical of initial stages of avulsion and are moderately diverse both texturally and structurally. Exceptions here are slurry flow deposits that contain rip-up clasts of paleosol aggregates. These crevasse splay deposits provide the first evidence of the fluvial environments of the Mid-Miocene mires (backswamp) in central Poland, and they split the currently exploited lignite seam, MPLS-1, in the study area. Thus, identification and description of lithofacies and lithotypes, and determination of their spatial distribution can contribute to a better understanding of the mire development, of which the examined lignite seam arose.

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1. Introduction

Overbank deposits occur in both ancient and modern depositional environments. Formation of these deposits is associated with fluvial systems, including braided (Miall, 1977; Nemec, 1992; Bristow et al., 1999; Tibert and Gibling, 1999), meandering (Horne et al., 1978; McCabe, 1984; Nemec, 1984; Zwoliński, 1992; Gębica and Sokołowski, 2001) and anastomosing systems (Smith and Putnam, 1980; Flores and Hanley, 1984; Smith et al., 1989; Makaske, 2001; Adams et al., 2004; Gouw and Autin, 2008), or any combination of these (Flores, 1981, 1986; Gradziński et al., 1995; Pieńkowski, 2004; Roberts, 2007). According to the majority of studies, seams of coal (Flores, 1979, 1981; Guion, 1984; Nemec, 1984, 1992; Rust et al., 1984; Kirschbaum and McCabe, 1992; Vessey and Bustin, 2000; Kędzior, 2001; Gradziński et al., 2005; Doktor, 2007; Davies-Vollum et al., 2012), lignite (Kasiński, 1986; Markič and Sachsenhofer, 1997; Davies-Vollum and Kraus, 2001; Rajchl et al., 2008; Ielpi, 2012; Kramarska et al., 2015) and peat (Smith et al., 1989; Farrell, 2001; Stouthamer, 2001; Stouthamer and Berendsen, 2001; Van Asselen et al., 2009; Kordowski et al., 2014) are often associated with overbank deposits.

Previous research on Polish lignites, based mainly on palynological studies, identified various sedimentary environments and morphological types (Ziembińska-Tworzydło, 1974; Sadowska and Giża, 1991; Piwocki and Ziembińska-Tworzydło, 1997; Ważyńska, 1998). An equally large morphogenetic diversity of the Miocene mires, where lignites are interbedded by mineral deposits, was suggested based on sedimentological and statistical research (Kasiński, 1986; Słomka et al., 2000; Kramarska et al., 2015; Mastej et al., 2015). These studies utilised borehole data due to the lack of good exposures in lignite opencasts. The few exceptions are sedimentological, petrographical and structural studies of lignites carried out in opencasts belonging to the Konin Lignite Mine (Fig. 1). So far, the aforementioned lignites included sporadic homolithic mineral intercalations up to 0.1 m thick (Widera, 2012b, 2014). In 2015, mineral deposits within a lignite seam were exposed in the Tomisławice lignite opencast mine in central Poland (Fig. 1). The relatively thick (>1.4 m) deposits were interpreted as crevasse splay deposits and represent the first high-quality outcrop of Miocene

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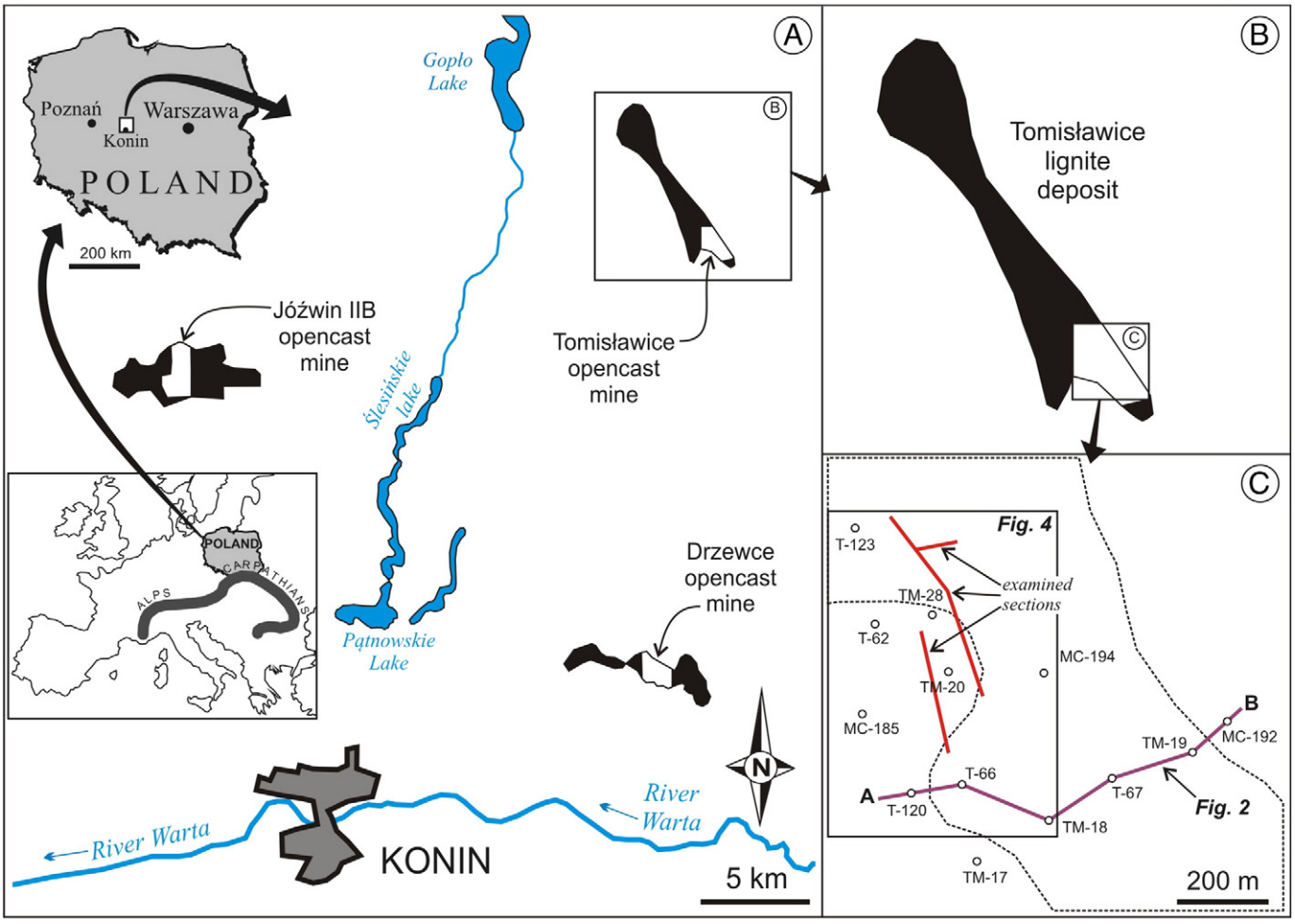

Fig. 1. Location of the study area. (A) Location in the background of Europe and Poland. (B) Outline of the Tomisławice lignite deposits (52°27'26"N, 18°31'16"E). (C) Location of the cross-section (see Fig. 2) and the examined sections in the Tomisławice lignite opencast mine (see Fig. 4). Note, black colour represents lignite deposit, while white colour represents exposures in the lignite opencast mines operating in autumn 2015.

crevasse splay deposits identified and described in Poland. Consequently, both the mineral intercalations and associated lignite seam are collectively classified as the overbank deposits in the present contribution.

This study aims to document and interpret the origin of the overbank facies of the mire and the coeval lacustrine and crevasse splay depositional environments that existed in the Middle Miocene in central Poland. Products of this sedimentation now form the Grey Clays Member, which consists of lignites, sands and fines. Therefore, this paper aims to: 1) identify and characterise sedimentologically all lignite lithotypes and clastic lithofacies; 2) assign the lithotypes and lithofacies to appropriate sedimentary sub-environments representing the various types of mire, lake and crevasse splay; and to 3) propose and discuss a conceptual model based, for the first time, predominantly on field studies of Middle Miocene overbank sedimentation in central Poland, when minable lignite seams were deposited.

2. Geological setting

The examined lignite-bearing Grey Clays Member is the best developed in central Poland. It covers a vast area (~75,000 km^2) of Polish territory (Piwocki, 1992). Together with the overlying Wielkopolska Member they comprise the Poznań Formation, which is the youngest Neogene-aged lithostratigraphic unit in the study area (Piwocki and Ziembińska-Tworzydło, 1997; Piwocki, 1998). In contrast to the muddy Wielkopolska Member, representing an anastomosing fluvial system (Badura and Przybylski, 2004; Widera, 2013a), the Grey Clays Member contains productive lignite seams that are extracted by the Konin Lignite Mine. Currently three opencast mines exist, including the Tomisławice, in the vicinity of Konin (Fig. 1A).

The Tomisławice lignite opencast mine occupies the southernmost part of the Tomisławice lignite deposit (Fig. 1B, C). It is located in a shallow tectonic depression in the Mesozoic basement of late Cretaceous age (Dadlez et al., 2000). The Cenozoic sedimentation started in the early Oligocene with the deposition of greenish glauconitic sands of marine origin (Widera, 2007; Widera and Kita, 2007). These deposits are more than 10 m thick (Fig. 2). The entire territory of central Poland was subsequently subjected to uplift in the late Oligocene (Jarosiński et al., 2009; Widera and Hałuszczak, 2011). Sedimentation of the sub-lignite deposits lasted from the Early to Middle Miocene and mostly consists of fluvial sands with carbonaceous intercalations up to several meters thick (Fig. 2).

The Grey Clays Member can be divided into the First Mid-Polish Lignite Seam (MPLS-1) and the overlying so-called 'grey clays' (Piwocki and Ziembińska-Tworzydło, 1997). This main lignite seam is up to 12.6 m thick; however, it is locally interbedded by clastics (i.e., sands and/or clays with silts) (Figs. 2, 3). In the Tomisławice lignite opencast mine MPLS-1 (the First Mid-Polish Lignite Seam) reaches an average thickness of 6.5 m (Wachocki, 2013) and is of Middle Miocene age (Sadowska and Giża, 1991; Ważyńska, 1998). It is a low-rank coal (i.e., humic ortholignite) characterised by a mean reflectance coefficient

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