Comparison of the Geology Presented in a Cross-Section and That Observed in The Field – A Lesson from the Tomisławice Lignite Opencast Mine, Konin Basin in Central Poland

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Abstract

This article briefly focuses on comparing geological information shown in a cross-section with field data. An example from the Tomisławice opencast mine, where the first Mid-Polish lignite seam (MPLS-1) is currently exploited for electricity production, is used where two sites present large and even surprising differences. In the first case, they are due to technical reasons, i.e., wet drilling. The second case is most likely caused by the compaction of peat during its transformation into lignite. The obtained results clearly indicate that the actual geological structure observed in the field may differ significantly from that which is interpreted on the geological cross-sections based on borehole data

Keywords: Comparison, Geology Cross-Section, Lignite Opencast Mine, Konin Basin, Poland

Introduction

Lignite deposits intended for mining have a borehole grid, for example, from 500 x 500 m to 50 x 50 m, or denser. This depends, of course, on the complexity of the geological structure of these areas, i.e., on the deposit exploration category [1-3]. In the case of lignite deposits from the Konin Basin, the borehole grid most often covers an area of 250–100 x 250–100 m. The majority of these deposits is characterised by a rather simple geology, where the lignite seams fill (in contrast to the 'Lubstów' deposit, where lignite mining was completed in 2009) shallow tectonic grabens [4, 5].

Data from boreholes are the fundamental information source for maps documenting the resources and reserves of the above-mentioned deposits, including the 'Tomisławice' lignite deposit [6, 7]. Cross-sections in both geological documentation and scientific studies are also constructed from this information [4, 5, 8-13]. However, direct field observations in lignite opencasts can verify much earlier geological maps and cross-sections. Such an example from the Tomisławice opencast is presented here, i.e., from the area of the 'Tomisławice' lignite deposit. Therefore, the main goal of this study was to explain the reasons for the significant differences between the geological cross-sections and field observations.

Geological Setting

The study area is located close the town of Konin in central Poland (Figure 1). The 'Tomisławice' lignite deposit fills a shallow and fault-bounded graben that is up to 20–30 m deep, although its tectonic origin is poorly expressed in some parts of it (Figure 2). This depression belongs to the Konin Elevation [5, 15], which is a segment of the Mogilno Trough, and this in turn forms a part of the Szczecin-Miechów Synclinorium [16].

Marls and limy sandstones of Late Cretaceous age constitute the sub-Cenozoic bedrock [17]. The Paleogene sediments are represented only by marine glauconite sands of early Oligocene age, whilst the Neogene is much more complete lithostratigraphically. The latter includes the lower Koźmin and the upper Poznań formations. The Koźmin Formation encompasses the sub-lignite siliciclastics, i.e., fluvial sands and coaly sands with lignite intercalations (Figure 2). The Poznań Formation covers the lower Grey Clays Member and the upper Wielkopolska Member [4, 18].

The Grey Clays Member consists of the first Mid-Polish lignite seam (MPLS-1), which is currently mined in the Tomisławice opencast, and the so-called 'grey clays' resting locally on its roof. This lignite seam is of Mid-Miocene age and up to 12 m in thickness (on average 6.9 m) in the study area. Similarly, the sediments of the Wielkopolska Member ('green and flamy clays') were not drilled by most of the boreholes (Figure 2), but were found in the field as documented in this article. They accumulated between the late Mid-Miocene and the earliest Early Pliocene as channel-fill muds and sands, and overbank muds [11, 19-21].

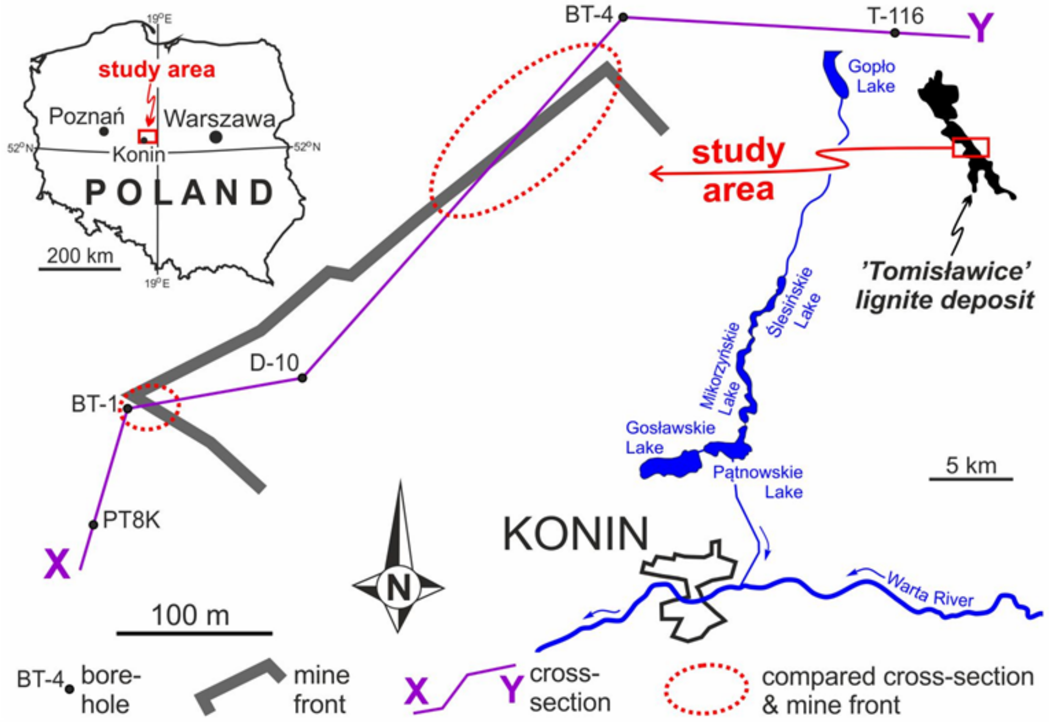

Fig. 1. Location of the 'Tomisławice' lignite deposit as well as the geological cross-section and observed mine front during fieldwork

The Quaternary succession caps the Neogene in the area of the 'Tomisławice' lignite deposit. Its thickness ranges from 35 to 60 m due to erosional and glaciotectonic processes. The majority of these sediments have a glaciogenic origin, i.e., glacial tills, fluvioglacial sands and gravels, as well as fluvioglacial-lacustrine muds (Figure 2).

Materials and Methods

Fieldwork was carried out in the Tomisławice lignite opencast in August and September 2022. The mine fronts and overburden walls were mapped at that time. Additionally, the deposits and their most important structural boundaries were documented photographically. The borehole data and mining maps, containing geodetic data, were obtained from the Konin Lignite Mine.

In this research, the geology of the study area is shown in the simplified cross-section X–Y, which was constructed using data from five boreholes with a depth ranging from 55 to 78 m. The mining activities allowed us to compare the stratigraphic architecture of the sediments shown in the aforementioned cross-section and that observed in the field, especially in the vicinity of borehole BT-1 and between boreholes D-10 and BT-4 (Figure 2).

Results

Cross-Section Description

The examined geological cross-section X–Y covers the middle part of the 'Tomisławice' lignite deposit and the northernmost part of the Tomisławice opencast (cf. Figures 1 and 2). It was constructed according to data from five boreholes. Three of them reach the Mesozoic bedrock, one ends in the Neogene, and one in the Quaternary sediments. Only two of them pierce the lignite seam (MPLS-1), i.e., boreholes BT-1 and D-10 (Figure 2).

The MPLS-1 shows little thickness in the cross-section (3.8 m in the borehole D-10) and is split into two lignite benches (0.8 and 1.8 m thick) in borehole BT-1. The Quaternary (Pleistocene) tills or muds most often rest erosively on the roof of the MPLS-1. The effects of deep Pleistocene erosion are best seen in boreholes BT-4 and T-116, which host no Paleogene and Neogene sediments in their original position. It is noteworthy that among the glaciotectonically disturbed Pleistocene tills, these two boreholes host 'grey clays' as well as 'green and flamy clays' that are of Neogene age and originally lay on the roof of the MPLS-1 (Figure 2).

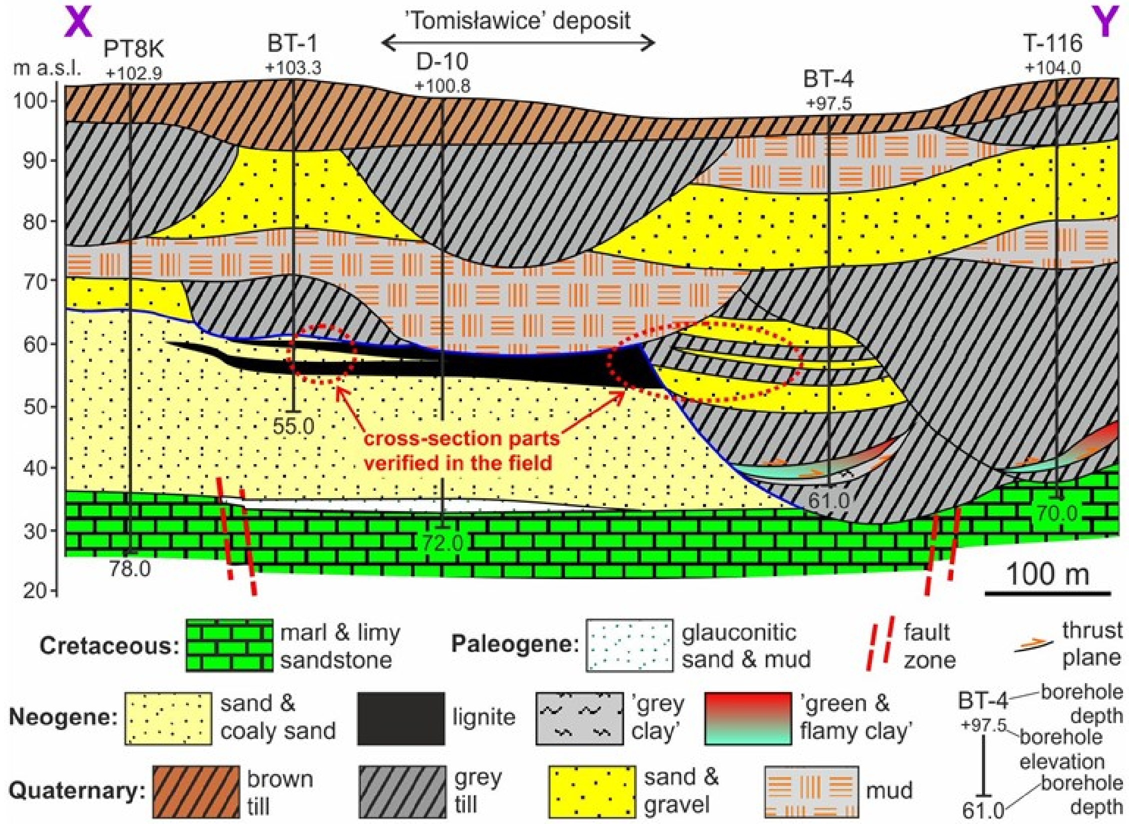

Fig. 2. Simplified geological cross-section through the 'Tomisławice' lignite deposit; for location of the cross-sectional line X–Y, see Figure 1

Field Observations

The results of detailed observations of mine fronts located ca. 10–20 m E of borehole BT-1 and ca. 50–300 m SW from borehole BT-4 are described here (cf. Figures 1-4). In the first case, the MPLS-1 consists of two lignite benches separated by a sand complex. Moreover, the upper lignite bench is erosively capped by glaciogenic tills (Figure 3a). On the other hand, the above-mentioned sand complex consists of several layers of sand and coaly sands as well as four thin (up to 10–60 cm thick) layers of lignite (Figure 3b).

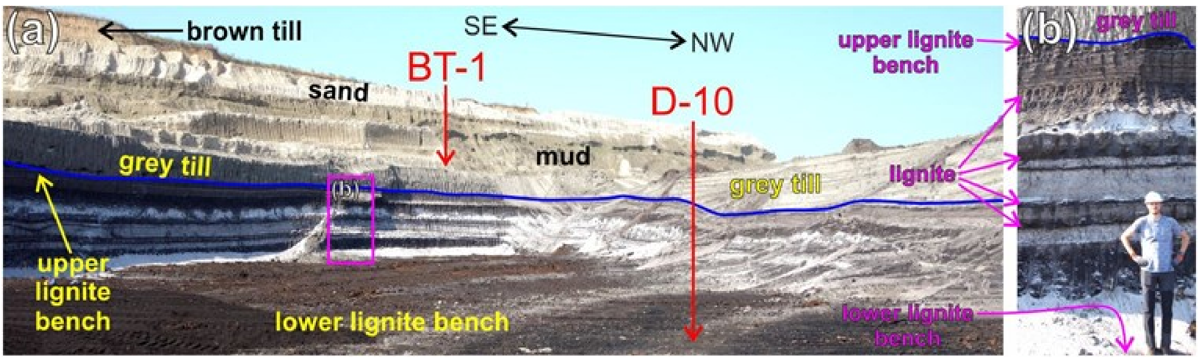

Fig. 3. View of the sediments in the borehole BT-1 vicinity (Tomisławice lignite opencast, August 2022); (a) broad view, (b) close-up view; for location, see Figures 1 and 2

In the second examined case, the MPLS-1 slopes very steeply towards E. At a distance of ca. 50 m, the elevation of its roof decreases by >6 m (Figure 4a). It is interesting that the so-called 'gray clays' and 'green and flaming clays' rest on the roof of the MPLS-1. The 'gray clays' contain dispersed organic matter and xylites, i.e., fossilised wood fragments >1 cm in size [4, 5]. On the contrary, the 'green and flamy clays' are characterised by 'cold' and 'warm' colours (Figures 4b, 4c). Both the MPLS-1 and the varicoloured 'clays' are erosively cut and covered by glaciogenic tills (Figure 4).

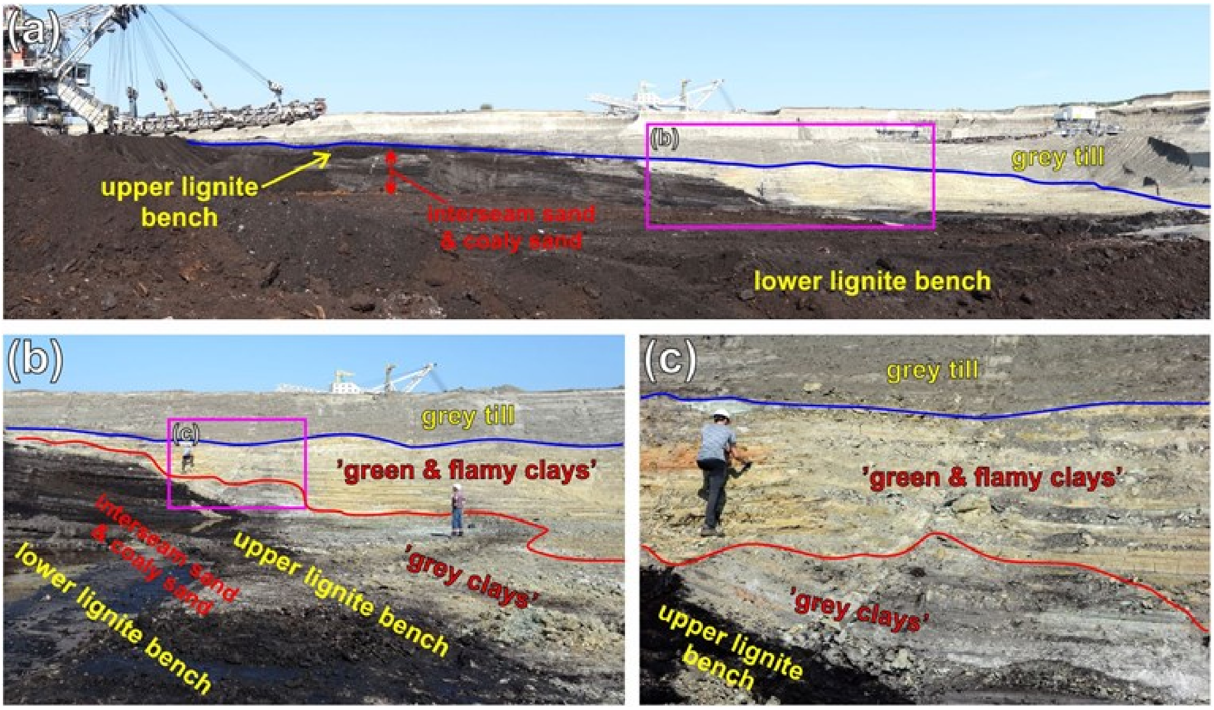

Fig. 4. View of the sediments between the boreholes D-10 and BT-4 (Tomisławice lignite opencast, August 2022); (a) broad view, (b), (c) close-up view; for location, see Figures 1 and 2

Interpretation with Discussion

Observations of the mine fronts in the Tomisławice opencast show large differences in the information presented in the above-described geological cross-section (cf. Figures 2-4). The first interpreted case confirms that the borehole information is very generalised, especially in cases where wet drilling was employed. The coaly sands positioned between the lower and upper lignite benches as described in the borehole chart (Figure 5a), in fact, consist of interbedded layers of sand, coaly sand, and lignite (Figure 5b).

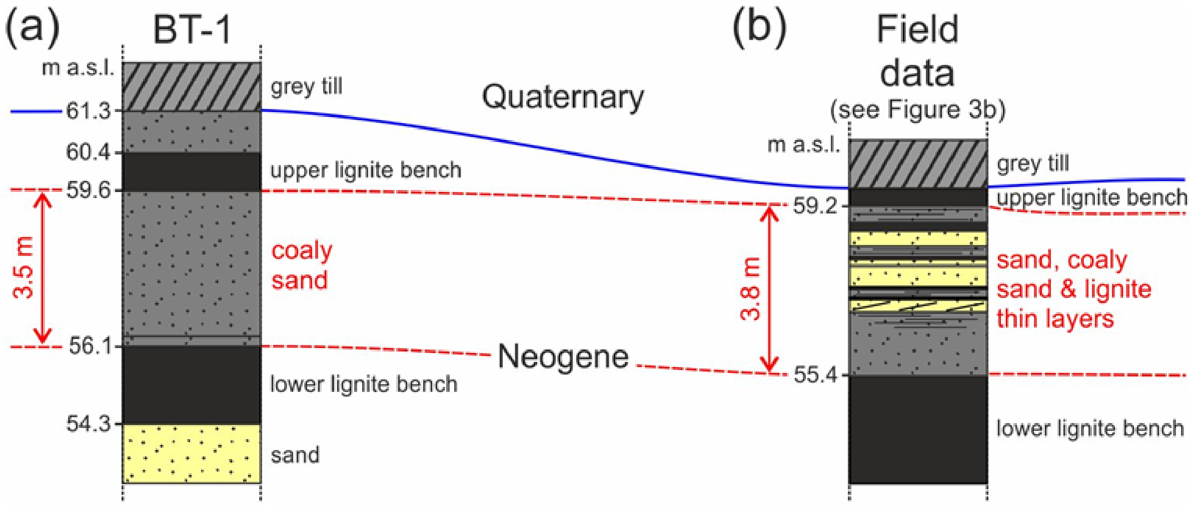

Fig. 5. Comparison of borehole and field data from the Tomisławice opencast; (a) sediments drilled in the borehole BT-1, (b) sediments exposed in the Tomisławice opencast close to the borehole BT-1; compare with Figure 3a and 3b, respectively.

In addition, field observations allow the identification of structural features of the sediments such as stratification and deformation (cf. Figures 3b and 5b), which cannot be seen when wet drilling has been used (see Figure 5a). This is especially important when clastics are subjected to detailed sedimentological analyses [10, 11, 13, 14, 19-21].

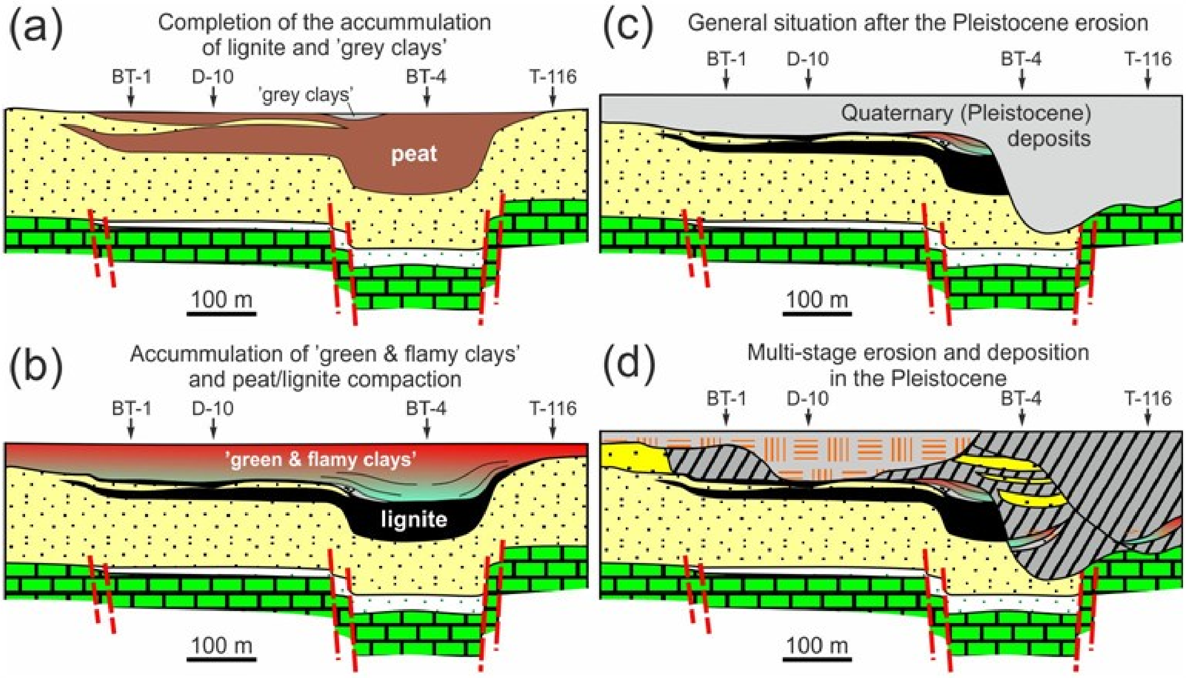

Fig. 6. Conceptual model of the sediment deposition, compaction and erosion between the boreholes D-10 and BT-4; note, the effects of peat/lignite compaction, i.e., the inclination of the layers of the above-lying 'clays'; compare Figures 2, 4 and 6d; for other explanations, see Figure 2

The significant inclination of the lignite seam (MPLS-1) and overlying 'clays' between boreholes D-10 and BT-4 is at least surprising (see Figure 3). At first glance, it may be associated with Pleistocene glacial and meltwater erosion, or with post-depositional tectonics, i.e., after the accumulation of peat. Considering other available borehole data, however, both of the above hypotheses were rejected, and the discussed phenomenon was attributed to the compaction of peat which was then transformed into the MPLS-1 (Figures 6a, 6b). It should be noted that the peat-to-lignite compaction ratio estimated for the MPLS-1 in the vicinity of Konin (central Poland) is on average ca. 2.0 [22-24].

Nearly all the Neogene 'clays' and top layers of lignite were eroded during the Pleistocene. Hence, boreholes BT-4 and T-116 contain no lignite or multi-coloured 'clays', which are instead glaciotectonically incorporated into the Quaternary sediments (Figure 6c, 6d).

Conclusion

A comparison of the geological cross-section and field observations in the Tomisławice opencast (Konin Lignite Mine, central Poland) led to more surprising conclusions than expected. First, the two analysed cases showed that the borehole data should be treated as preliminary, both for practical purposes (documenting the extent, resources, and reserves of the lignite deposit) and for cognitive ones (e.g., sedimentological and tectonic studies). Second, borehole data are often necessary in addition to field observations to correctly verify scientific hypotheses, as evidenced by the latter case analysed in this article.

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