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Influence of the geology of coal deposits on their extraction and urbanistic development: a case study of Petřvald (Czech part of the Upper Silesian Basin)

Introduction

The influence of the discovery and subsequent mining of mineral deposits on the development of settlements has long been known. This relationship has been the subject of many literary works (e.g., Kirshner and Power 2015; Gold 2016), especially those that study the relationship between the development of mining and population growth. These links are usually easily explained because the development of settlements was and is even today still considered the result of increased demand for workers in mines and service sectors. Literature likewise also documents the reversal of this trend that results from the exhaustion of reserves of exploited deposits, consequently causing a decline in mining. These processes lead to population decline and stagnation in the development of settlements, or even to their

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gradual extinction, if new job opportunities and new investments are not provided in advance in a region affected by a phase-out of mining.

However, in addition to the above-mentioned "global impacts" of deposits on the development of settlements, a set of influencing factors derived from the geological structure of deposits also exists. In areas where they occur, these factors have a considerable effect on the development of settlements as well. They have a bearing on sub-issues concerning settlement development and may, therefore, be indirectly used for more detailed analyses of urban development in areas where mining and mineral deposits occur, or to explain some of their causes. The aim of this paper is to focus on precisely these relationships and factors. Petřvald, a mining town in the Czech part of the Upper Silesian Basin, serves as an example to demonstrate these relationships. This town is particularly suitable for this purpose because the impacts of the development and decline of mining in its area were not concealed and suppressed by the development of other industries and activities, as in the case of the nearby city of Ostrava.

1. Geological situation

The Upper Silesian Basin is currently the most economically important European coal basin (Malon and Tymiński 2018; Starý et al. 2018). It lies in the territory of Poland and the Czech Republic (Fig. 1A, B). Approximately four-fifths of the basin area are located in Poland, while the remaining part lies in the Czech Republic. The present-day extent of coal-bearing sediments of the Upper Silesian Basin is influenced by post-sedimentary erosion. The origi- nal extent of the basin was therefore undoubtedly larger (Dopita ed. 1997; Jureczka et al. 2005; Probierz et al. 2012).

The Carboniferous sediments of the Upper Silesian Basin (of Upper Mississippian to Pennsylvanian age), which contain bituminous coal deposits, develop gradually from the underlying marine sediments of the Moravian-Silesian Paleozoic Basin (Kalvoda et al. 2008; Tomek et al. 2019). A shallowing sea and the end of siliciclastic flysch sedimentation (Culm facies) led to the so-called paralic type of sedimentation. Environments suitable for the formation of coal swamps began to develop under such conditions. The complex of sediments that formed in these environments is referred to as the Ostrava Formation (and as Paralic Series in the Polish part of the basin – Kotas and Malczyk 1972). The Ostrava Formation is subdivided (from oldest to youngest) into the following members: Petřkovice, Hrušov, Jaklovec and Poruba (Dopita ed. 1997).

In the Ostrava part of the Upper Silesian Basin, the Carboniferous strata are overlain by the Neogene sediments of the Carpathian Foredeep and subsequently by sediments of the Quaternary age. Natural outcrops of sediments of the Upper Silesian Basin are, therefore, rare and of a small areal extent. In the vicinity of the outcrops, the sediments of the Upper Silesian Basin that contain coal seams occur at minimum depths below the surface (Dopita ed. 1997). That is why mining in the Upper Silesian Basin began in these areas.

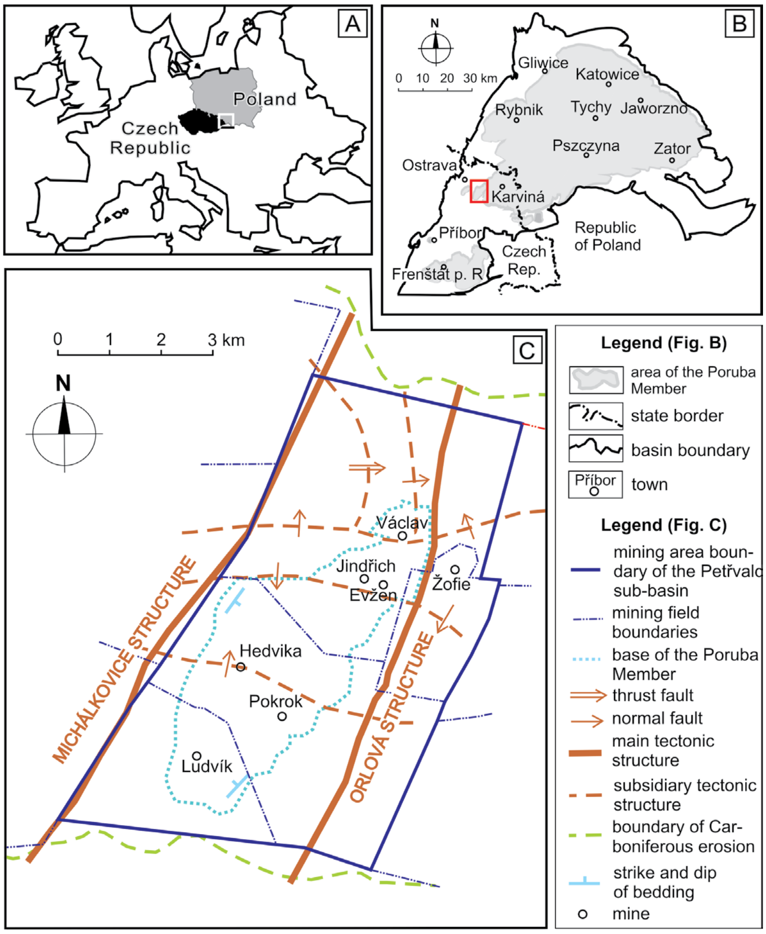

Fig. 1. A – Location of the Czech Republic and Poland within Europe; B – Location of the Petřvald sub-basin within the Upper Silesian Basin (according to Jirásek et al. 2013, modified); C – Basic geological structures of the Petřvald sub-basin (according to Brieda et al. 1977; Aust et al. 1997, simplified)

Rys. 1. A – Lokalizacja Czech i Polski w Europie;
B – Lokalizacja subzagłębia Petřvald w obrębie Górnośląskiego Zagłębia Węglowego;
C – Podstawowe struktury geologiczne subzagłębia Petřvald

The large present-day industrial areas of Ostrava in the Czech Republic and of Katowice in Poland first emerged in these parts of the basin.

The average thickness of the coal seams of the Ostrava Formation is 0.73 m. With regard to the surface area of the basin, they may be considered as occurring locally because they usually split, merge and wedge out, which corresponds to the conditions under which they were formed (Sivek et al. 2003). The coal-bearing Carboniferous of the Upper Silesian Basin is disrupted by tectonic and fold structures, which are more frequent in the west of the basin (Ptáček et al. 2012). Major structures are used to subdivide the basin into smaller parts.

This also applies to the Petřvald sub-basin, which belongs to the Ostrava part of the basin. The Petřvald sub-basin, which is the subject of this study, is separated from the Ostrava part of the basin by the Michálkovice Structure and from the Karviná part of the basin by the Orlová Structure (Fig. 1C). Concerning the mining area of the Petřvald sub-basin, the Carboniferous surface (relief), which is unconformably overlain by sediments of the Tertiary and Quaternary age, plays an important role as well. The thickness of these sediments significantly affects the development of coal deposits. This parameter is also referred to as the thickness of overburden (abbreviated as cover thickness), i.e. the thickness of sediments located in the overburden of deposits containing coal seams. The Carboniferous sediments nearest the surface are deposited in a E-W trending belt running approximately through the town center of Petřvald (Dopita ed. 1997; Fig. 2). From this elevation of the Carboniferous relief, its surface dips southward toward the so-called Bludovice Depression and northward toward the Dětmarovice Depression. The thickness of the overburden, which overlie the coal-bearing strata of Carboniferous age, increases in these directions as well. The surface of the Carboniferous lies at the center of the depressions, at depths of about 800 to 900 m

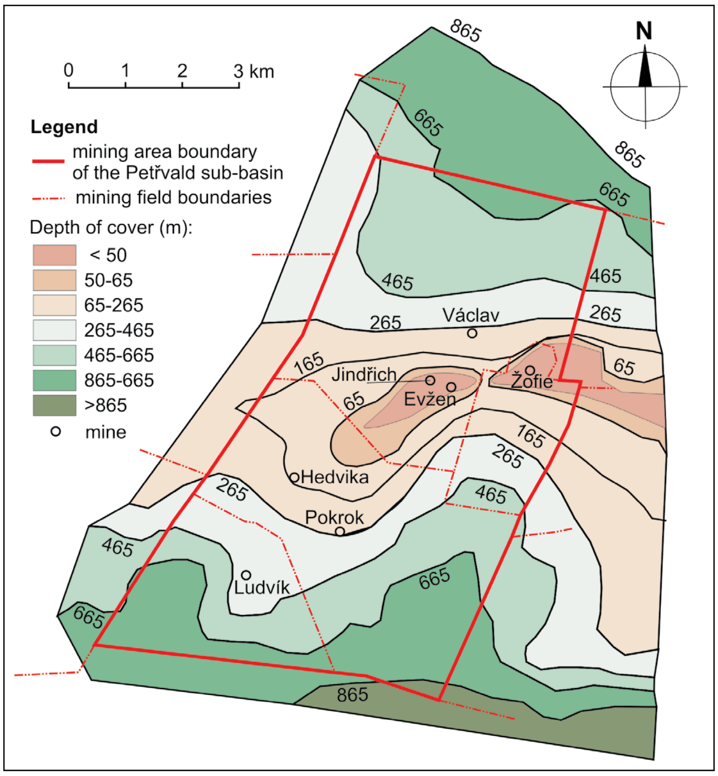

Fig. 2. Thickness of the sedimentary cover on the coal-bearing Carboniferous. According to Dvorský et al. 2007, modified

Rys. 2. Grubość pokrywy osadowej na węglonośnym karbonie

(Dvorský et al. 2007). These depressions on the Carboniferous surface are filled with younger sediments. Lower Badenian basal clastic are typical for mining dangers: water inflows and methane and carbon dioxide migration (Janáček et al. 1998).

The Michálkovice and Orlová structures to the west and east and the surface of the Carboniferous to the north and south define the Petřvald part of the basin (Fig. 1C), which represents a relatively autonomously evolving mining area of the Ostrava-Karviná Coalfield. This area is separated from the western Ostrava part and eastern Karviná part of the Upper Silesian Basin. The coal-bearing Carboniferous in the Petřvald part of the basin is represented by the Ostrava Formation, which from the bottom up comprises the Petřkovice, Hrušov, Jaklovec, and Poruba members. The uppermost part of the Poruba Member is eroded. The Poruba Member is least eroded in the area of the above-mentioned Carboniferous elevations. Only the coal seams of the Poruba and Jaklovec members were exploited in the Petřvald sub-basin. The coal-bearing capacity of the deposits of these lithostratigraphic units is 1.8% and 1.6% in the case of the Poruba and Jaklovec members, respectively (Dopita ed. 1997). The underlying stratigraphic units (Hrušov and Petřkovice members) were never exploited in the studied area. The main reason was the depth of their occurrence. They are separated from the Jaklovec Member by the 200 m thick or thicker Enna group of marine horizons, which lacks coal seams. The coal seams in the upper part of the underlying Hrušov Member are poorly developed and unfavorable to mining as well.

2. Influence of the geology of coal deposits on their extraction in the past

The geological structure of deposits, their quality, geological setting, and other geological conditions are decisive for the development of mining and consequently also for the development of nearby communities. This also applies to coal deposits. The chronology of their development, extraction, and decline due to geological factors is influenced particularly by:

- the thickness of overburden, the depth at which coal seams occur,
- the quantity and quality of the coal reserves (coal-bearing capacity of sediments),
- the development of coal seams, the complexity of their geological structure (e.g. tectonic structures) and other geological conditions.

As coal mining began in the late 18th and early 19th centuries, the thickness of overburden along with the depth at which coal seams occurred was the most important geological factorb for the prospecting for coal and for the selection of sites where coal mining was first attempted. In the basin areas where coal seams were first discovered and mined, the thickness of overburden was very close to zero. This means that the coal-bearing layers cropped out directly at the surface. The other geological factors were largely insignificant in the early days of coal mining. The low technical level of coal mining and outdated mechanization in subsurface and surface mines meant that mine production was very low. Apart from this, the demand for coal was initially low as well and the future of coal as an energy source was uncertain. The situation changed with the development of metallurgy and with the construction of the railway network.

The expansion of industry, as well as the construction of railways, increased the demand for coal, which began to displace the use of charcoal in metallurgical and industrial production. The initial primitive stages of mining were replaced by the construction of the first actual underground mines that were already equipped with mechanical devices that led to increased production. The first of these mines were still usually located, where geological conditions permitted, in areas with thin overburden. Primitive mining operations during the early period of coal mining gradually transformed into an independent industry, which in turn began to play an important role in the economic development of countries (Freese 2016).

Industrial development accelerated in the second half of the 19th century. Coal became a fundamental source of energy, thus putting pressure on its production. Technological progress, which rapidly spread to coal mining, was also the reason why the thickness of overburden gradually ceased to be a major technical obstacle in mine construction even though to this day it continues to be an economic factor in the opening up of deposits. The mines of this stage of mining were already at a much higher technical level than the mining operations during earlier stages. Of the geological factors, mainly the quantity and quality of coal reserves of the deposits that were opened up gained in importance. Mines were designed with incomparably higher production capacities than in previous stages. Their construction became extremely expensive. The sinking of shafts usually required the penetration through thick overburden, which sometimes contained dangerous water-bearing horizons that hindered and increased the cost of the work. The required mechanization of mines, which enabled their construction and high production, also became much more expensive than in the past. Coal mining thus gradually became the domain of financially and technically strong mining companies and financial institutions.

The mentioned trend in the development of coal mining escalated during the 20th century. The mines continued to employ technologically more complex equipment, which is, however, not adaptable to changes in the geological conditions. The irregular occurrence of coal seams (the merging, splitting, wedging out of seams and changes in their thickness) and tectonic events (faulting and folding) had a far greater impact on the output of technologically advanced coal mining operations than on manual mining. For these reasons, a sufficiently detailed deposit survey of new mining fields became one of the requirements for the successful opening of modern mines, which was not common in the early days of coal mining.

3. The history and development of coal mining in the Petřvald area as a result of the geological structure of coal deposits

3.1. Exploration and initial phases of extraction (ca. 1830 to 1844)

The beginnings of mining in the Petřvald part of the coalfield date back to the 1830s. At that time, coal was already mined in the Ostrava and Karviná parts of the coalfield, albeit to a limited extent and in small quantities. Attempts to discover coal in the area of the Petřvald part of the coalfield were made primarily by Count Heinrich Larisch-Mönnich, who owned lands on the Rychvald, Poruba and mainly Petřvald estates. He was interested in developing mining activities in the Ostrava area and gaining a foothold in the center of the emerging industrial area, because his main mining areas were located in the Karviná area. At that time, that was a considerable disadvantage due to the absence of a railway network (Zářický 2004). Count Heinrich Larisch-Mönnich failed in those endeavors and, therefore, focused on the Petřvald area, which is much closer to Ostrava. Prospecting in the Petřvald area began after 1830. On 13 January 1835, Count Heinrich Larisch-Mönnich was granted his first mining claim – Jakobi, followed by others (Dombrovský and Prek 2003; Zářický 2004). Prospecting works commenced in the northern part of the present-day cadastral area of Petřvald (Fig. 1C), in an area where coal-bearing layers are overlain by several-meter-thick overburden (Fig. 2, also see item 1 on the list of geological factors influencing the prospecting for and development of coal deposits in chapter 2).

The preserved prospecting works (primarily shallow excavations) show that the second item from the list of favorable geological factors required for the development of mining was initially not entirely met because the coal seams in this area did not occur immediately beneath the surface. The prospect shaft Bedřich was the first to reach a coal seam in 1835 at a depth of 72.8 m and to produce coal regularly in Petřvald in 1836. Seams were also uncovered by other prospect shafts. However, many others did not yield any positive results.

Martin Adit was driven in 1838–1841. It attained a length of 2,713 m and is located near the Evžen Mine (Janků et al. 2005). The mouth of the Martin Adit was located at the level of the Rychvald Stream into which the adit was also drained. The adit was used until 1874 to drain the oldest mine workings in the area of the Bedřich and Karel mines. The output of shallow shaft mining could not be increased significantly. As the mining operations approached the level of the Martin Adit, mine water management became increasingly difficult. For this reason, but also due to the imminent connection of the entire Ostrava region to the railway network (1847, Emperor Ferdinand Northern Railway), which was expected to lead to increased coal sales and further development of the steelworks in Ostrava, Count Heinrich Larisch-Mönnich commenced with the construction of the first underground mine in the Petřvald part of the coalfield in 1844 (Dombrovský and Prek 2003; Zářický 2004). Thus, the second phase involving the development of the coal-bearing Carboniferous was initiated in Petřvald part of the coalfield.

3.2. Beginning of regular underground mining (1844 to 1871)

The Heinrich Mine was the first underground mine ever to operate in the Petřvald sub-basin. Its purpose was to exploit the coal seams below the Martin Adit. Other prospect shafts that ventilated the mining field opened up by the Heinrich Mine were gradually merged with the mine. In 1844, the first steam engine was installed at the Heinrich Mine in the Petřvald part of the coalfield for mining and mine drainage purposes. By around 1850, three steam engines had already been installed at the Petřvald mines, which were worked by about 250 miners (Zářický 2004).

The Heinrich Mine was the sole mine until 1862 when a second underground mine was established in the Petřvald part of the coalfield. It was named Evžen after the heir of Count Heinrich Larisch-Mönnich, Eugen Larisch-Mönnich. The distance between both mines was relatively short. The Heinrich Mine had four separate levels, the last of which was at a depth of 195 m. Its output gradually declined and the mine gradually became a ventilation shaft for the Evžen Mine, with which it was later merged for ventilation and mining purposes. During its existence, the mine was renamed several times (Dombrovský and Prek 2003; Klát 2003). It continued to operate as a separate mine until 1955 when it was merged with the Václav Mine (Fig. 3) because both mines were to be reconstructed together. The reconstruction never took place. However, the mine continued to produce coal until 1972.

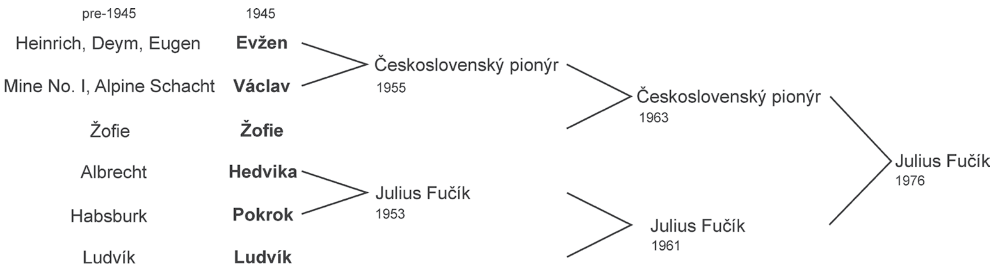

Fig. 3. Explanation of changes in mine names in the Petřvald area during the time.
According to Janáček et al. 1998, modified

Rys. 3. Wyjaśnienie zmian nazw kopalni w rejonie Petřvald w analizowanym okresie

This stage is known for the construction of the first underground mines in the Petřvald area. Both mines, Heinrich (in Czech Jindřich) and Evžen, were located in an area with thin cover sediments and with a relatively shallow depth of the uppermost coal seams beneath the surface. Their location was based on knowledge gained during so-called shallow mining (Zářický 2004). The construction of the two mines occupied, and thus exhausted, the area in which coal-bearing sediments of Carboniferous age occur at shallow depths in the Petřvald part of the coalfield (Fig. 2).

3.3. Mining of the deeper seams (1871 to 1963)

The beginning of the third stage of mining development in the Petřvald area dates back to 1871 and 1872. The Žofie Mine in Poruba began to be sunk in 1871 and the Albrecht (later Hedvika – see Fig. 3) Mine in Petřvald in 1872. This stage of the Petřvald Coalfield development focused on the construction of new mines south and partially north of an E-W trending elevation of the Carboniferous sediments (Fig. 2). For each of the mines, the sinking of new shafts occurred through one hundred meters or more of overburden that also contained water-bearing horizons (so-called detritus, Dvorský et al. 2007), which was a difficult task due to technical and safety issues (Fig. 4). Borehole surveys of the coal-bearing sediments were already conducted before the construction of mines during this stage. Counts Larisch-Mönnich ceased to be the sole miners in the Petřvald area as other financially strong mining companies, such as the Österreichische Berg- und Hüttengesellschaft, entered the coal mining business. The first mine of this stage of development was the Albrecht

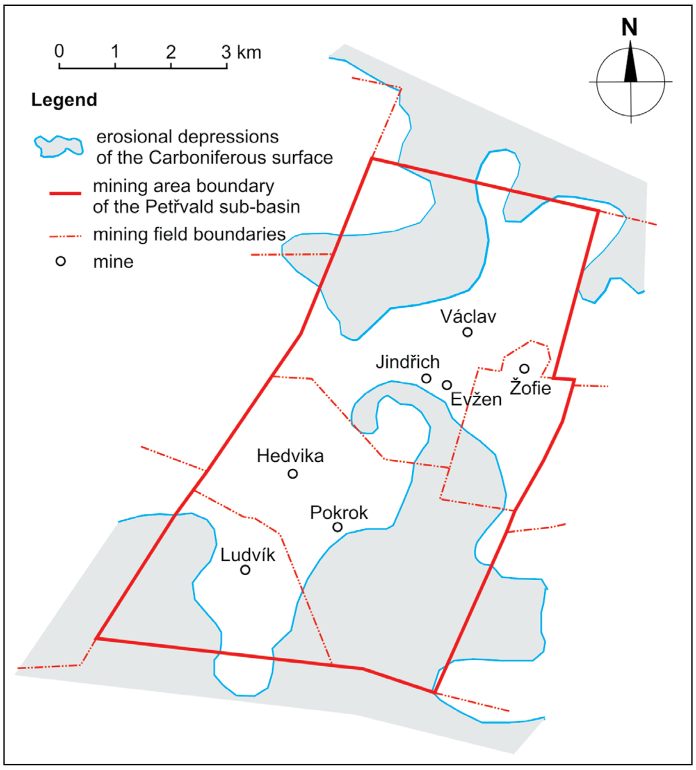

Fig. 4. Erosional depressions of the Carboniferous surface with possible occurrences of water-bearing clastic sediments ("detritus"). According to Dvorský et al. 2007, modified

Rys. 4. Erozyjne obniżenia powierzchni karbońskiej z możliwymi wystąpieniami wodonośnych osadów klastycznych (detrytus)

Mine (1872) (Dombrovský and Prek 2003; Zářický 2004). World War I production peaked in 1916 with the production of 1.6 mil. t, which fell at the end of war to 2/3 of this amount (Fig. 5, Dombrovský 2003).

In 1917 a new main shaft was developed near the Albrecht Mine, which was renamed Hedvika. The Carboniferous deposits occurred at a depth of 156.0 m beneath this mine. The opening up of the Petřvald part of the coalfield continued with the southernmost Ludvík Mine. The sinking of the main shaft in 1898 was accompanied by continued water problems in the overburden that was 290.0 m thick (Zářický 2004).

The sinking of the main shaft called Alpineschacht (renamed to Václav in 1929 – see Fig. 3) at the northernmost mining site in the Petřvald sub-basin commenced in 1899. The opening up of the Petřvald part of the coalfield ended with the construction of the Habsburg Mine (Pokrok Mine since 1920 – see Fig. 3). The main and air shafts were sunk in 1912 and mine production began in 1913. The Carboniferous deposits occurred in the shaft at a depth of 155.8 m (Zářický 2004).

There is no significant drop of the coal production during the Great Depression. We can see production slow down between 1930 and 1936 (Fig. 5), but in the total amount, there was

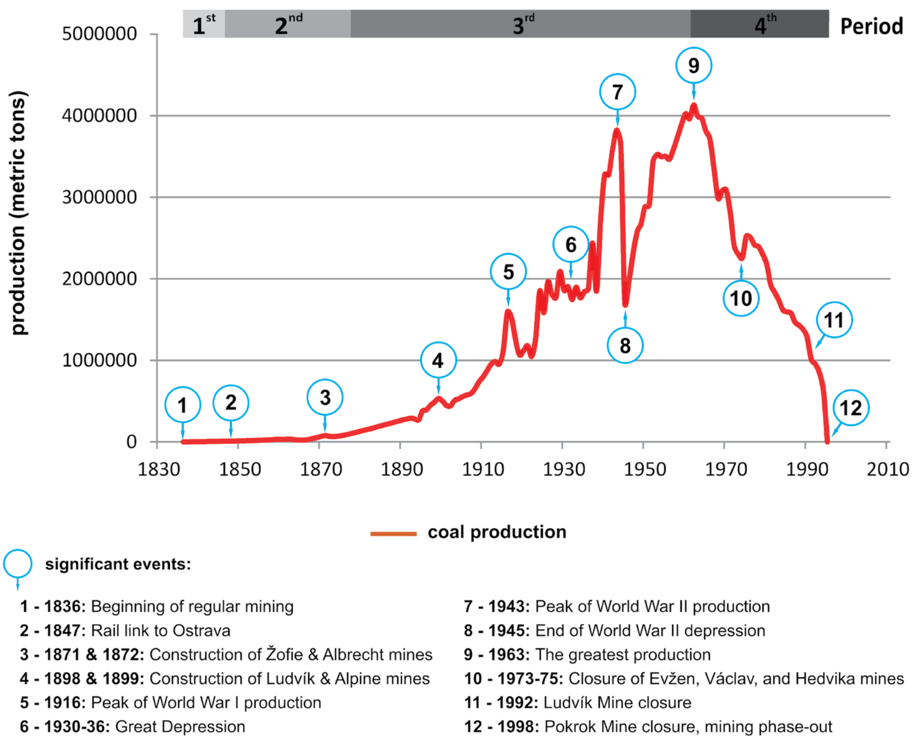

Fig. 5. Production of the mines in the Petřvald sub-basin and the most important moments in its development (Janáček et al. 1998)

Rys. 5. Produkcja węgla z kopalń subzagłębia Petřvald i najważniejsze momenty jego rozwoju just a 0.3 mil. t drop between 1929 and 1932, when the output was at its lowest. World War II production peaked in 1943 with the production of 3.8 mil. t, which dropped at the end of war to 45% of this amount (Fig. 5, Janáček et al. 1998). But the mine infrastructure remained almost intact, so there was no significant break in the production due to war damage.

All the mines were nationalized in 1945, after the end of WWII. An increasing trend in coal production after 1945 with a maximum output of almost 4.2 mil. t in 1963 (Fig. 5) was realized from the mines opened before 1912 (Janáček et al. 1998). No new shafts were constructed. Extraction shifted to the peripheral parts of the Petřvald sub-basin.

3.4. From the peak production to the phase-out of mining (1963 to 1998)

The fourth and final stage of mining development in the Petřvald part of the coalfield involved the phase-out of mining. Its first signs were generally observable after 1963, when production in the Petřvald part of the coalfield began to decline steadily (Dombrovský 2003; Klepek 2003 – Fig. 5). This was mainly the result of a decline in economically recoverable coal reserves primarily in the northern Petřvald area. The main limiting factors for the production were the main tectonic structures both from the east and west (Fig. 1C) and by erosional depressions of the Carboniferous surface from the north and south (Fig. 4) of the Petřvald sub-basin. Possible development to the deeper parts was also limited by the unfavorable geological situation described in the last paragraph.

In northern part of the sub-basin, mining was phased out at the Evžen Mine in 1974, at the Václav Mine in 1973 and, somewhat later, at the Albrecht (Hedvika) Mine in 1980. The Heinrich Mine was already closed earlier (1928). Even though mining in the Petřvald area was declining continuously, a sharp production downturn occurred in the 1990s. It was related to the transformation and restructuring of the Ostravsko-karvinské doly, Inc. mining company, which owned all the mines in the Petřvald part of the coalfield. After the transition to a market economy after 1989, the Ludvík Mine (of the J. Fučík Colliery) was affected by the first stage of the mining phase-out (1991–1992). The second phase-out stage (1993–1996) did not directly involve any mines in the Petřvald part of the coalfield. The third stage of the mining phase-out was stipulated by Government Resolution No. 558/1995 of the Czech Republic (GR 1995). It affected the Pokrok Mine (of the J. Fučík Colliery), where mining ceased in 1998.

As in the case of mine construction and mining development, the geological conditions of coal deposits also have a decisive influence on the phase-out and liquidation of mining operations at the deposit sites. All mines in this part of the coalfield exploited the coal seams of the upper part of the Ostrava Formation, thus those from the top down of the Poruba and Jaklovec members. The deepest seam of the Jaklovec Member is separated by a roughly 200 m thick barren sequence of sediments (i.e., the Enna group of marine horizons) from the nearest underlying coal seam, which already belongs to the Upper Hrušov Member. The seams of the Upper Hrušov Member are discontinuous, thin and contain higher amounts of ash. These geological factors were the main reasons why the mines in the Petřvald part of the coalfield were not deepened and why mining was usually terminated after the exhaustion of the lowest coal seam of the Jaklovec Member.

The increase of mining efficiency during this time can be described by following numbers – in 1894 was production ca. 128 t per person employed in mines, in 1911 ca. 260 t, in 1929 ca. 400 t, in 1953 ca. 408 t, and in 1976 ca. 520 t (calculation based on data from Klepek 2003).

4. Coal reserves and their utilization

At the present time, after ca. 200 years since the beginning of coal extraction, it is not possible to objectively determine the total amount of bituminous coal reserves in the Petřvald sub-basin. We only know the total extracted quantity, which is relatively reliable and varies according to sources from 202.5 mil. t (Janáček et al. 1998) to 205.0 mil. t (Dombrovský 2003). The vast majority of mining came from the Poruba and Jaklovec members. Coal mining from other lithostratigraphic units (the uppermost part of the Hrušov Member, the Lower Suchá and Saddle members) was significantly smaller (Janáček et al. 1998).

If we accept the average share of mineable reserves from geological reserves for the Poruba and Jaklovec units, we can work with values of 11.1%, resp. 12.1% (Dopita ed. 1997). It can, therefore, be estimated that the original geological reserves in the mining areas of the Petřvald sub-basin would be approximately 1700 million tons. Although estimates, the above figures were also verified by calculations from the mining area (ca. 46 km^2 – Janáček et al. 1998), the thickness of strata units and the coal-bearing capacity of given lithostratigraphic units (both in Dopita ed. 1997).

The residual reserved after the mine closure listed in the last reserve estimation proved 250 mil. t of bituminous coal in so-called geological reserves (total resources in English), but most of them in the category "potentially economic", meaning that they are currently unexploitable due to their unsuitability for technical and/or economical conditions of mining (Janáček et al. 1998).

5. Influence of the geological structure on their extraction history and the urbanistic development

The area of the Petřvald municipality comprised typical farmland before the discovery of coal seams. At the beginning of the 19th century, the population of Petřvald was around 1,000 inhabitants. The earliest period of mining starting in 1836 did not significantly influence the development of settlements. The mines had only a small number of miners, most of them probably seasonal workers who still worked mainly in agriculture. The initial production in the Petřvald part of the basin amounted to 326.7 tons in 1836 (Zářický 2004 – Fig. 5).

In subsequent years, output ranged between 2,000 and 4,000 tons and fluctuated sharply. It was not until 1850 that it exceeded 10,000 tons. The earliest record regarding the number of workers in the mining industry dates back to 1850. He mentions "about 250 miners". That year, Petřvald had a population of 1,397 (Zářický 2004).

The beginning of the second stage of mining development in 1842 brought a sharp increase in coal production. The output of the Petřvald mines amounted to 3,760 tons of coal in 1840, 35,528 tons in 1862, and as much as 77,315 tons in 1871. The population of Petřvald grew as well, surpassing 2,500 inhabitants (Fig. 6) in the early 1870s (Zářický 2004). The population growth was undoubtedly a result of new forms of housing provided for the miners in the coalfield. This involved the establishment of mining communities, so-called colonies. The first such settlement in the Petřvald area was the mining community of the Heinrich (Jindřich) Mine, which was established in 1866–1869 (Fig. 7). The younger community of the same mine, mine workers' housing Bedřich, dates back to 1879. The second oldest mining community in the Petřvald area was located at the Evžen Mine and named the mine workers' housing Evžen. It was built in 1873–1874 (Bílek 1966).

The construction of some settlements occurred in stages over a relatively long period. The location of these communities was usually determined by the location of lands owned by mining companies. Nevertheless, efforts were made to establish mining communities as close as possible to the mining companies. The short distance between homes and mines was important because miners went to work on foot. It must also be taken into account that 12-hour shifts were not changed to 10-hour shifts until 1890 (Myslivec 1929). Only some parts of the mining communities have survived to the present day.

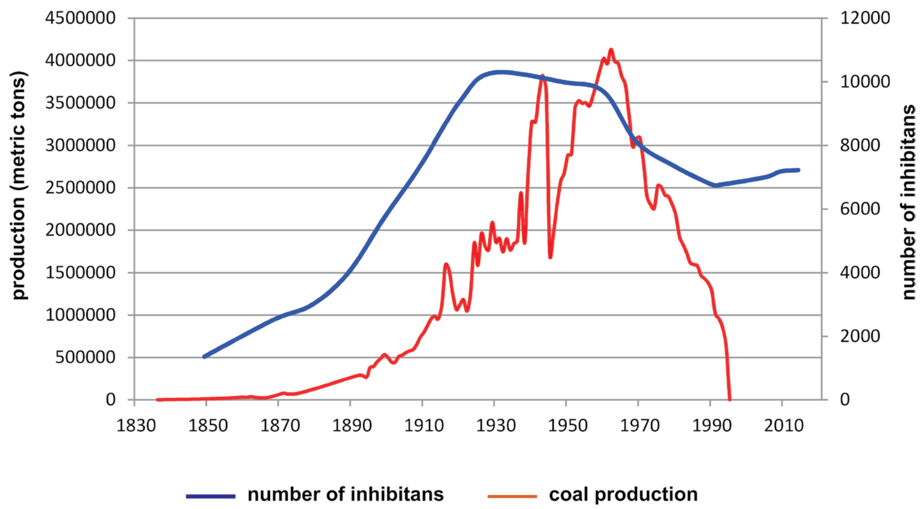

Fig. 6. Development of coal production in the Petřvald sub-basin and population growth in Petřvald (Klepek 2003; Zářický 2004)

Rys. 6. Rozwój produkcji węgla w subzagłębiu Petřvald i wzrost liczby ludności w Petřvald

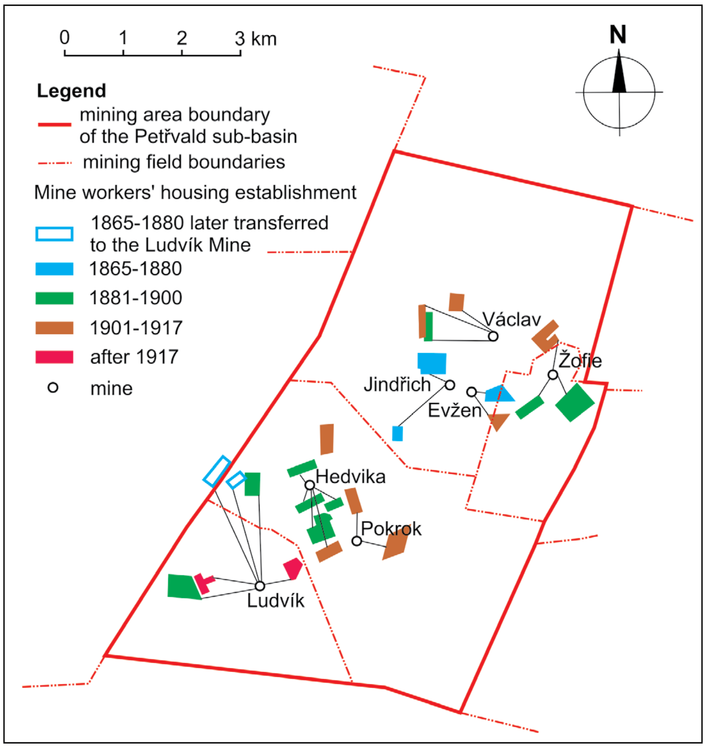

Fig. 7. Location of the mine workers' housing of the mines in the Petřvald sub-basin (Myslivec 1929; Matějíček 1985)

Rys. 7. Lokalizacja mieszkań pracowników kopalń subzagłębia Petřvald

The beginning of the third stage of mining development in the Petřvald area dates back to 1871. From a technological perspective, these mining sites represented a completely new level of mining in comparison with the mines of the second stage. Production and the population of Petřvald (Fig. 7) peaked during the third stage of mining development in the Petřvald area. However, the highest production was a reflection of the later modernization of individual mines after World War II. A total of 24 mining communities belonging to various mines were thus gradually established in the Petřvald area (Myslivec 1929; Bílek 1966). Each mine in the Petřvald part of the coalfield had a mining community.

The fourth and final stage of mining development (after 1963) is also reflected in the decline of the population of Petřvald (Zářický 2004 – Fig. 6). After the cease of mining in 1998 all the mines were phased-out and liquidated with the sole exception of the Žofie Mine, which is used to pump water from the abandoned and flooded mine works. The head-frame of the Pokrok (Habsburg) Mine stands to this day as well as that of the Žofie Mine. The complex of the Pokrok Mine was recognized as a cultural monument by the Ministry of Culture of the Czech Republic in 1997. Due to the critical conditions, parts of a complex were later removed from the list of cultural monuments and demolished. The only remaining cultural monument protected by the Czech legislation is the headframe itself (Matěj et al. 2009).

However, it is necessary to keep in mind, that our analysis is focused on Petřvald inhibitans, and not on the mining employees. The Petřvald municipality was, during the time, not the only source of employees for the local mining. While in 1890 the inhibitant/Petřvald sub-basin mining ratio of employees of 6:1, as soon as in 1900 it tured to 1.8:1. The most extreme was year 1961, when it became 0.9:1, meaning that mining employed more people than there was inhibitans in the town itself (based on the data from Dombrovský 2003).

Conclusion

The development of coal mining in the Petřvald area is largely a perfect example of the expansion of and decline in coal mining as typically reflected in the development of mining and the population in Petřvald (Fig. 6). Initially, mining grew relatively slowly, with typical rises in production due to the development of steel production and the construction of the railway network in the region of Ostrava. A further development of production, marked by increased growth dynamics and peaking mine production, is also typical. A gradual decline in output ensued mainly due to the exhaustion of the economically recoverable reserves of individual mines. The curve indicating the coal production of the Petřvald sub-basin is identical to the curve introduced by Hubbert (Hubbert 1956). The curve indicating the population of Petřvald, whose settlement in the 19^{th} and 20^{th} centuries was largely influenced the development of coal mining, has a similar shape. This curve also reflects the expansion, peak and gradual decline of mining in the Petřvald area.

The example of the Petřvald sub-basin demonstrates that the exploitation of coal deposits usually develops in connection with their geological structure and location in the Earth's crust. Analyses also clearly show that the development of mining influences the development of settlements and communities in their vicinity. This fact, therefore, leads to the logical conclusion that the geological structure of deposits through mining development affects the development of communities and settlements within close range.

Coal mining in the Petřvald area and also in the more extensive areas of Ostrava and Karviná is undoubtedly an integral part of the history of the region´s development. The remaining technical monuments do not only demonstrate the technical ability of our ancestors but also their relationship to architecture and their way of life. That is why our attitude to the preservation of these monuments is also a measure of our connection to our past. Even though much has been done, it is important that these issues are given constant attention. Time cannot be stopped, and what is once demolished can hardly be rebuilt.

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INFLUENCE OF THE GEOLOGY OF COAL DEPOSITS ON THEIR EXTRACTION AND URBANISTIC DEVELOPMENT: A CASE STUDY OF PETŘVALD (CZECH PART OF THE UPPER SILESIAN BASIN)

Keywords

coal, coal mining, geological structure, urbanism, Hubbert curve

Abstract

Petřvald is a typical mining town in the Czech part of the Upper Silesian Basin. Since the Petřvald sub-basin is limited by significant tectonic structures, its development was to a great extent independent from other areas of the basin and can serve as an example of the influence of the geological structure on the development of mining and residential communities. In the first phase of mining development (ca 1830 to 1844) first claims begin to occur in the area. Thick coal seams were available in shallow depths. Due to missing railway connection, the demand for coal was not very large and the village economy was focused on agriculture. In the second phase (1844 to 1871), the first underground mines start to operate in the area. They were situated in favorable areas with thin overburden. Also, the connection to the railway improved the sale opportunities and a significant share of the local population worked in the mines. The third phase of mining (1871 to 1963) brought still increasing demand for coal, which resulted in establishing new coal mines in geologically less favorable areas (thicker overburden, water-bearing horizons). From the 1930s to the end of the 1950s the extraction peaked, which coincided with the urbanistic and cultural climax. New housing was provided for miners and their families by the companies. The final stage of mining development (1963 to 1998) is connected with the steady decline of production and phase-out of mining. The reason was a lack of economically recoverable coal reserves connected to unfavorable geological conditions. We conclude that the results of studies concerning specific geological parameters of coal deposits can be used for more detailed analyses regarding the development of urbanism, or to explain its causes.

WPŁYW GEOLOGII ZŁÓŻ WĘGLA NA ICH WYDOBYCIE I ROZWÓJ URBANISTYCZNY: STUDIUM PRZYPADKU PETŘVALD (CZESKA CZĘŚĆ GÓRNOŚLĄSKIEGO ZAGŁĘBIA WĘGLOWEGO)

Słowa kluczowe

węgiel, wydobycie węgla, struktura geologiczna, urbanistyka, krzywa Hubberta

Streszczenie

Petřvald jest typowym miastem górniczym w czeskiej części Górnośląskiego Zagłębia Węglowego. Ponieważ subzagłębie Petřvald jest ograniczone znacznymi strukturami tektonicznymi, jego rozwój był w dużej mierze niezależny od innych obszarów subzagłębia i może służyć jako przykład wpływu struktury geologicznej na rozwój wspólnot górniczych i mieszkalnych. W pierwszej fazie rozwoju górnictwa (ok. 1830–1844) w okolicy zaczynają pojawiać się pierwsze roszczenia.

Grube pokłady węgla były dostępne na płytkich głębokościach. Z powodu braku połączenia kolejowego zapotrzebowanie na węgiel nie było bardzo duże, a gospodarka wsi koncentrowała się na rolnictwie. W drugiej fazie (1844–1871) pierwsze podziemne kopalnie zaczęły działać na tym obszarze. Umieszczono je w sprzyjających obszarach z cienkim nadkładem. Połączenie z koleją poprawiło także możliwości sprzedaży i warunki życia znacznej części miejscowej ludności pracującej w kopalniach. Trzecia faza wydobycia (1871–1961) przyniosła wciąż rosnące zapotrzebowanie na węgiel, co zaowocowało utworzeniem nowych kopalń węgla na obszarach mniej korzystnych geologicznie (grubszy nadkład, poziomy wodonośne). Od lat trzydziestych do końca lat pięćdziesiątych ubiegłego wieku wydobycie osiągnęło szczyt, co zbiegło się w czasie z punktem kulminacyjnym urbanistyki i kultury. Firmy zapewniły nowe mieszkania dla górników i ich rodzin. Ostatni etap rozwoju górnictwa (1961–1998) związany jest ze stałym spadkiem produkcji i likwidacją wydobycia. Przyczyną był brak ekonomicznie wydobywalnych zasobów węgla związanych z niekorzystnymi warunkami geologicznymi. Stwierdzamy, że wyniki badań dotyczące konkretnych parametrów geologicznych złóż węgla można wykorzystać do bardziej szczegółowych analiz dotyczących rozwoju urbanistyki.