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ASSESSMENT OF DAMAGE CAUSES OF MONUMENTAL OBJECTS LOCATED IN MINING AREAS – CASE STUDY

The paper presents an example illustrating the problems of assessing the causes of damage that occurred to building structures located in mining and post-mining area. It is frequently necessary to determine whether probable damages came from other, non-mining causes or were caused by underground mining. This issue is particularly significant when it comes to monumental, historical objects because the cost of repairs is typically very high. The purpose of this work is to demonstrate, using the magnificent church as an example, that damage to building objects situated in mining areas does not necessarily result from mining activities. As a result, every such situation should be thoroughly evaluated to determine whether such a relationship exists. For the assessment of such a conclusion, multidirectional studies in the framework of this work were carried out: hydrogeological, mining and technical factors that cause the damage to the church building in question were analysed.

Keywords: mine closure; hydrogeological changes; mining impact on building structures; mining damages; protection of mining areas

1. Introduction

The negative impact of mining on the environment has been the subject of numerous studies and publications [10,11,25,34,40]. The literature indicates that this impact results in the most significant issues in terms of the development of both continuous and discontinuous deformations of the rock mass as well as modifications to the water conditions [34]. It is clear that in the

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case of the deformation of a mining area, the problem mainly comes down to damage inflicted on buildings as well as objects of technical infrastructure.

The work [17] indicated numerous aspects related to the impact that mining extraction had on buildings, such as material, economic, social and environmental damage.

The impact that mining extraction has on buildings should not only be considered in terms of the development of continuous and discontinuous deformations but should also take into account the changes to hydrographical conditions [1,32,34,39]. They are manifested by the occurrence of floodplain areas and inundations [11,19], along with the changes to groundwater levels [21,28,38,45], regardless of the method used for coal deposits extraction (underground, opencast or borehole). Mining-induced high-energy tremors of rock mass on the buildings pose a separate problem [20], especially when they occur repeatedly [7]. Consideration should be given to the joint impact of both effects of mining stated above, namely deformations and shocks [35], which increase the likelihood of building damage. A broad spectrum of impacts that coal mining had on buildings was presented in the works: [8,25,29].

In many cases, the deposits of useful minerals lie beneath highly urbanised areas. In such cases extracting such deposits, especially with underground methods, is much more difficult and requires mining and construction prevention [9]. Investments in mining and post-mining areas require using good judgement and deep analyses aimed at determining the kind of structures that could be erected in specific areas [30,31].

Rational spatial planning of mining areas requires, firstly, adequate mathematical methods of forecasting deformations [11,24,25,34,40] as well as appropriate computer software [2,37]. Based on the obtained forecasts of deformations, it is possible to design appropriate protection measures against the influence of mining on existing and planned constructions [22,25,27]. Moreover, mining continues to have an impact on the environment after the extraction is finished. The post-mining impacts include the development of continuous [3] and discontinuous deformations [36], gases emission [43], as well as very serious changes in hydrographical conditions [12].

Hence, it is clear that construction works in mining areas are exposed to the threat of considerable damage [16,44]. But mining-geological law in Poland imposes on mining entrepreneurs to develop all the necessary preservation works before extraction is started, together with repairs when the extraction is finished. With such an arrangement of underground mining plans taking into account the minimisation of mining impact on the surface, underground extraction may be led effectively in highly urbanised areas, even under, or in the vicinity of monumental, historical objects. Protecting and revitalising historic buildings, which are often sacred objects, requires a particularly great deal of effort and expertise, also related to legislation. In Poland, mining extraction has been carried out under several such buildings, ensuring the conditions for their continued operation through appropriate mining prevention methods [26] as well as construction ones [13,14,18]. Of particular interest is the innovative structural protection of the church building in Ruda Śląska – Wirek, which allowed the building to be used without danger [26]. The church building in Bytom – Miechowice [5] can also be mentioned among sacral buildings effectively secured against mining influences.

It is important to keep in mind that structural damage can occur from factors beyond just underground mining. According to [34], other factors also contribute to damage. These factors include structural wear and tear, as well as industrial, biological and soil factors, among others. Therefore, damage to buildings in mining areas should not be automatically associated with the extraction of mineral deposits [4,6]. To determine the causes of damage inflicted on buildings, a thorough analysis should be conducted by experts in mining, geology and civil engineering.

The next sections of this paper present the results of the analysis conducted for the monumental church building located in one of Upper Silesia cities, where some damages occurred, so it was necessary to determine if they were tied with underground mining activity in the past.

2. The characteristics of the object and its technical state

The building of the Basilica of Saint Mary of the Angels in Dąbrowa Górnicza city was built in the 2nd half of the 19th century in the Neo-Gothic style – Fig. 1. It is made of two architectural structures: the church of Saint Alexander is the original structure built between 1875 and 1877, whereas the main structure of the Basilica, built between 1898 and 1912, was formally built as an expansion to the original church. The new structure was constructed at the entry to the old church after the demolition of the old bell towers (Fig. 2).

Fig. 1. General view of the church building

Fig. 2. The original church of Saint Alexander together with the adjacent Basilica object

The main building of the church consists of three aisles, with the main aisle on the eastern side of the building ending with the apse and presbytery. There are two transverse aisles set crosswise to the nave corpus: the eastern transept designed on the side of the presbytery and the western transept located at the main entry to the Basilica. On the northern side of the western transept, there is a passage to the original church, which serves as a side chapel (Fig. 2).

There is an approx. 15 cm threshold in the floor in the passage from the building of the Basilica to the original church. It is separated by a steel rail, which is slightly bulged, while the tiles in its vicinity are loose – Fig. 3.

The main entrance to the Basilica is expanded with three towers. The fundamental dimensions of the building are: 68 m long and 30 m wide in the transepts, whereas the main aisle is 20 m high and the main tower is 86 m high. The church is made of brick, covered with brick rib and stellar vaults, and a wooden rafter framing. The building has no heating system.

Fig. 3. Threshold in the floor between the original church and the Basilica

In the second half of the 90s of the 20th-century renovation works began. The renovation was conducted in stages that continue till today. The renovation of the main and southern towers was completed in 2005. A program of conservatory works was conducted in 2007, according to which the northern tower was renovated, and subsequently, polychromy was also restored. The damage to the structure was primarily caused by environmental factors. The surface of the face brick was affected by corrosive chemical processes and fungal attack, resulting in efflorescence. Additionally, climate-related factors contributed to the deterioration of the grouts and mortar, causing further damage to the structure. The outer surface of the face brick was also affected, resulting in blubs, scalings, and defects. Vertical cracks were present in brick pinnacles, buttresses, and straining arches, as well as other instances of damaged façade layers in the brick construction. A complex renovation comprised cleaning the surface, bricking the cracks, and filling in the damage in walls and grouts, as well as structural hydrophobisation. The works were carried out under the supervision of the conservator based on conservator documentation.

In 2006, numerous instances of damage to the ceramic tile floor were observed. The damage was concentrated mainly in the transverse aisles: in the eastern and western transepts as well as in the apse. The tiles were loosened, uplifted and cracked – Fig. 4.

Fig. 4. Damaged floor tiles

Taking into account the location of the church in the post-mining area, it was necessary to analyse if former mining activities could have caused the damage observed in the building after 2006.

Therefore, the possible effects of the following mining-related factors were analysed: a direct mining impact manifested as continuous deformations (subsidence troughs), discontinuous deformations, tremors of mining origin, as well as changes in hydrographical conditions due to mining operations. A detailed review of the aforementioned factors, along with the assessment of their potentially detrimental effect on the building was presented in the subsequent part of this paper.

3. The analysis of geological and mining conditions

3.1. The structure of the rock mass

The rock mass in the vicinity of the church is made of the beds of the Quaternary and Carboniferous layers. The Quaternary overburden is made of yellow-rusty as well as grey, dusty and fine-grained sand. There are also clays in some places. The total thickness of these formations ranges from approx. 4 m to approx. 12 m. Underneath the beds of the Quaternary, productive Carbon in the form of the "Rudzkie" coal beds (this name and others throughout the paper are used according to the Polish classification of Carboniferous layers) made of alternating sandstones and clay shale occurs. Sandstones constitute the vast majority of the strata, and the thickest layer is 24.5 m thick. The "Siodłowe" coal beds lay under the "Rudzkie" coal beds. The main bed of these strata – the 510 coal bed, is located on their roof. The structure of the rock mass is illustrated in the geological cross-section below – Fig. 5.

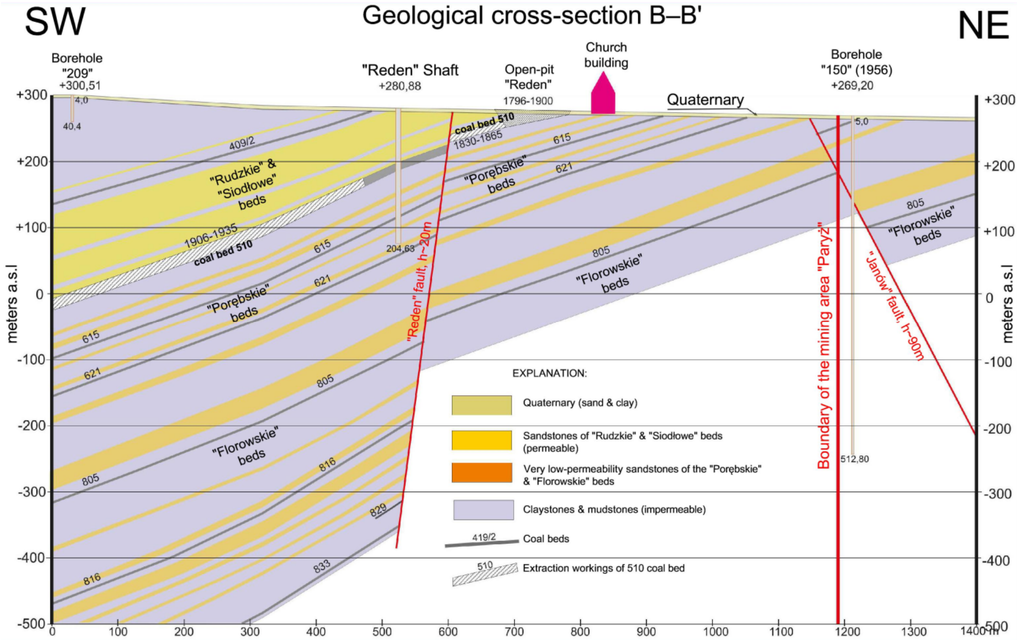

Fig. 5. Geological cross-section through the rock mass in the vicinity of the church

3.2. Tectonics

The rock mass in the study area is formed from regular layers – no continuous folding deformations are observed. The strike direction of the rock mass layers follows a north-west to south-east direction. The strata dip in a south-west direction; the angle of the dip is approximately equal to 15°.

Two tectonic faults are located in the area of the church: the "Janów" fault and the "Reden" fault. Both of these faults are oriented from the north-west to the south-east. The outcrop of the "Janów" fault at the Carbon roof is formed at a horizontal distance of approximately 235 m from the building. It is a northeast dipping fault with a throw of $h = 90$ m. There is another north-west to south-east facing fault splitting away from this fault with south-westward throws of $h = 15$ m. The "Reden" fault ranges east of the "Reden" shaft and west of borehole No. 153. It is a south-west dipping fault in the north part of the fault plane and a westward dipping fault in the south part of the fault plane of $h = 20$ m height.

The building is located approximately 150 m away from the outcrop of this fault. The location of these faults against the position of the church building, together with the general rock-mass structure is shown in Fig. 5.

As can be seen from this sketch, the relatively great distance between the nearest located outcrops of faults and the direction of faults' dip "outside" the building location concludes that the presence of tectonic disturbances did not affect the church's technical condition.

4. The analysis of the impact of selected factors on the damage to the church building elements

4.1. Old coal mining and its possible impact on the church building

In the direct neighbourhood of the building, open pit mining of the 510 coal bed at the outcrop was conducted in the past. The boundaries of mining extraction were marked with the outcrop located approximately 30 m away from the building – Fig. 6.

Open pit mining was conducted between 1863 and 1905. According to the archival maps, underground mining to the south of the open pit was conducted until 1918. Whereas near the church, underground mining was conducted to the west of the open pit and north of the "Reden" shaft. The last extraction in the vicinity of the building (to the south of it) was conducted in the 1930s. It should be noted that at that time, the shortwall mining method was applied for underground mining. According to the mining maps, the open pit was then used to drive roadways accessing coal beds and preparing for underground extraction. The liquidation of the open pits commenced at the end of 1945 using slag from the nearby still plant. The area of the former open pit was transformed into a 50 ha park, which exists today – Fig. 7.

At a greater distance from the building (over 1000 m), the "Brzeżne" layers were mined with underground methods. The mine was closed in 1995.

Fig. 6. General view of the "Reden" open pit of the 510 coal bed. This photograph was taken in the early 20th century. (source: http:\www.eksploratorzy.com.pl)

Fig. 7. General view of the park in the former open-pit mine area

In order to determine the impact of underground mining, calculations of the influence of the entire extraction carried out in the vicinity of the church were made. The calculations were based on the Budryk-Knothe theory [24] and the DEFK-Win computer programme [37]. The following parameter values were taken:

- coefficient of roof control a = 0.8,
- Parameter describing the influence range: tgβ = 2.0.

The dipping of the bed was not taken into account in the calculations, because this would result in distancing the building from the impact range of mining. This could result in a misinterpretation as regards the assessment of the impact of underground mining on the building. Fig. 8 shows the location of the underground and open-pit workings in the 510 coal bed against the location of the church building. The figure also shows the limit of the influence range (green line). The impact of underground mining ranged from approximately 96 m away from the building. Therefore the church building was not directly impacted by the past underground mining. Unfortunately, confirmation of the accuracy of the calculations through geodesic measurements is impossible due to their absence.

To analyse the risks associated with the possible occurrence of discontinuous deformations, maps of deposits as well as the map of the roof Carbon layers and applicable cross-sections were analysed. According to the data, it can be concluded:

- Due to the lack of shallow underground mining workings in the direct vicinity of the church, there is no risk of sinkholes formation,
- The only factor that may cause linear discontinuous deformations are outcrops of the faults on the roof of Carboniferous beds due to possible fault slip. Fig. 5 shows the location of the faults in the area of the building. The large distance of the faults outcrops excludes the possibility that such deformations were formed.

The possible impact of mining-originating tremors on building damage was also assessed. It was concluded that at the time when the damage was caused to the building, there were no rock mass tremors with epicentres within a dozen or so km from the church.

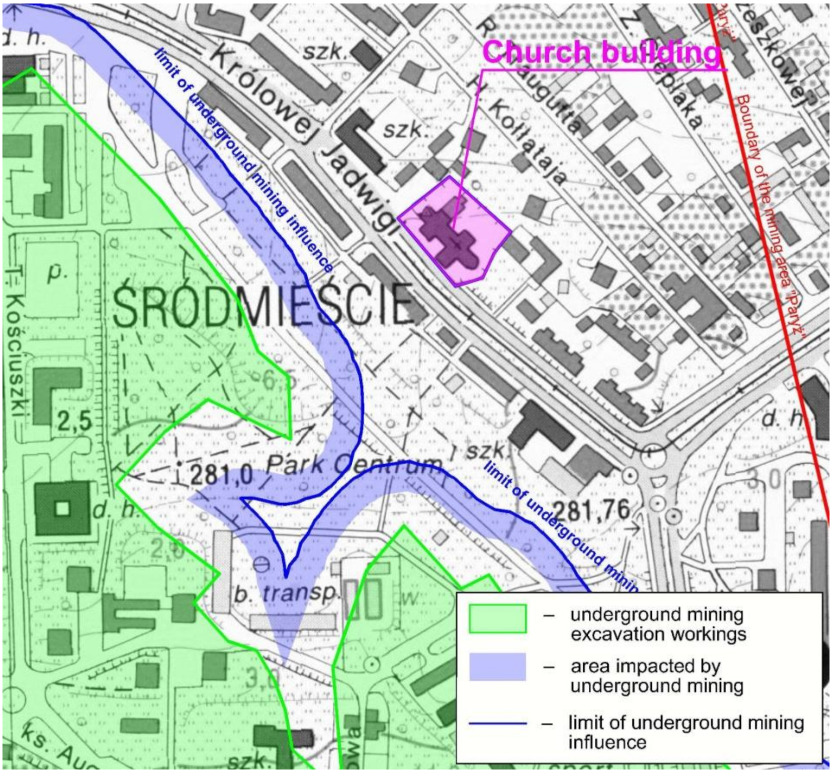

Fig. 8. Calculated the limit of influence of the underground mining carried out in the past in the area of the church

4.2. The impact of the mine liquidation on the changes in hydrographical conditions

The active "P" mine was drained through a system of stationary pumping stations, located at the main shafts at the depths of 250 m and 390 m. There were several field pumping stations in the mining fields, which were forcing the water to flow from the mine workings to the main levels. Between 1990 and 1991, the water supply to the mine was about 21.0 m^3/min, including approximately 16.0 m^3/min on the level of 250 m, and approx. 5.0 m^3/min on the level of 390 m. The average depth of the Carboniferous rock mass draining through the mine workings can be assumed to be –120 m a.s.l. (ordinate of level 390 m), the maximum depth of draining –240 m a.s.l. (vertical ordinate of the deepest underground extraction works).

The closure of the mine and termination of mining in June 1995 did not allow for the shutdown of the drainage system of the closed mine due to the need to protect the active mines against water hazards. It turned out that it was necessary to continue pumping water from the workings of the closed mine.

Currently, the water level in the abandoned workings of the "P" mine is approximately +110 m above sea level. As on 31 August 2020, the water level in the workings was +108.3 m a.s.l. The valid allowable impoundage of water is +140 m a.s.l. Water supply to the submersible pumping station in the "C" shaft between 2015 and 2020 was, on average, 10 m^3/min.

In the area under consideration, the drainage of the rock mass by mining works resulted in the development of a cone of depression in the water-bearing Quaternary sandy aquifers, the range of which included the area of the building. The quaternary layers were drained already at the end of the 18th century due to the "Reden" open-pit mine, and then they were driven deeper as underground mine workings. The cone of depression formed in the Quaternary in the area of the outcrop of the goafs of the 510 coal bed and overwhelming sandstones of the lower "Rudzkie" coal beds has not changed significantly since the open-pit mine "Reden" was launched. This state has continued uninterruptedly until the present day and has been ongoing for over 200 years. This situation may change only if the draining of the former "P" mine is stopped, and the mine will be completely flooded. This will allow the groundwater table to return to the state close to the original one, and the cone of depression in the Quaternary formations will be filled. The groundwater will then return to the natural catchment cycle based on surface watercourses.

The difference in the water circulation patterns in the Quaternary and Carboniferous formations in the discussed area during the mine's operation and at present is only in the method of collecting the water flowing into the workings. During the mine's operation, the primary drainage pumps were used to collect water. However, at present, submersible pumps collect water from a reservoir created in the old flooded workings, as shown in Figs. 9 and 10.

Changing the position of the water table causes a change in the stresses in the water-logged rock mass, which results in deformations of the aquifer [33,41,45]. When the hydrostatic pressure is lowered, the aquifer settles as a result of increasing load. The magnitude of ground subsidence depends on the size of the depression formed, the thickness of the aquifer and the mechanical properties of the rocks expressed by their modulus of compression.

The size of soil settlements caused by lowering the water level could be determined based on the formula [33,34]:

$$w = \frac{\Delta\gamma \cdot S}{M}\left(H - S + \frac{S}{2}\right) = \frac{0.008 \cdot 3}{50}\left(4 - 3 + \frac{3}{2}\right) = 0.0012\,\text{m} = 1.2\,\text{mm} \tag{1}$$

where:

H — original thickness of the drained aquifer with unconfined water table, $H = 4$ m,
S — the size of depression in the potentiometric surface, $S = 3$ m,
$\Delta\gamma$ — increase in the unit weight due to the elimination of upthrust,
$\Delta\gamma = \gamma_w \cdot (1 - n) = 0.01 \cdot (1 - 0.20) = 0.008$ MN/m^3,
γ_w — specific weight of water, 1 G/cm^3 = 0.01 MN/m^3,
n — soil porosity, $n = 0.20$,
M — modulus of compression of water accumulated soil, the value of which for semi-dense sand ranges between 50 and 100 MPa [42]; the lower value from the given range was adopted $M = 50$ MPa.

Taking into account the values of the calculated subsidence of the area (approximately 1.2 mm), any relation between the existing damage to the subject building and changes in hydrostatic pressures in the soil should be excluded.

4.3. The possibility of suffosion occurring at the foundation of the building

In mining regions with sandy rocks in the Carboniferous overburden, the process of mechanical suffosion might be initiated, and filtration deformations of soil might occur in the area of the cone of depression as a result of drainage. The water movement in sandy soils may disturb their structure and lead to the destruction and deformation of the soil skeleton. Such hydrogeological processes could result in the formation of sinkholes, which is observed not only in mining or post-mining areas, as shown in the work e.g. [15].

Seepage water exerts pressure on soil particles in the direction of their movement called runoff pressure, the value of which is proportional to the hydraulic gradient:

$$P_s = \gamma_w \cdot i \tag{2}$$

where:

γ_w — specific weight of water,
i — hydraulic gradient.

The occurrence of suffosion depends on hydrodynamic conditions (hydraulic gradient) and structural conditions (heterogeneity in grain size distribution and types of soil). In sandy soils, the process of mechanical suffosion is initiated when hydraulic gradients reach the value of one, which occurs most often during a free vertical downward filtration, when the hydraulic gradient reaches the value: $i = 1$.

The formation of the water table in the Quaternary formations within the range of the cone of depression was approximated on the basis of the model of the unconfined aquifer fed by the infiltration of atmospheric precipitation [33,41]. The equation of the depression curve of the unconfined aquifer with water filtration in a parallel stream is:

$$y = \sqrt{h_0^2 + \frac{h_1^2 - h_0^2}{a} \cdot x} \tag{3}$$

The hydraulic gradient of the unconfined water table along the depression curve can be determined from the formula:

$$i = \frac{h_1^2 - h_0^2}{2a \cdot \sqrt{h_0^2 + \frac{h_1^2 - h_0^2}{a} \cdot x}} \tag{4}$$

where:

y — height of the lowered water table (hydrostatic pressure) at a distance x from the drainage zone,
i — hydraulic head gradient of unconfined water table,

h_0 — the height of the lowered water level at the initial point of the cone of depression, where $x = 0$ (at the point of the outflow of water from the aquifer into the open-pit zone filled with made ground), the taken value of $h_0 = 0.1$ m,

h_1 — the height of the lowered water level at the point of the cone of depression, which corresponds to the central point of the building (where $x = a$), the taken value $h_1 = 1.0$ m,

a — distance from the starting point to the point corresponding to the centre of the building ($x = a$).

The results of the calculations of the basic parameters of the depression cone, such as the position of the free water table and the amount of hydraulic slope along the depression curve, are presented in Table 1. The shape of the depression curve in the Quaternary aquifer due to the influence of mining drainage is shown in Fig. 9.

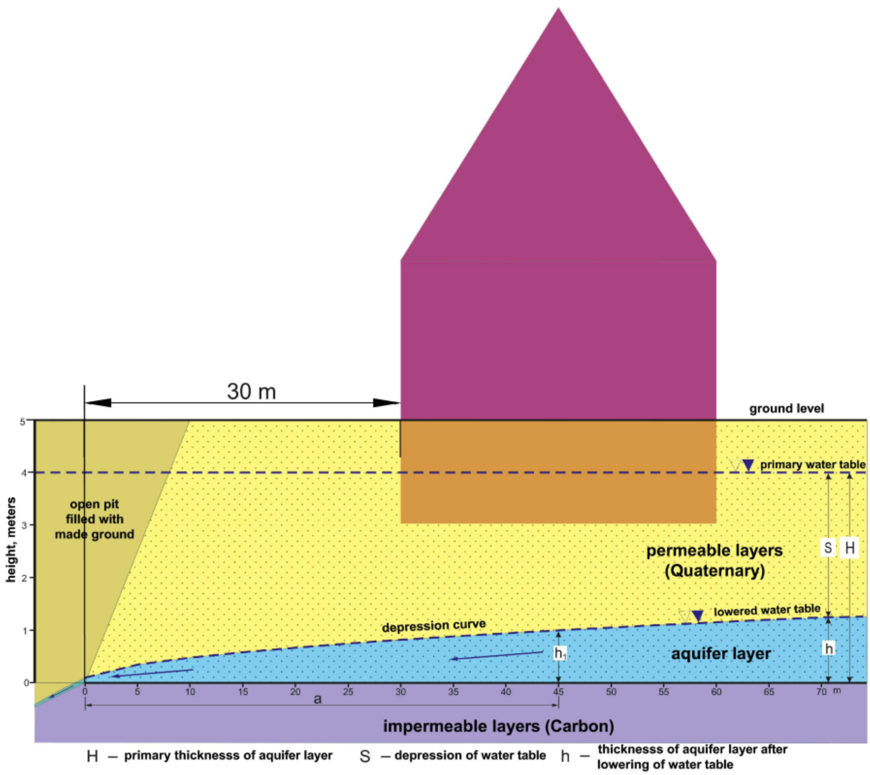

Fig. 9. The cone of depression in the Quaternary aquifer in the vicinity of the church

The hydraulic (head) gradient of the unconfined water table in the area of the cone of depression, in the area under the building, was assumed at the value of approximately $i = 0.008$ on the east side of the building (at distance $x = 60$ m) to approximately $i = 0.016$ on the west side (at distance $x = 30$ m).

TABLE 1

Parameters of the cone of depression developed in the Quaternary aquifer in the vicinity of the church

No.	Distance	Water table height at distance "x"	Hydraulic head gradient	Comments
	x	y	i	
	[m]	[m]		
1	0	0.10	1.100	
2	5	0.35	0.092	
3	10	0.48	0.048	
4	15	0.58	0.032	
5	20	0.67	0.024	
6	25	0.75	0.020	area inside the building outline
7	30	0.82	0.016	
8	35	0.88	0.014	
9	40	0.94	0.012	
10	45	1.00	0.011	
11	50	1.05	0.010	
12	55	1.10	0.009	
13	60	1.15	0.008	
14	65	1.20	0.008	
15	70	1.24	0.007	

The results allow us to exclude the possibility of the occurrence of mechanical suffosion in the sandy soils of the Quaternary layers as a result of the formation of the cone of depression due to mine drainage in the Quaternary aquifer layer and water filtration on the cone of depression in the direction of abandoned workings of the 510 coal bed. In conclusion, it should be stated that the existing damage to the church building cannot be associated with mining works of the former "P" mine and with the currently ongoing partial flooding of the mine workings, including changes in water damming in the abandoned workings.

4.4. Deformations related to the change of hydrostatic pressure in Carboniferous sandstones of the "Brzeżne" beds

The Carboniferous beds (the "Brzeżne" beds) under the church comprise mainly impermeable rocks (claystones and mudstones) and secondarily thin layers of poorly permeable sandstones. From the Carboniferous beds to the depth of the coal bed No. 816 (approx. 370 m thick rock complex), sandstones account for approximately 25% of the Carboniferous beds (approx. 92.5 m).

Water-bearing Carboniferous sandstones of the "Brzeżne" beds (sandstones of the "Porębskie" and the "Florowskie" beds), which occur in the deep ground of the building, were drained only locally in the area located at a considerable distance from the church. In general, the cone of depression has a low range due to the limited depth and low permeability of Carboniferous sandstones.

Due to the drainage of the rock mass by underground workings and then subsequent flooding of these workings, changes in hydrostatic pressures of the aquiferous layers occur within the boundaries of the cone of depression. Changes in the hydrostatic pressure cause changes in the stress state in the water-logged rock mass, which result in elastic deformations of the aquifer [33]. When the hydrostatic pressure is lowered, the layer settles as a result of increasing load, whereas when the hydrostatic pressure increases, the layer expands and lifts again. The size of vertical (elastic) deformations depends mainly on the magnitude of changes in the hydrostatic pressure, the thickness of the aquifer as well as the mechanical properties of the rocks expressed by their elastic modulus.

The maximum possible depression of the potentiometric surface of the aquiferous layers of Carboniferous sandstones, which occur at the foundation of the building, was estimated at 100 m (Fig. 10).

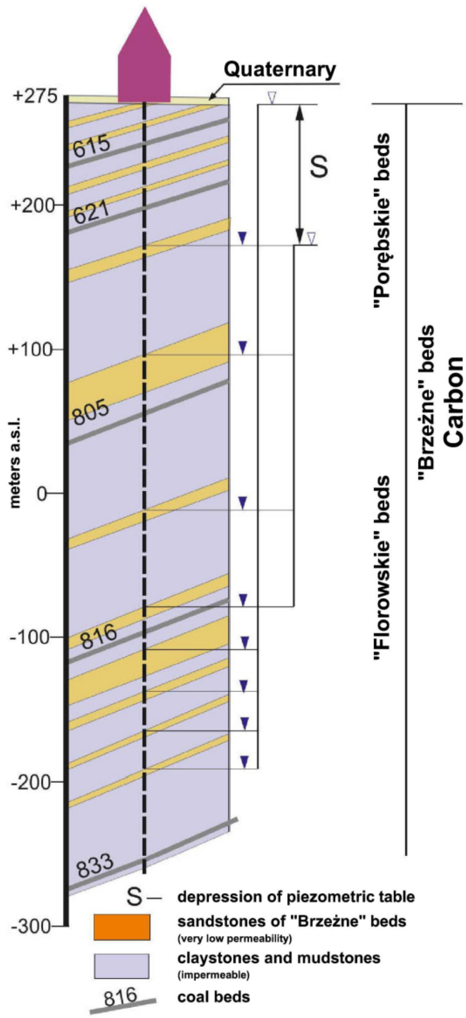

Fig. 10. Calculation scheme for ground subsidence caused by lowering of the hydrostatic pressure of Carboniferous sandstones

The following formula was used to determine the size of the subsidence of aquifers caused by hydrostatic pressure changes [33]:

$$w = \frac{m \cdot \Delta\sigma}{E} = \frac{92.5 \cdot 1.0}{11000} = 0.0084\,\mathrm{m} = 8.4\,\mathrm{mm} \tag{5}$$

where:

- m — thickness of the drained aquifers, $m = 92.5$ m,
- $\Delta\sigma$ — load increase as a result of lower hydrostatic pressure, MPa, $\Delta\sigma = S \cdot \gamma_w = 100 \cdot 0.01 = 1$ MPa
- S — the size of depression in the potentiometric surface, $S = 100$ m,
- γ_w — specific gravity of water, 1 G/cm^3 = 0.01 MN/m^3 (0.01 MPa/m),
- E — modulus of elasticity of rock, the value of which for compact Carboniferous sandstones ranges between 11000-12800 MPa [11,23]; the lower value from the above-mentioned range was taken $E = 11000$ MPa.

Taking into account the value of the calculated subsidence of the area (approximately 8.4 mm), the relation between the existing building damage and changes in hydrostatic pressures in the Carboniferous rock mass should be excluded.

The changes in the hydrostatic pressure system in the aquifers drained by mining excavations, and then pressure build-up in the rock mass as a result of flooding of the former mine did not cause significant deformations that could pose a threat to the building in the area where the church is located.

5. Possible causes of building floor damage

After conducting a study, it was found that there is no direct link between the damage to the church's floor and the impact of previous mining operations. The analysis included geological, mining and hydrogeological conditions in the area of the building.

Non-mining factors that should be considered here as potentially having an impact on the state of the floor include the conditions of the foundation, in particular, the poor load-bearing capacity of the ground or soil that's been subjected to frost-heave. However, the good state of the load-bearing structure of the walls, ground walls, and visible foundation wall fragments does not suggest localised ground heaving forces or uneven ground compression.

A reliable assessment of the actual geotechnical conditions of the foundation of the existing building is possible only based on in situ tests performed according to the design documentation.

Subsequently, other causes of damage should be considered, such as those resulting directly from the floor construction methods and means of utilising the building. A similar conclusion should be made concerning the aforementioned causes, as only local unveiling of the ground under the floor would allow us to determine the floor construction method, and to assess the foundation layers, their type and condition.

Based on the analysis of the building, it can be assumed that the ceramic floor in the aisles and transepts is not original. This may be indicated primarily by the existing difference in the floor levels between the main church and the original structure constituting the northern chapel. The place of the wall plinth in the passageway between the parts of the building shows a visible gross geometric disproportion between the massive wall and the height of the plinth in the area of the church.

It also seems improbable that the constructors responsible for the expansion of the building carried out between 1898 and 1912 weren't concerned about connecting the new and the original building on the same floor level, especially considering the great care taken with regard to other architectural details. Therefore, it should be assumed that the level of the floor within the main building was initially equal to the level of the stone floor of the original church. Probably in subsequent periods of use, an additional layer of backfill was laid on the surface of the floor, on which ceramic tiles, visible to this day, were placed. It can also be assumed that for some reason they were placed on the "old" floor, hence the difference in the levels. However, the unveiling of the ground under the floor would be necessary to verify this. It should be emphasised that no signs of high natural wear of the tiles have been noticed on the surface of the floor, and in such a long period of use, one should expect the occurrence of areas of increased abrasion, and surface treading, especially in passageways.

When analysing the geometric conditions from the outside, it should be noted that the floor level in the building in relation to the ground level is significantly raised. From the side of the main entrance to the building, the difference between the floor and ground levels is currently approx. 1.0 m. In such a situation, any possible increase in the floor level in the church by approx. 15 cm was not a big problem, especially since the entrance stairs had certainly been replaced or rebuilt.

The floor laid within the main building of the church was not dilated, and as a result, it consists of a very large single horizontal plane. Additionally, the tiles were laid without grouting. It can be assumed that the problem with the uplifting of the ceramic floor tiles results from their instalment on the primary base using a layer of backfill material of an unknown origin and without gaps between the tiles. Such a structure is very sensitive to thermal and humidity changes resulting from the so-called normal conditions of use of the facility. When washing the floor, moisture might penetrate the foundation layer, and because the building is not heated and the foundation has been "closed" between "new and old" tiles, the draining of moisture is limited. In addition, frequent washing of the floor is performed in the autumn and winter periods, when the outside temperatures are low and sub-zero. Therefore, it can be assumed that in the closed foundation, the phenomenon of freezing and heaving of the backfill material might have occurred, which caused the floor to be elevated.

6. Conclusions

Based on the analysis carried out as part of this work, the following conclusions and final comments are presented:

1. Damage to the church floor did not directly result from earlier mining operations. This is indicated by the long time that passed since the end of mining extraction in the area of the building (in the 1930s), as well as the lack of damage to walls and other building structures. Moreover, according to the results of the presented calculations, the building was outside the range of the influence of underground mining.
2. There were no epicentres of rock mass tremors caused by mining extraction within a dozen or so kilometres from the building; hence, rock mass tremors could not have caused the observed damage.

3. The possible impact of hydrological changes in the rock mass on the building damage could be also eliminated based on the analysis of changes in underground water conditions. There was also no possibility of suffosion or deformations caused by the dehydration of the Carboniferous sandstones of the "Brzeżne" beds.
4. Technical errors during the repair works connected with the replacement of the floor, which were indicated in point 5 of the article, are the most likely causes of damage to the floor.
5. The example presented in this paper shows the need for an in-depth analysis of the causes of damage to buildings located in mining and post-mining areas. Often, unjustified assumptions are made that mining is the cause of damage to a building simply based on the building being in close proximity to a mining area.

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