Hydrogeological conditions and consequences of closing down the "Gliwice" colliery

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Abstract: The main factors that have decided about adopted plan and method of carrying out the process of closing down of the "Gliwice" colliery have been characterised on the background of hydrogeological bed layout and mining conditions. The option of turning the main de-watering system off and complete flooding of the liquidated colliery in the aspect of water risk to the adjacent operating collieries as well as danger to the natural environment because of change of water relationships in the mass rock has been evaluated.

1 INTRODUCTION

Ceasing water pumping and flooding the workings is the most convenient solution for colliery liquidation, because both of the economical and environment protection reasons. In this way all the costs referred to further water pumping and salted water dump are completely eliminated. However, because of possible occurring of water risk within the regions adjacent to the flooded cavings, especially at high hydrostatic pressures, providing secure conditions for adjacent mining plants is the basic condition on which water may be dammed up in cavings of the flooded colliery. It is why possible hydraulic contacts that occur within the border zones between the liquidated colliery and the operating mines in the neighbourhood will decide about possibility of flooding the colliery being closed down.

Preliminary analysis of hydraulic connections between the "Gliwice" colliery and the adjacent coal mines revealed no direct hydraulic connections, what indicated possibility of total flooding of the colliery (Szewczyk, Darski, Maszczyk, 1995). Although, in light of detailed analysis of hydrogeological and mining conditions, flooding the "Gliwice" colliery turned out to be much more sophisticated problem that it seemed to be before and such a solution was not accepted to be carried out (Drzęźla, Cempiel, Kozyra *et al.,* 1999). In this paper the main factors that have decided about the way of closing down of the "Gliwice" colliery have been characterised on the background of hydrogeological bed layout and mining conditions.

2 GEOLOGICAL AND MINING CONDITIONS

The “Gliwice” colliery is situated in the North - West part of The Upper Silesian Coal Basin; area of the mining area is 101.7 sq. km. The colliery borders, on the East, on the former “Pstrowski” colliery, and on the South – East and the South, on the “Sośnica” and the “Knurów” collieries (Figure. 1). The “Gliwice” colliery started its mining activity in 1913; since that time until 1998, over 65 million Mg of coking coal have been outputted.

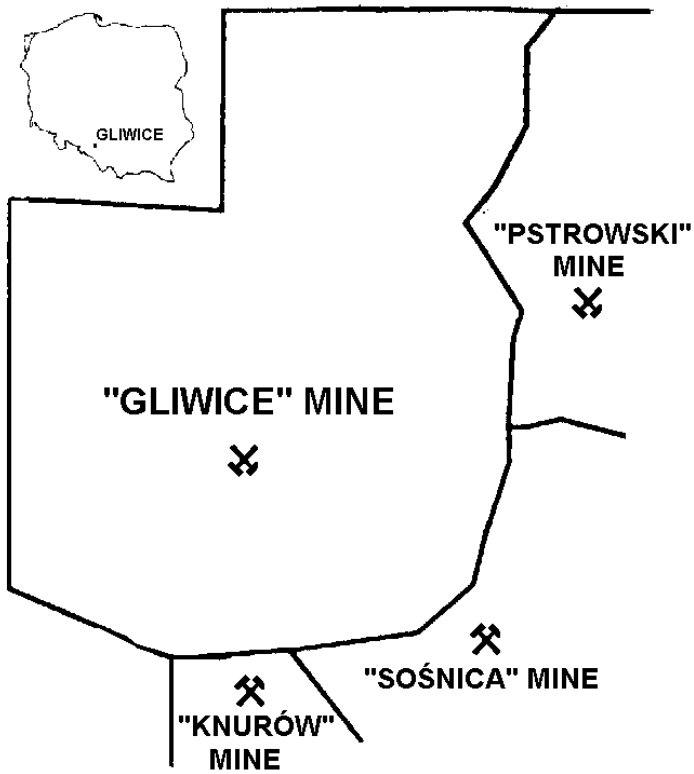

Figure 1 Location of the “Gliwice” colliery

The geological profile of the mass rock consists of Quaternary and Tertiary as well as Triassic and Carboniferous beds.

The Quaternary beds with thickness from several up to 85 meters are formed as clay dumps, sand and gravel. There exists two water-carrying levels that linger irregularly, some of them are very rich with water and are exploited by high-deep wells.

The Tertiary beds occur in the middle and the South part of the area, where their thickness reaches 300 meters. They are formed as silt and silt-based sediments with layers of sand, plaster, limestone and marl. The crack-type

water-carrying layers connected with plaster and limestone are of important significance.

The Triassic beds, represented by mussel limestone and Bunter sandstone, occur in the middle and the North parts of the area, where their thickness reaches 190 m. The Triassic water-carrying beds encompass the carbonate series of shell limestone and Roethian as well as sand-based forms of Bunter sandstone. The series of Triassic limestone and dolomite forms a very rich in water reservoir of the fractured-cavernous-porous type with an unstable water table. Water of that level are used for drinking purposes by many high-deep wells with significant productivity. The dammed-up water level of the lower-Triassic sandstone series lays directly on carbonic sediments and within the region of mining exploitation water has been drained by mining workings.

The Carboniferous series is built by border layers formed as silt-based and mud-based rocks as well as sandstone with coal beds lying among them. The coal beds are thin, in most cases they do not exceed 2 meters. The bed is strongly affected by tectonic activities, it is featured by folded structure and is cut by a series of faults with drops that reach maximum few hundred meters. The carbonic water-carrying levels are connected with sandstone layers, their rate in the carbonic profile is, in average, about 35%. The carbonic limestone is low-porous and characterised by low permeability.

Geological structure of the bed rock has decided about spatial development features of the both "Gliwice" colliery and the adjacent ones. The complex structure of the bed cased, that coal beds were not been outputted within border zone neither in the "Gliwice" colliery, nor in the adjacent ones. Exploitation works were carried out in regions located rather far away one from another, the closest horizontal distances between edges of the beds that have been completely exploited, are as follows:

- about 750 m – between the "Gliwice" and the "Sośnica" collieries,
- about 2000 m – between the "Gliwice" and the "Pstrowski" collieries,
- about 3000 m – between the "Gliwice" and the "Knurów" collieries,

The "Gliwice" colliery is also not connected with adjacent mines by means of direct horizontal workings.

The closest distances between mining workings of the "Gliwice" colliery and workings of the adjacent coal mines, occur in the South – East part of the mining area, within the border zone of the operating "Sośnica" colliery (Figure. 2). In the 1980's the "Gliwice" colliery carried out mining works within the borders of mining area of the "Sośnica" colliery, on the level of 403 m and 520 m. The works were located in the region of the G drifts, where the 618, 620 and 622 beds were exploited as well as in the region of L and M drifts, where horizontal workings were being drilled.

Natural water income to the colliery during the few recent rears was approximately on the amount level of 5.5 m^3 per minute. The whole income is concentrated on the deepest level (level 520 m), where water is pumped out top the minehead. It is low-salted water with global mineralization within the range 15 – 20 g/dm^3.

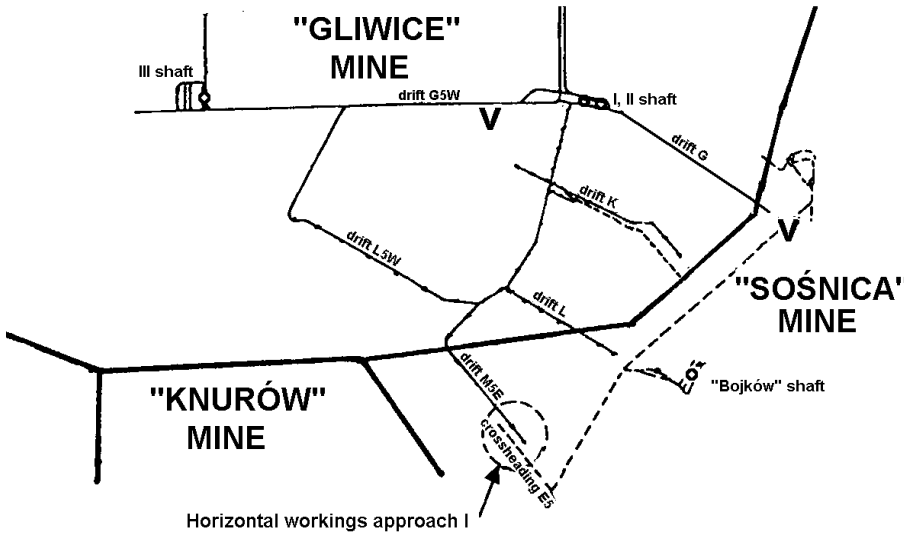

Figure 2 Main horizontal workings of the "Gliwice" colliery on the level of 520 m and the adjacent "Sośnica" colliery on the level of 550m.

3 ANALYSIS OF THE BOUNDARY-ADJACENT REGION OF THE "GLIWICE" AND "SOŚNICA" COLLIERIES

The Quaternary and Tertiary bed rocks as well as Carboniferous ones represented by post-forest layers occur within the boundary zone between the "Gliwice" colliery that is to be closed down and the operating "Sośnica" mine.

A thick silty complex of Tertiary top rock dominates in the overlay profile. Carboniferous layers are folded, they form a number of synclines and anticlines with amplitudes about 400 m (Figure. 3). Axles of main structural components are elongated along the NE-SW direction and sink to the South at the angle of about 10°. Within the region of the G drifts the saddles 0 and 1 can be distinguished with layer slope reaching 60°. In the South direction along the line of the M drifts, the saddle 1 with layer slope up to 85° can be distinguished. The folded structure formed in such a way is cut up by a number of non-continuous dislocations, they run mainly along the N-S direction and have drops reaching even 100 m. From the litological point of view, the carbonic formations are built of silty clay, mudstone and sandstone, the rate of silty clay and mudstone is less than 65%. The Carboniferous rocks show high firmness and mechanical resistance apart from coal beds.

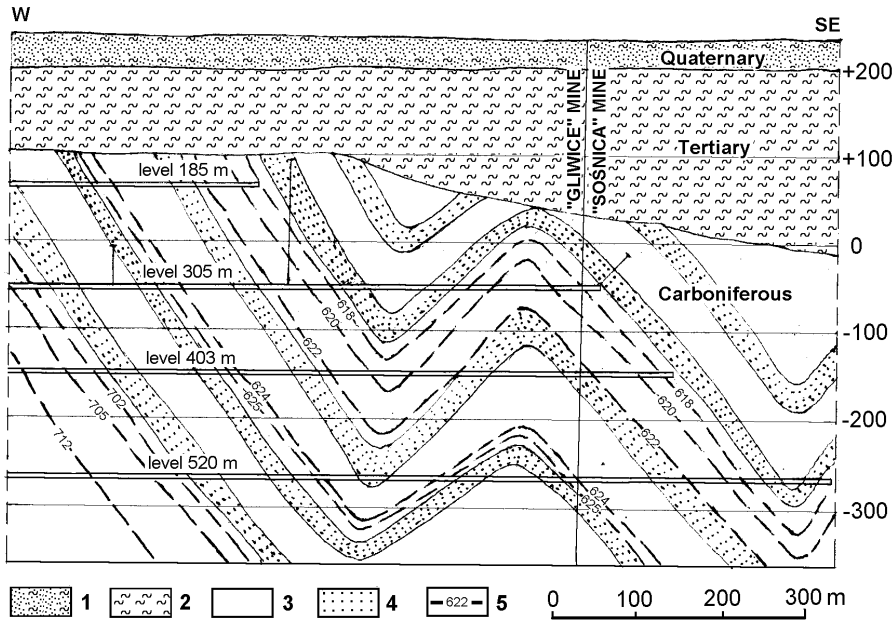

Figure 3 Geological cross-section V – V
1 - sands and clays, 2 – clays, 3 – claystones and mudstones, 4 – sandstones, 5 – coal

Within the boundary region adjacent to the "Sośnica" colliery, nearby the G, L and M drifts there exist 5 sites, which have been classified and zones of indirect hydraulic contacts, where horizontal workings of the "Gliwice" colliery (levels 403 and 520 m) and the ones of the "Sośnica" colliery (levels 385 m and 550 m) approach one close to another and their mutual distance is from 32 to 93 m. Among those indirect hydraulic connections, the most important is indirect contact of the M5E drift on the level of 520 m with the E5 crossheading and the level 550 m – close-up I, Figure. 2. It should be mentioned, that occurrence of that contact decided about necessity of permanent de-watering of the "Gliwice" colliery, even after having it closed down.

The contact zone of the M5E drift and the E5 crossheading is built of alternately stratified layers of silty slat and sand slat, that present 62.0% of the profile, sandstone – 35.2 of the profile and coal beds - 2.8% of the profile. The layers are inclined along the direction towards E at the angle from 60° to 85°. Thickness of coal beds is from 0.4 to 2.3 m. The M5E drift, which was constructed in the 80's in the "Gliwice" colliery (-261.0 above sea level was located over the E5 crossheading of the "Sośnica" mine (-296.9 above sea level) Those workings, within the section of about 350 m, run directly one above the other and their vertical distance is 32 m. (Figure. 4).

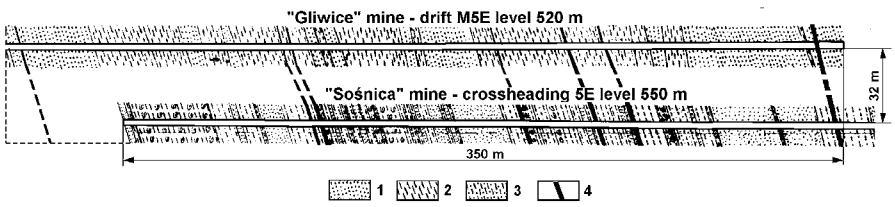

Figure 4 Geological cross-section in the region of approaching of the M5E drift (level 520 m) to the E5 crossheading (level550m)
1 – sandstones, 2 – claystones, 3 – mudstones, 4 – coal

In the 90's, both the M5E drift and the E5 crossheading were liquidated by removing the lining in some places and damming after that.

4 ANALYSIS OF POSSIBILITY OF FLOODING THE "GLIWICE" COLLIERY

Evaluation of allowed height of water damming up is very important from the point of view of water hazard, it enables to make assessment of possibility of flooding the "Gliwice" colliery, which has direct contacts with the operating mine. That height can be calculated by determining the allowed hydrostatic pressure that loads a rock shelf, which serves as safety pillar, that shelf separates flooded cavings from workings of the operating colliery. Assumption of the appropriate calculation model to existing geological, hydrogeological and mining condition is also essential.

Calculation of the maximum allowed height of water damming up in the liquidated "Gliwice": colliery have been carried out following the W.D.Slesarev's model, where a pillar is considered as an elastic plate operating against tension force (Konstantynowicz *et al.,* 1974).

Among zones of direct contacts, the worst conditions from the point of view of tensile strength and stability of mother rock, occur in the approaching site I, where mutual distance between workings is only 32 m and length of mutual contact section is about 350 m (Figure. 4). The vertically – located coal beds with thickness up to 2.3 m are the weakest components of the mother rock, moreover they are criss-crossed by workings. The worst possible model assuming, that along the whole section of approaching (about 350 m) mass rock consists of the weakest material, i.e. coal. The allowed hydrostatic pressure that loads undisturbed coal in the approaching site I can be calculated following the formula:

$$p = 1.33 \cdot \frac{R_r}{n} \cdot \frac{d^2}{e^2} - \gamma \cdot d \cdot \sin\alpha \qquad [1]$$

$$p = 1.33 \cdot \frac{0.35}{10} \cdot \frac{27.5^2}{4.44^2} - 0.013 \cdot 27.5 \cdot sin\,80^o = 1.4 \text{ MPa}$$

where: R_r – temporary coal tensile strength, 0.35 MPa
n - safety coefficient, $n = 10$,
d - distance between workings reduced by height of cracking zone over the lower working:
$d = D - c = 32.0 - 4.4 = 27.5$ m
D - distance between workings, 32.0 m,
c - height of the relaxed zone over the working, following Protodiakonov:
$c = a/2 \cdot f = (4.5/2) \cdot 0.2 = 4.5$ m,
f - coal firmness coefficient, $f = 0.5$
γ - coal weight per volume, 0.013 MN/m^3,
α - slope angle of the bed, about 80°,
e - equivalent span of the slope:
$e = a \cdot l/(a + l) = 4.5 \cdot 350 / (4.5 + 350) - 4.44$ m
a - crossheading width thorough the breakout, 4.5 m,
l - length of the approaching section of workings, about 350 m.

It results from the exercised calculations, that maximum allowed height of water damming up in workings of the "Gliwice" colliery is about 140 m of water column. Therefore, full flooding of workings of 'Gliwice" colliery is not possible because of water hazard to the adjacent operating "Sośnica" mine, partial flooding can be only considered, with damming water up to the level of 380 m (520 m – 140 m = 380 m).

Other zones of indirect hydraulic contacts do not pose any hazard, neither breaking the rock shelf, nor increased filtration to the workings of the "Sośnica" colliery. Flooding the working of the "Gliwice" colliery would start, undoubtedly, water filtering towards the "Sośnica" colliery in sites of approaching of workings, especially in those places, where fault fissures had been cut. Having taken into account special features of geological structure as well as geological and engineering properties of mass rock, there is no threat neither of excessive leaking nor destroying rock structure by filtering water. Through lack of detailed examining hydraulic parameters, the flooding process should be carried out step-by-step and be carefully monitored.

It should be mentioned, that decision about flooding the "Gliwice" colliery up to the level of 380 m, because of water hazard to the operating "Sośnica" colliery can be made only after checking the technical condition of the E5 crossheading of the 550 level of the "Sośnica" colliery at its the far end section as well as confirming value of rock shelf thickness that has been assumed for calculation (d = 27.5 m). It is an essential condition due to the method of liquidation of that working – lining withdrawing. Along sections, where lining has been removed, ceiling breakdown could occur, though disturbing of the rock shelf, which separates the workings, cannot be excluded. Examining of technical condition of the rock shelf between the M5E drift and the E5

crossheading was an indispensable condition to make decision about establishing a safety pillar and, if needed, making necessary protective construction in that area.

5 FINAL CONCLUSIONS

Taking into consideration providing of safety the adjacent "Sośnica" colliery and suffering from the want of unambiguous data about technical condition of the rock shelf between the ceiling of the E5 crossheading and the floor of located within the distance of 32 m the M5E drift, full flooding the liquidated "Gliwice" colliery was impossible. As the workings that had been liquidates are unavailable and cannot be directly penetrated and, thereby, assessment of the present state of the rock shelf and its possible reinforcement and mass rock sealing is unfeasible, even partial flooding of the "Gliwice" colliery up to the level of 380 m turned out to be unworkable. In such condition further de-watering of workings of the liquidated colliery up the level of 520 m remained necessary during the period of functioning the "Sośnica" mine, what is connected with keeping the de-watering system operated. Water dump is 5 m^3/min and amount of dumped salt is about 100 Mg per day. It should be mentioned here that the existing system of hydrogeological conditions of the region will not be changed at such a solution.

For the accepted way of closing down of the "Gliwice" colliery, which consists in permanent de-watering of workings of the liquidated mine from the level of 520 m, the fact, that horizontal working in the boundary region have been liquidated and dammed around and are unavailable, is essential. Liquidation of those workings that had been carried out by means of lining withdrawal, did not take into account the problem of water hazard, though neither filling was exercised nor mass rock sealing was anticipated.

The case of the "Gliwice" colliery shows, how important the problems of water hazard are while liquidation of workings is executed within boundary zone. The same applies to every operating mine which is covered by restructuring process. The way of liquidation of workings in such zones can influence further way of closing down a way. Examination of mass rock in those zones, within the range necessary for further liquidation process, is also of high importance.

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Uwarunkowania i konsekwencje hydrogeologiczne zatopienia wyrobisk likwidowanej KWK „Gliwice"

Edward Cempiel, Marek Pozzi

Streszczenie: Przedstawiono problematykę hydrogeologiczną związaną z likwidacją kopalni „Gliwice". Przeanalizowano układ hydrogeologiczny złoża i warunki górnicze w nawiązaniu do problemów wodnych jakie ujawnią się w procesie likwidacji kopalni. Omówiono konsekwencje hydrogeologiczne zatapiania kopalni „Gliwice" oraz scharakteryzowano główne czynniki natury przyrodniczej i techniczno – organizacyjnej, które mają istotne znaczenie przy wyborze optymalnego rozwiązania likwidacji zakładu górniczego. Oceniono możliwość wyłączenia systemu głównego odwadniania i całkowitego zatopienia likwidowanej kopalni w aspekcie zagrożeń wodnych dla sąsiednich czynnych kopalń a także zagrożeń dla środowiska na skutek zmiany stosunków wodnych w górotworze.