

HYDRODYNAMIC MODEL OF THE COAL MINE SUVODOL

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Abstract: *The designed open-pit mine of the Underlying Coal Series (UCS) is specific for the method of tailings excavation, which is performed in very complex geological and technical conditions, since the tailings material above the coal does not have a constant height, and therefore the technological parameters of the excavation are changing by the phases of exploitation. The current way of defense from surface water at open-pit mine UCS has included the drainage of water with perimeter canals, and from the working areas in the mines by level, connecting or transverse canals connected to watercollectors located at the lowest levels of tailings, coal levels and underlying soil. Water from watercollectors is pumped by suitable centrifugal pumps and pipelines to the existing recipients. When talking about the protection of mines from groundwater, in order to provide favorable conditions for the coal exploitation, it was necessary to build drainage facilities to achieve this (drainage wells, drainage ditches, drainage of operation levels).*

Keywords: *underlying coal series, wells, watercollector, canals*

INTRODUCTION

Tailings excavation on the open-pit mine SUVODOL will be performed in a very complex geological-technical conditions (narrow space for excavator maneuvering, taking into account the dimensions of the bucket-wheel excavator, the

height of the excavator reach due to the geomechanical stability conditions on one side and the technical and technological capabilities of the excavator itself, the height of the excavated area, the proximity of the belt conveyor and the time period in which it operates) [3]. Due to the irregularity of the coal layer dip, the tailings ma-

terial above the coal does not have a constant height, which is why the technological parameters of the excavation are changing by the phases of exploitation.

HYDROGEOLOGICAL COLLECTORS

In the current area, four hydrogeological collectors have been isolated in which the overlying (O), interlying (I_1 and I_2) and underlying (U) aquifer were formed [1].

Overlying aquifer (O) is formed in silty sand of heterogeneous granulation and sandy silt with a general decline from south to north, consistent with a general decline of the coal series. Within the complex lens-like sand of the larger granulation appear. The value of the filtration coefficient of these sand series is approximately $5 \times 10^{-4} \text{m/s}$ [1].

Replenishing of the complex is along the perimeter of the neogene basin at the contact of the base rock made of gneiss, and atmospheric precipitation in the open part of the open-pit mine. In natural conditions the complex is being emptied in the middle, which is hypsometrically lowest and is located north of the observed area. The artificial emptying conditions are performed at the mining facilities at open-pit mine UCS.

Interlying aquifer (I_1) is formed in silty sand of

different granulation and sandy silt. The filtration coefficient is approximately $2 \times 10^{-5} \text{m/s}$ [1]. This complex is an extension of the overlying aquifer.

Interlying aquifer (I_2) is formed in sandy silt and in silty sand of different granulation. The thickness of this complex is up to 5 m, while going north increases and expands. A complex of sandy sediments “lies” within the underlying series in the form of intercalations. At the perimeter of the basin, this aquifer is in hydraulic connection with other neogene sediments. The value of the filtration coefficient of these sand series is approximately $1 \times 10^{-5} \text{m/s}$ [2].

Underlying aquifer (U) is formed in gneiss and in silty sand which are located in the immediate overlying coal series. Immediate coal overlying are coal clay, gneiss and silty sand. The surface of direct contact of silty sand and coal is increasing in the north direction. The value of the silty sand filtration coefficient is of the order of magnitude $1 \times 10^{-5} \text{m/s}$, and gneiss filtration coefficient, obtained on the basis of granulation is of the order of magnitude $1 \times 10^{-4} \text{m/s}$ [1]. The groundwater level at the beginning of making the technical documentation is shown in Figure 1.

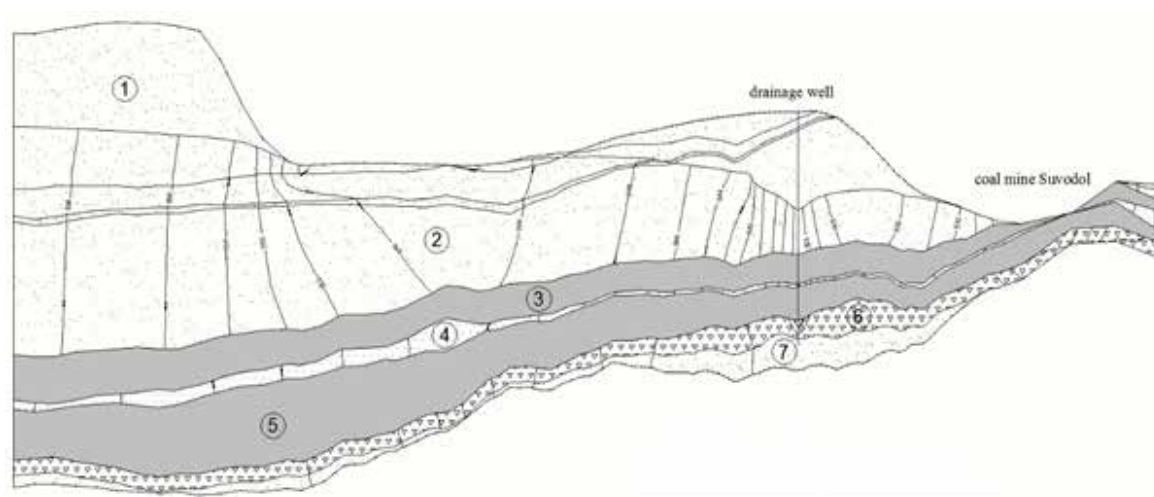


Figure 1, Profile with Initial Groundwater Level for All Three Aquifers [2].

LEGEND: 1-Silty and clay sediments; 2-Silty sediments; 3-The first coal layer; 4-Fine grain sand; 5- The second coal layer; 6-Coal clay; 7-Underlying sand; — — — Equipotential groundwater level lines.

The method used before for defending mine from surface water has consisted of collecting waters from working areas, perimeter, connecting and transverse canals connected to water-collectors. Water is pumped from the water-collectors, with appropriate centrifugal pumps, to the existing recipient.

HYDRODYNAMIC MODEL

Hydrodynamic model of the open-pit mine Suvodol was designed and constructed as a multi-layer model, with a total of ten layers, observed in a vertical profile. Each of these layers corresponds to a specific realistic layer, schematized and separated based on the terrain knowledge and the results of the conducted analysis of extensive field exploration operations.

Observed from the surface of the terrain, the corresponding layers of the model and terrain are:

1. The first model layer – silty and clay sediments that form disposal area;
2. The second model layer – silty sand widespread on terrain surface;
3. The third model layer – clay sediments;
4. The fourth model layer – silty sand with poor filtration characteristics;
5. The fifth model layer – silty sand in which free level aquifer is formed;
6. The sixth model layer – the first coal layer;
7. The seventh model layer – fine grain sand, silty;
8. The eighth model layer – the second coal layer;
9. The ninth model layer – coal clay;
10. The tenth model layer – underlying sand.

Of particular interest are the fifth, seventh and tenth model layers so that they are dedicated the greatest attention.

Based on the existing results of the geological and hydrogeological structure of the subject area, a hydrodynamic model was developed to analyze the operation of the projected open-pit mine drainage facilities. The mathematical model was made using the finite element method, and the SPRING package was used as software [2]. The basic dimensions of the model are 3000x1500 m, or about 4.5km². The dis-

cretization of the stream field in the plan was performed by a non-homogeneous series of elements of size from 50 m to 5 m. The time step is one year (Figure 2).

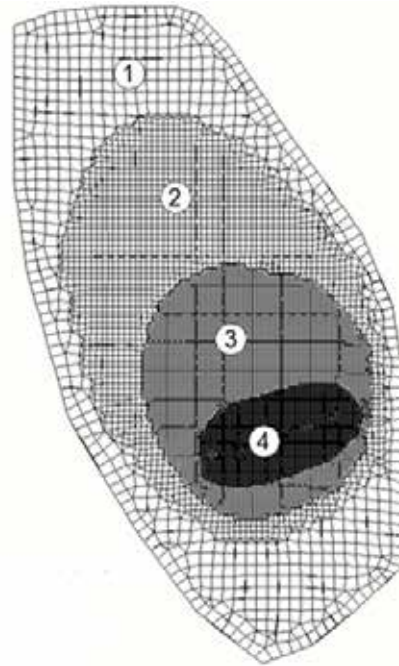


Figure 2, Discretization View of the Hydrodynamic Model [2].

LEGEND:

- 1 – Elements of size 50m x 50m;
- 2 – Elements of size 25m x 25m;
- 3 – Elements of size 12m x 12m;
- 4 – Elements of size 5m x 5m.

The mathematical-hydrodynamic model was set up as a water-bearing multilayer porous environment, with representative filtration parameters and given boundary conditions. Groundwater flow was calculated as stationary, under pressure and free-flowing, where appropriate conditions were fulfilled over time. The area of the model is defined by the boundaries of the spreading of the underlying aquifer. As boundary conditions, the model hydrodynamic conditions of the replenish zones are given, as contours with a given potential, in the field wells, or horizontal drainages, canals, are specified as drainage facilities, as needed.

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The underlying aquifer is formed in the underlying sand and, although small in thickness, represents a complex problem, primarily because of good filtration characteristics of the underlying sands, but also due to the spread of the layer which allows high piezometer level in the aquifer. On the model are set “windows” (Figure 3), the zones of direct contact of the underlying aquifer with coal series.

Through this „windows“ground water passage on the terrain surface during coal exploitation is enabled. The moment of opening the “window” is a critical moment, given the high pressures prevailing in the underlying aquifer and it is therefore necessary to ensure acceptable, normal conditions of coal exploitation. A favorable circumstance is that the moment of the opening of the underlying aquifer occurs in two to three years, which gives enough time to reduce the pressure.

Whereas the concept of drainage of the underlying aquifer was adopted, representing the use of wells in the front and at the rear of the opera-

tions. The goal is to bring down the groundwater level of the overlying aquifer below the future level of the operations. In accordance with the adopted concept of drainage, and testing in the model, the number, layout and dynamics of construction of drainage facilities - wells were defined. Following the dynamics of mining operations, it was necessary to ensure favorable conditions for excavation at all times.

On the model the given dynamic levels are set as input data, while pumping capacities were used for verification in the model calibration process. Groundwater level condition at the end of the fifth year of exploitation is shown in Figure 4.

CONCEPTION OF MINE PROTECTION FROM SURFACE AND GROUND WATER

The basic protection concept of open-pit mine UCS from surface water involves collecting water from working areas, perimeter, connecting and transverse canals connected to watercollectors. Water is pumped from watercollectors, with appropriate centrifugal pumps, to existing recipients. [2].

The perimeter canals accept water that gravitate into the work area, as well as atmospheric water that fall into the work area of the mine. They

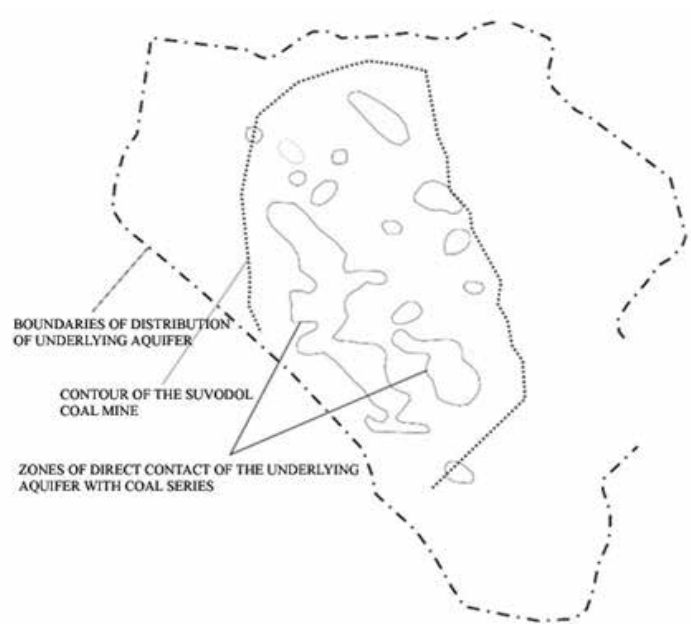


Figure 3, Spreading Contours of the Underlying Aquifer [2].

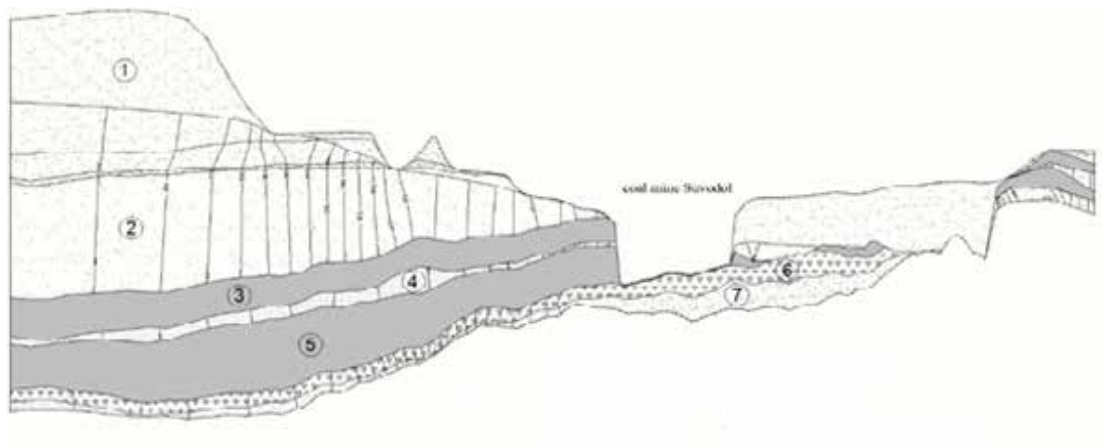


Figure 4, Profile Showing Equipotential Groundwater Level Lines for All Three Aquifers in the Fifth Year of Exploitation [2].

LEGEND: 1-Silty and clay sediments; 2-Silty sediments; 3-The first coal layer; 4-Fine grain sand; 5- The second coal layer; 6-Coal clay; 7-Underlying sand; — Equipotential groundwater level lines.

are directed to the watercollectors from where they are taken out of the mine by the pump aggregates.

Level canals are made on tailings and coal levels in order to collect atmospheric water and water that gravitationally exits from level slopes, and then by the shortest way is gravitationally conducted to the temporary and main watercollectors. The production of level canals is directly dependent on the dynamics of mining operations progress.

The technical solution of the mine protection from ground water foresees construction of [2]:

- Drainage wells;
- Drainage ditches and;
- Temporary canals.

Drainage wells are in the function of protecting the working figure of the mine during exploitation and their construction must take precedence over the advancement of the mining operations front.

Drainage ditches are made at the underlying soil of the mine, behind the mining operations, parallel to the toe of the lowest coal level and allow groundwater from the gneisses to be received. At the same time they can be used as collecting canals for protection from surface water.

Temporary canals collect ground water that run out from level slopes and direct it to the level canals, and then to the nearest watercollector.

In order to obtain data on the groundwater regime and the effects of the drainage system operation, it is necessary to perform monitoring, which includes:

- Mine level and disposal mapping;
- Making piezometer network and measuring level of ground water;
- Measuring well flow;
- Collecting data on rainfall and processing the obtained data.

With this technical solution of mine protection from water, it is possible to provide optimal conditions for the operation of basic mining machinery for the excavation and transportation of coal and tailings mass.

CONCLUSION

Available geological and hydrogeological data show an uneven exploration picture and insufficient information on the working environment and environment of open-pit mine UCS. Regardless of the level, quality of processing and interpretation of the available hydrogeological data, it is not possible to provide a reliable de-

termination of the hydrodynamic model of the working environment and of the system for protection of the open-pit mine from water. It is necessary to establish high-quality, continuous hydrogeological monitoring of the working environment and surroundings, and in harmony with the development of exploitation operations on the open-pit mine, to continue with hydrogeological exploration in order to possibly adapt the project solutions of the system for the protection of the mine from water.

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