

IMPACT ON REGIONAL AQUIFERS OF COAL EXPLOITATION IN OLTENIA REGION

Daniel Scrădeanu

Faculty of Geology and Geophysics
Universitatea București
Romania

Marin Palcu

Foradex S.A.
București
Romania

ABSTRACT

Mining works connected with coal extraction in Oltenia have an important effect on regional aquifers, such regional dacian artesian aquifer.

In the natural regime period the main flow direction in the artesian aquifer, in the zone of the huge quarry from the Oltenia (Rosia de Jiu), was north-south, with a hydraulic gradient of about 1%. As a consequence of a strong drainage in the artesian aquifer a great depression zone appeared (a drawdown about 90 m).

The variations of groundwater level under the conditions of a relatively constant recharge change the relations between regional aquifers and also the chemical characteristics of groundwater.

In many others regions (like Motru, Prunișor, Mihăița etc.), the water drainage change the natural regime of aquifers. The effects of are changes of chemical characteristics of groundwater and also on the stability of the slopes.

The paper presents some results of quantitative evaluation of mining works effects on aquifers in Oltenia region. Results are obtained with stochastic and numerical models for local and regional aquifers.

Key words: mining works, coal extraction, water drainage, stochastic model (kriging, conditional simulation), numerical model (finite difference), hydrodynamic and hydrochemical changes, monitoring network

INTRODUCTION

Mining works associated with coal exploitation in Oltenia have many kind of impact on aquifers systems that are important resources for water supply of towns, agriculture and industry:

- disappearance of shallow aquifers in the area of quarries (by excavation of aquifers);
- dewatering of shallow aquifers (above of the lignite bed number five, the deeper exploited in Oltenia's quarries) in the area of quarries
- dewatering of deep aquifers (confined artesian aquifers) in the area of quarries and their neighbourhood (below the coal bed number five).

Environmental impact assesement is realised on the base of a comparative analisys of the parameters of aquifers before the beginning of coal exploitation and after that..

In the areas of coal querries from Oltenia, the most affected aquifer by the dewatering system is the artesian aquifer situated below the coal bed number five.

The artesian confined aquifer system situated below the coal bed number five have the next main characteristics:

- the most developed pliocene aquifer in the Oltenia region, with a very good continuity;
- the superior pontian and dacian deposits of artesian aquifer are represented by:
 - fine, medium and coarse grained sands at the bottom of the aquifer

- medium sand, fine sand, silt and clayey sands at the top of the aquifer

- a complex structure in the west side of Oltenia (between Danube River and Jiu River: ten or twelve permeable layers of sand separated by impermeable or semipermeable layers of clay) that became a simple one with no more than one or two layer at the east of the Jiu River.

The artesian-confined aquifer connects all effects of coal exploitation on all shallow aquifer systems that are in hydraulic communication with this regional aquifer. This aquifer can be the main physical support for a numerical model, used as a principal tool for development of environmental politics in Oltenia region, a region with an accelerated mining activity.

Specific aims of environmental assesement of lignite exploitation on aquifer systems from mining Oltenia region are:

- assesement of hydrodynamic regimen of aquifer systems;
- monitoring and prognosis of hydrodynamic regimen in the quarries for lignite exploitation;
- monitoring and prognosis of hydrochimic regimen in the quarries for lignite exploitation;
- identification of appropriate tools for removal of the negative effects of lignite exploitation on environment (for long life of "clean" aquifers).

ENVIRONMENTAL ASSESMENT METHOD

Environmental assesment of impact of lignite exploitation on aquifer systems from mining Oltenia region is realised on the basis of: selection, validation and storage of data, mathematical modelisation of aquifer system and assesment of mining impact on aquifer by numerical simulation.

The main criteria of *data selection* was the objectives of the project and database include:

- natural hydrodynamic regimen of the artesian aquifer system,;
- hydrodynamic regimen of the aquifer for the entire period of exploitation;
- chemical characteristics of groundwater

Validation of data was realized by processing of experimental data and new hydrodynamic tests in some area like Motru (Fig.3) and Rosia de Jiu. All information are separated in two categories: hydrogeological parameters of aquifers and technical characteristics of exploitation process. National Company of Lignite Oltena (NCLO) is the beneficiary of the database realized.

Mathematical model have two components:

- the first component is for *stochastic analysis* of time series and spatial distribution of hydrogeological parameters;
- the second one for numerical simulation of flow in the artesian aquifer

Stochastic analysis of time evolution of piezometric head was used for identification of correelations between flow of dewatering system, dynamic resources an recharge of aquifer. Because of irregular measurement program, the stochastic analysis was necessary for identification of general trend of piezometric head. The spectral analysis and Markov chains was used to find the stuctures of time series: periodical character, time-correlations etc.

For a complex analysis of spatial distribution of hydrogeological parameters of numerical model was used kriging method [4]. The fictiv point method was used for improvment of monitoring network of aquifer systems.

Numerical simulation of artesian aquifer is realized on the basis of a finite difference model. We use the numerical model for simulation of dewatering system impact on aquifers for different scenario. Conditional simulation was used to evaluate the degree of uncertainty of the results of mathematical simulation.

DATABASE

Geological investigation of lignite deposit was realized in Oltenia by a huge number of wells (Fig.1). Hydrogeological exploration is not so detailed like the geological one. The main characteristics of monitoring network for aquifer systems:

- the monitoring network is developed especially in the area of quarries;
- too few observation points between areas with mining works;

- an irregular program for measurements in the observation points
 - not enough number of chemical analysis for groundwater.
- The achievement of a monitoring network for a realistic evaluation of impact enforces a *new strategy*. The main

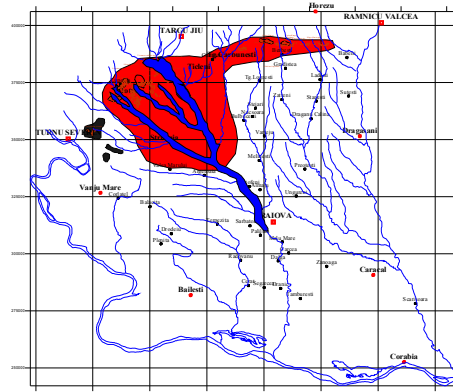
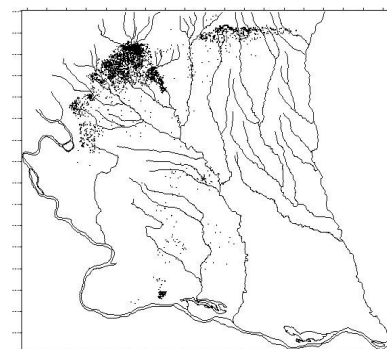


Figure 2. Zona de impact a exploatării cărbunelui asupra acviferelor

objectives of this new strategy for monitoring of aquifer systems are:

- a new permanent monitoring network for piezometric head of aquifers with a uniform spatial distribution on entire Oltenia region (not only in the area of mining works!);
- evaluation of an *optimal frequency* of measurement for piezometric head and water sampling for chemical analysis;

-



monitoring of dewatering system (geometry of the drainage net, flow of drainage net etc.)

This objectives of this new monitoring network hint at protection of aquifers against the dewatering effects in the area of quarries for lignite exploitation.

The permanent network will use the existing water wells supply from mining areas and other piezometers situated

outside the mining areas, till the boundary of dewatering influence.

At the moment, in the mining areas NCLO have 60 water wells supply. The spatial distribution of this wells is not

adequate for a strict delimitation of influence area of dewatering system for quarries and mining works.

For the estimation of the impact on the artesian aquifer was used data measured between 1970 and 2001, in different mining areas (Motru, Prunisor, Rosia de Jiu etc.).

RESULTS

There are different effects of lignite exploitation on aquifer systems from Oltenia region (Fig.2):

- *total or partial disappearance of aquifers be cause of:*
 - the excavation works;
 - the execution of drainage trench;
 - induced leakage
 - drainage and dewatering in the areas of the quarries
- *local and regional reduction of groundwater resources*

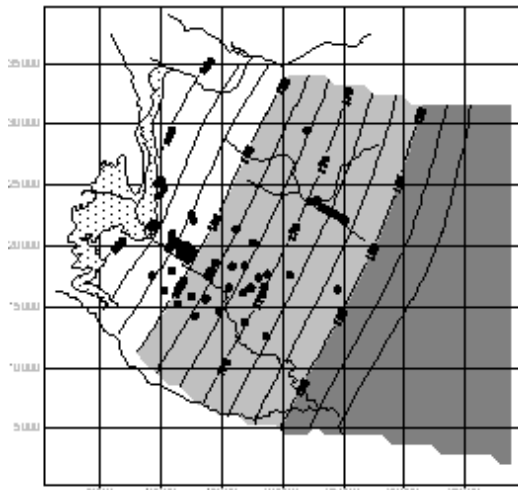


Figure 3. Natural regimen of flow in the aquifer situated below the lignite bed number one (area E.M.Motru)

settled by:

- drawdown of piezometric surface in the areas of quarries;
- change of hydraulic gradient;
- decreasing or disappearance of elastic store of confined aquifers;
- increasing of deficit of water balance for regional aquifers
- pollution of groundwater in some areas because of leakage and dewatering system
- deterioration of water resources because of intensive exploitation
- *the emptiness of groundwater resources by:*
 - complete destruction of permanent water resources of aquifer;
 - intensive leakage of aquifers and exploitation for water supply; lock

- *decreasing of shallow aquifer recharge by:*
 - closure of pore, especially from shallow aquifer, with dust of lignite
- *destruction of domestic supply well by :*
 - total drainage of groundwater resource

Figure 1. Foraje geologice de explorare pentru zăcămintele de lignit din Oltenia

- disappearance of shallow aquifers

In this first stage, the assessment of coal exploitation impact on aquifers from Oltenia region consider only the drawdowns induced by dewatering systems of quarries and tapping of groundwater from mining areas.

For the analysis of piezometric head variation, from existing documentation, was selected 197 drainage wells from dewatering system of Rosia's quarry. In the analysed period, October 1979-December 2000, was realised a number of 8600 measurements of piezometric head.

The evolution of piezometric head in artesian aquifer (below the five lignite bed) in the five drainage lines of Rosia quarry indicate a variation of drawdown of piezometric head between 50 m and 75 m, with a stationary character at the beginning of studied period.

Natural hydraulic gradient of the flow in the area of Rosia quarry has not any influence on stationary character of piezometric head evolution for a long period of time.

For the area of Rosia quarry, on the basis of the hydrogeological parameters of artesian aquifer, was realized a hydrodynamic finite difference model for the simulation of the dewatering system effect. The drawdowns induced by the dewatering system for the entire period of dewatering have values between 80 and 95 meters.

Another hydrodynamic model was elaborated for the aquifer situated below the lignite bed number one, in the area of mining works Motru [1]. In this area the tapping of groundwater for the Motru town have an important impact on the aquifer. Natural regimen of groundwater flow (Fig.3) is influenced on some areas around the water wells supply (water catchings: Matasari, V.Manastirii-Lupoiaia, CET.Motru, Lupoiaia; Fig.4). The drawdown induced by the tappings of water has values between 15 and 20 meters.

In a second stage, these models and others, elaborated for different areas like Prunişor (Palcu, M., 1985), Albeni (Scrădeanu D., 1990), was joining in a single model. This new hydrodynamic model will be used for the prognosis of the effect of lignite exploitation in the future and for the recovery of the piezometric surface after the closer of lignite exploitation in Oltenia region (Palcu, M., 2003).

Quality of groundwater was affected by lignite exploitation. In some areas was identified high concentration of ammonia, organic matter, nitrite, and nitrate (M.Palcu, 2002). Because of poor quality of chemical data, now is impossible to elaborate a representative hydrochemical model for the artesian aquifer system.

Pollution sources are represented by agriculture activities in the plane area and overflow meadows and mining works in the areas of quarries. Due to the incomplete burning of coal, the redox reactions and the others activities connected with lignite exploitation are introduced in the aquifers: carbon gaz and ammonia, oils from deposits and another contaminants from the waste dump.

CONCLUSIONS

Preliminary analysis of results measurements and simulation with hydrodynamic models make possible the following conclusions:

- impact of lignite exploitation on regional aquifer systems is important in the neighbourhood of coal quarries (drawdown of 95 m in the area of Rosia de Jiu quarry, 20 m in the areas of tapping of groundwater of Motru town);
- dynamic resources of regional aquifers from Oltenia region are huge so the time recovery of piezometric surface is very short, after the end of dewatering activities (only in the case of artesian aquifer and not for the destroyed shallow aquifers)
- natural quality of groundwater is affected because of the new hydrodynamic relations between aquifers, induced by dewatering systems of quarries and mining works.

For the big proportion of mining works and dewatering systems connected with the coal exploitation in the Oltenia region, the impact on artesian aquifer is not so important because of his huge dynamic resource. Is possible a spectacular recovery of this aquifer in a short time after the end of exploitation of deep lignite beds in the west part of Rosia de Jiu quarry.

Although at regional scale, the recovery of artesian aquifer is quite rapidly, the unpleasant effects of coal exploitation at local scale are important for water supply of villages, landslides in the area of roads and railways. This damages can be resolved with low costs if will be realised a monitoring network for environmental parameters. We already have been proposed a

monitoring network on the basis of our hydrodynamic model,

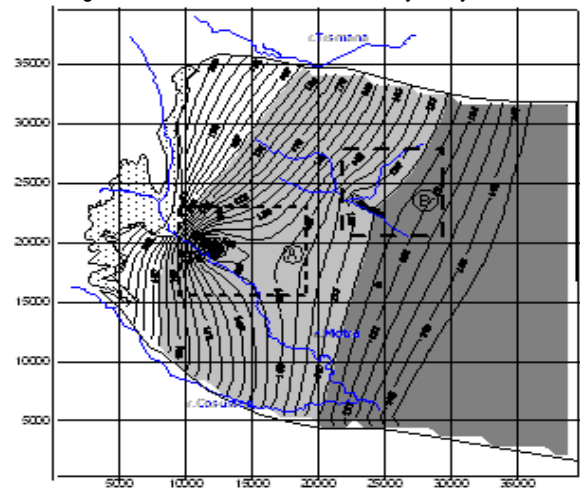


Figure 4. Regimen of flow in the aquifer situated below the lignite bed number one influenced by tapplings or water (area E.M.Motru)

with the following main objectives:

- the degree of fragmentation of shallow and confined aquifers, the main cause of reduction of groundwater resources and pollution of groundwater.
- the quality of groundwater in the water wells and the tapping of groundwater, affected by the changes of hydrodynamic relations between aquifers;
- the piezometric head of the regional and local aquifers, the main signal of dewatering systems influence on aquifer;
- groundwater level in the sterile dump situated inside and outside the quarries, an important cause of the landslides
- Subsidence of the land induced by dewatering and underground mining works, also an important cause of the landslide.

The data obtained from the monitoring network are used to make actual the hydrodynamic and hydrochemical models of aquifer systems for the prognosis of impact of coal exploitation on environment in Oltenia region.

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*Recommended for publication by Department
, Faculty of Mining Technology*