An Interdisciplinary Response to Mine Water Challenges - Sui, Sun & Wang (eds)
©2014 China University of Mining and Technology Press, Xuzhou, ISBN 978-7-5646-2437-8

Coal Mining Influence on the Groundwater System of the Chezhou Mountain Syncline Mine Areas

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Abstract To study the effects of coal mining on the groundwater system, the Chezhou Mountain syncline mine areas were simulated by the groundwater modeling system (GMS). The results show that under mining conditions, the whole hydrogeologic system was affected, inflow-drainage conditions of aquifers directly water-filled coal seams in local area changed significantly. Limited by the aquifer's permeability, the actual influence scopes are not as large as expected. Once mine water drainage stopped, the ground water level would recover quickly. The paper laid a theoretical foundation for the feasibility research on mining drainage and aquatic ecosystems' recovery in closed mines.
Keywords coal mining, Chezhou mountain syncline, aquifers directly water-filled coal seams, GMS, permeability

Introduction

Chezhou Mountain syncline is a narrow asymmetric coal-bearing syncline. It's like a "tongue" in the plane of which the northwest wing is vertical and the southwest wing is relief. Syncline axis faces to the southeast-dipping, and buried depth of axial is more than 1000 meters. The angle with the vertical surface is about 20°, and the southwest of plunging is 13°.

In order to clarify the hydraulic connection of each aquifer of Donghuantuo and Lugezhuang and hydraulic connectivity of syncline wings and other geological structures, aquifer of No.5 coal roof and 12 ~ 14 coal measures' were selected as the main research objects. Combined with the existing geological and hydrogeological data, the corresponding mathematical model was established. The flow characteristics of groundwater in the study area and the hydraulic connectivity between two mines were studied by using the GMS (Groundwater Modeling System).

Hydrogeological model in the study area

(1) Lugezhuang mine and Donghuantuo mine were selected as the simulation objects with a total area of about 45.5 km^2. (2) The interpolative SOLID module of GSM software was used to establish a three-dimensional model of hydrogeological structure in the study area. The model can be multi-view and three-dimensional to show space combination form of aquifer in the study area and to realize a three-dimensional visualization about aquifer (fig.1). (3) Aquifer hydraulic characteristics: Under drainage conditions, groundwater flow elements changed over time. The flow is unsteady. The flow of each aquifer follows the unsteady three-dimensional Darcy law. (4) Boundary condition: in the quaternary gravel aquifer at the bottom of the overlying distribution first lxundary is relatively stable multi-layer water-resisting layer, so it's unnecessary to consider the rainfall infiltration, evaporation and surface water supply, the top is zero flux boundary. The floor is an imperious boundary. Because the aquifer bottom of coal seam lies a stratum of bauxitic clay rock. second, lateral boundary, Lateral boundaries of each aquifer are generalized as flow boundary. The Darcy's low was used to get the flow value according to the characteristics of underground flow.

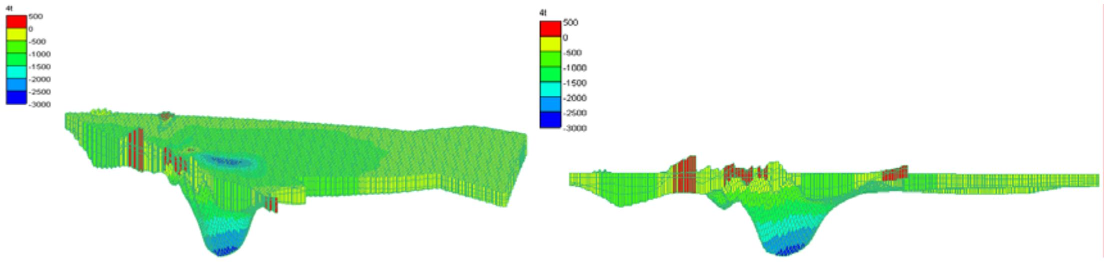


Fig. 1 *Study area and spatial distribution of aquifer in stereogram and in crosssection*

Mathematical model

According to the hydrogeological conceptual model, the following equations were chosen to describe the underground flow:

$$\begin{cases} \frac{\partial}{\partial x}(k_x\frac{\partial h}{\partial x})+\frac{\partial}{\partial y}(k_y\frac{\partial h}{\partial y})+\frac{\partial}{\partial z}(k_z\frac{\partial h}{\partial z})+\varepsilon=S\frac{\partial h}{\partial t} & (x,y,z)\in\Omega \\ h(x,y,z)\big|_{t=0}=h_0(x,y,z) & (x,y,z)\in\Omega \\ k_n\frac{\partial h}{\partial n}\big|_{\Gamma 2}=q(x,y,z,t) & (x,y,z)\in\Gamma_2 \end{cases}$$

In the formulas:

Ω—porous media region;

h—The level elevation of underground water(m) ;

K_x, k_y, k_z— permeability coefficient on x, y, z direction (m/d);

K_n—permeability coefficient on normal direction of boundary surface (m/d) ;

S—Unit storage coefficient of aquifer under the free surface (1/ m);

ε—source sink term of aquifer(m/d);

Γ_0—The upper boundary of seepage area, namely the free surface of groundwater;

Γ_2—The second kind boundary in seepage;

q(x,y,z,t)—Aquifer boundary flow per unit area (m^3 / m^2, d).

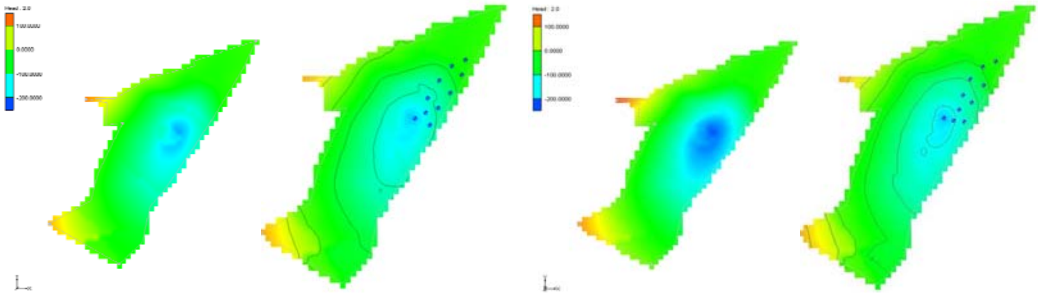
Finite difference method was applied to the mathematical model for finite difference equations. Then the Modflow which is in the software package of GMS (Groundwater Model System) was used to solve the partial differential equations.

Numerical model was identified and debugged based on the observation hole dynamic data of 5 coal roof aquifer and 12-14 coal measures aquifer. The period from April 2005 to April 2006 was set as the recognition phase. By adjusting the related parameters, the reasonable water level was got. Finally, the hydrogeology parameters were determined.

Groundwater flow prediction

The features of the flow field when the two mines drainage at the same time

The water inflow forecasting of existing groundwater was done by using the numerical model. After running the model for one year simulated time, groundwater flow field was shown in figure 2. The features of groundwater runoff variation are as follows: (1) It showed a small drawdown of groundwater in the two mines, (2) The flow direction of groundwater didn't change obviously and still run from the northwest to the southeast. With the influence of local drainage, the surrounding water flow to the pumping well. (3)The dynamic change of groundwater in the observation holes is consistent with the actual situation.



(a) aquifer on 5 coal roof *(b) aquifer between 12-14 coal seams*

***Fig.2** The groundwater flow field contrast between draining from two mines and one stoped*

The flow field characteristics of Lugezhuang mine when draining stop

The results (fig.2) show that, the aquifer water level in Donghuantuo mine and Lugezhuang mine was affected because of the close of drainage wells in Lugezhuang mine since August 2013. It shows an apparent recovery of the aquifer water level after drainage stoped. And the water level increasing gradient in Lugezhuang mine is larger than that in Donghuantuo mine. It is because that the influence was more serious in west wing of the syncline than that in the east wing of the syncline. After the drainage wells closed in Lugezhuang mine, the aquifer recharge has increased,the water inflow increased by a big margin in the early time ,as time goes by , Donghuantuo mine groundwater recharge displacement tended to balance, the groundwater flow field will become normal dynamic changes in Donghuantuo mine.

Analysis and conclusions

Under natural conditions, the groundwater flow slowly along the bedding from northwest to southeast wing. There is a hydraulic connection between the two mines.

(1) Under natural conditions, groundwater in the northwest wing was supplied by accepting water infiltration bedding of the bottom gravel layer of Quaternary pore. Moving along the inter-layer transport by deep synclinal axis; groundwater moves to the southeast wing, after the completion of their cycle of alternating hydro, used bottom anti-infiltration" recharge Quaternary aquifers backwater. Similarly, the karst water outcrops from the southeast wing in the "backwater" way vent into the bottom of the Quaternary aquifer. It shows the characteristics of runoff complementary cross row.

(2) The water level of each aquifer declined in varying degrees with the excavation. The water level of roof aquifer of No.5 coal seam and the floor aquifer of No.12-2 coal seam increased greatly due to the water level difference. The movement of the other aquifers changed fundamentally because the existence of the two aquifers. Water flows to the two aquifers through the outcrop and the geologic structures. And then the mining face was like a discharge area while the outcrop of the adjacent area in the north and the south side was like a recharge area. But it is so partial and limited that cannot change the characteristics of groundwater.

(3) The conceptual model and mathematical model were established based on the characteristics of No.5 coal seam roof aquifer and the No.12-14 coal seam floor aquifers. Numerical model was identified and debugged based on the observation hole dynamic data of 5 coal roof aquifer and 12-14 coal measures aquifers. The maximum water inflow of the two

mines is predictive index to forecast the hydrophobic antihypertensive effect. Results show that the flow characteristics of groundwater are in good agreement with the actual situation. There still small difference existing between the simulation results and the actual situation. It is because that the actual water points are dispersive while it is concentrated during the simulation process.

(4) Practice shows that the sparsed conclusions which obtained from simulation results are consistent with the actual situation. Although the hydrogeological unit can be affected by dewatering, the influence range is limited because of the low permeability. The water flow is greater at the beginning and decays slowly with time. The simulation results and the mining practice show that after Lugezhuang mine drainage stopped, the regional water level recovers fastly which indicates that the hydrophobic buck mining can be implemented locally and the water level can be restored and groundwater ecology can be repaired.

Acknowledgements

This work was supported by the National "Twelfth Five-Year" Plan for Science & Technology Support (2012BAK04B04), National Science Foundation of China (51074075), Hebei Natural Science Foundation (E2012508001).

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