Large scale grouting to reconstruct groundwater barrier and its geoenvironmental impact

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Abstract This paper presents an investigation of large scale grouting and its environmental effect on hydrogeological conditions of coal mines. In order to control and mitigate water inrush disasters while mining above or under aquifers, which generally are reinforced by using grouting as an impermeability treatment. The research of the hydrogeological environmental variation can provide theoretical and technical support for the safe mining above or and aquifers and to maximize the economic efficiency of coal production. Based on the water yield and water table of coalmines, the effect of hydrogeological environment have been analyzed in this study.

Key words aquifers, environmental variation, hydrogeology, grouting

Introduction

Grouting applications in many engineering fields, such as foundation and dam reinforcement, groundwater inrush and its prevention and control and sand consolidation, shutdown of abandoned mine, and flooded mine recovery production (Andjelkovic et al. 2013; Kociánová et al. 2016; Li et al. 2016). Groundwater inrush is the most common geological hazard in coal mines in China. In order to prevent and control water inrush disasters when mining above or under aquifers, which generally should be reinforced by using grouting as an impermeability treatment (Xu and Yang 2014). The hydrogeological parameters of aquifers such as permeability coefficient have changed considerably, especially the groundwater seepage field after grouting reconstruction. Hydrogeological characterization of aquifers due to coal mining are important for preventing panels from water inrush, reducing mine drainage and surface water pollution and ensuring mining safety (Xu et al. 2013; Zhang et al. 2006).

The aquifers, coal seam and geological structure and other geological objects are mostly hidden in the ground when mining above or under aquifers. The hydrogeological conditions which are complex to simple will be beneficial to mining, although the structure and function of groundwater environment system have been changed. The research of the hydrogeological environment viration can provide theoretical and technical support for the safe mining above or under aquifers and to maximize the economic efficiency of coal production. Based on the hydrogeological parameters of coalmines in which aquifers have been grouted reconstructions, the negative and positive effect of hydrogeological and groundwater en-

vironment have been analyzed in this study. The characteristics of aquifers with grouting as an impermeability treatment have been obtained. Finally, the effect of hydrogeological environment has been provided for mining and grouting reference.

Grouting for the reinforcement of aquifers

Mining engineering is a typical environmental reconstruction process, the project not only to ensure the safety of mining, but also to ensure that the environment is not destroyed (Zhou et al. 2007). Grouting reinforcement as a method and means to change the hydrogeological condition of rock mass. Grouting reinforcement is a effective method which tries to eliminate the disadvantages of traditional drainage, and strive to promote the realization of safe, efficient and low cost mining. Under certain pressure, the slurry is dehydrated, consolidated or gelled in the void or channel which was originally occupied by water in the grouting purpose layer. The combination of stone body or gel and surrounding rock mass. In this way, the water leakage of the floor rock is blocked, and the strength of the water layer and the water separation performance are improved. The aquifer is changed into a aquiclude , and the water inflow of the panel will be significantly reduced. At the same time, it can protect the precious groundwater resources. The grouting reinforcement of aquifer realized by drilling, and the panel of the borehole is connected with the grouting target layer. When the aquifer is rich in water and the head pressure is high, or the bottom of the coal seam floor is thin, and the aquiclude has a water control structure broken zone. The transformation of the bottom aquifer and aquifuge grouting water control method, by increasing the thickness of water resisting layer which can reduce water inrush coefficient and the water inrush risk, and has significant effect and scale of the project, is currently applied in most coal mines. There are two drilling methods for grouting, drilling underground and ground surface, as shown in Figure 1.

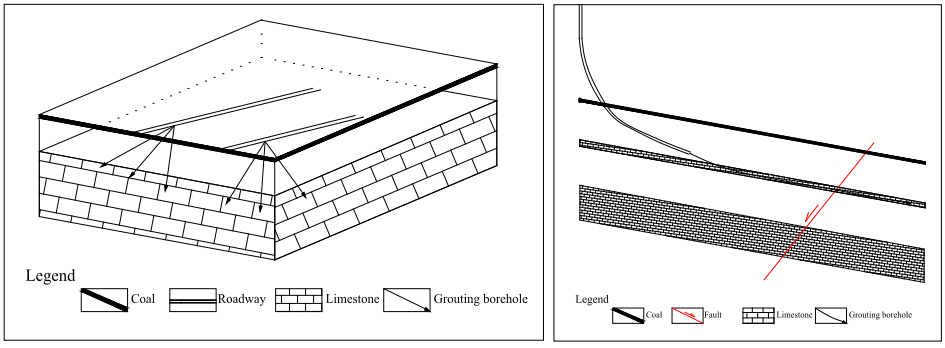

Figure 1 *Aquifer grouting reinforcement technique principle*

Geological conditions

The Zhuxianzhuang Coalmine is located in the southeast of Suzhou, in Anhui Province in China (Figure 2). Coal measures in the Zhuxianzhuang Coalmine is covered by the Cenozoic, which averages 255m in thickness. The Seam 8 is a productive coal seam which occured in Shihezi Formation of Permian. The thickness of Seam 8 is between 7.0 and 13.0 m with an

average thickness of 10.03 m. There aquifers and aquiclude in the Cenozoic are is formed multi-layer composite structure due to the interactive deposition. The first, second, third, fourth aquifers in the Cenozoic, the fifth aquifers in the Jurassic, karst fractured aquifer in the Carboniferous and Ordovician respectively are mainly aquifers in the coalmine, as shown in Figure 3 .

Figure 2 *The location of the Zhuxianzhuang Coalmine*

There has been hydraulic connection among the fourth, fifth, karst fractured and limestone of the Ordovician aquifers. The water yield property gradually becomes stronger with the increase of conglomerate thickness. There a water inrush has been occurred in the panel of 866-1, and the water source was from the fifth aquifers in the Jurassic. Thus, the overburden failure due to the mining results in the fifth aquifer to be communicated. The fifth aquifers in the Jurassic must be transformed by grouting or dewatering.

Determination of the scheme

The area of coal seam which is covered with the fifth aquifer is 2.8km2. 1120 drills needed as the spacing is 50m. The cost of the grouting project is at least $ 667 million. The cost of this scheme is too high, and it is difficult to exploit under high water pressure. There has been hydraulic connection between the fifth and other aquifers. When the pressure of the aquifer was reduced by dewatering, the fifth aquifer will recharged by the other aquifers, which results in the cost of dewatering is high and a long time need.

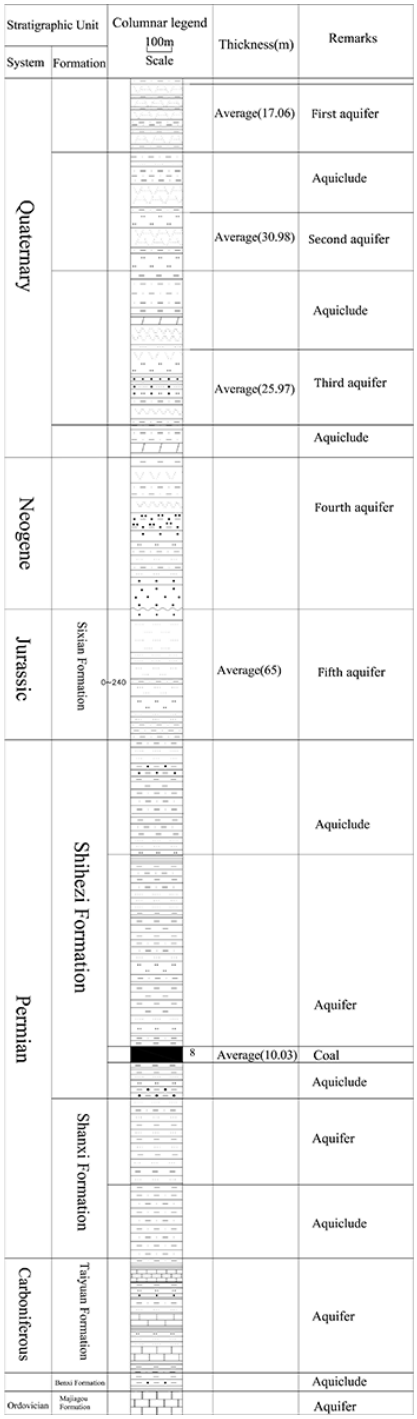

Figure 3 *The aquifers and aquiclude in the coalmine*

Consequently, a curtain wall is need that will prevent the fifth aquifer recharged by the aquifers outside the wall. Then, the water pressure of the fifth aquifer can be reduced by dewatering inside the wall. The curtain wall has been constructed in the east and north of the field with 3.13km in length and 40m in thickness. The drilling footage will be 73,098m, and 150,000t cement concrete and 120,000t fly ash will be consumed.

Geoenvironmental impact

With the large scale grouting was performed, the underground water level has been changed inside and outside the wall, as shown in Figure 4. The characteristics of the fifth aquifer with grouting as an impermeability treatment can be obtained. The water level of fifth aquifer is lower inside than outside of the wall. Because of the pressure of the grouting, and the surface has been changed. Figure 5 shows the surface above on the fifth aquifer around the grouting drilled has been uplifted as a result of grouting stress.

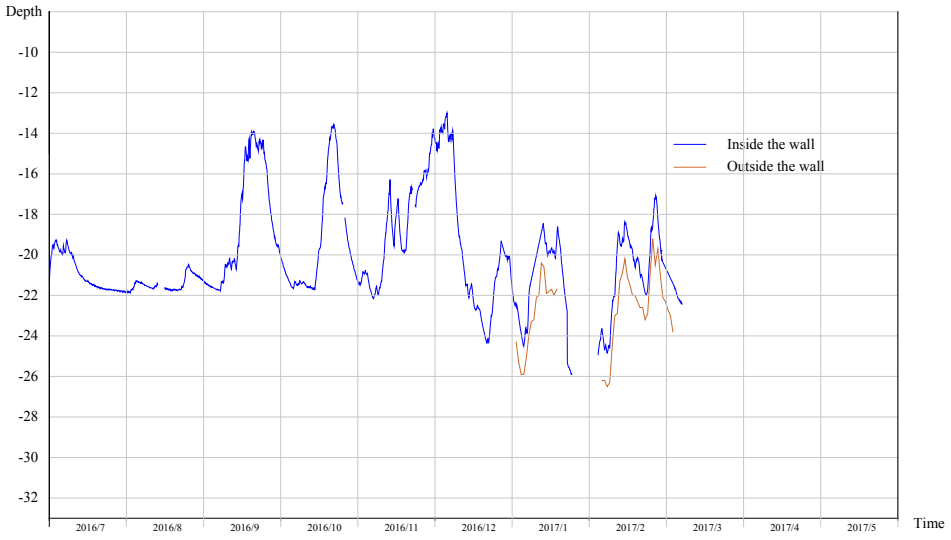

Figure 4 *The water level of the fifth aquifer inside and outside the curtain wall*

Conclusions

In order to prevent and control water inrush disasters when mining under aquifers, a curtain wall has been constructed by using the grouting as an impermeability treatment. The curtain wall will be constructed in the east and north of the field with 3.13km in length and 40m in thickness. The groundwater environment of the coalfield will be reengineered. The influence of mining activities on groundwater environment and surface environment will be reduced. Based on the water yield and water table of coalmines in which aquifers have been grouted reconstructions, the effect of hydrogeological environment have been analyzed in this study. Finally, the effect of hydrogeological environment has been provided for mining and grouting reference.

Figure 5 *The surface around the grouting drilled*

Acknowledgements

The authors would like to acknowledgment financial support from the 973 Program under Grant No. 2013CB227903, and a Project Funded by the Priority Academic Program Development of Jiangsu Higher Education Institutions.

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