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Pumping Test to Determine Hydrogeological Parameters of Coal Seam Roof Aquifer

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Abstract. The coal seam roof aquifer often enters the mine as a water-filled source during coal mining. In this paper, the hydrogeological parameters of the aquifer in the Taran Gale coal mine were determined by various methods, which provides a basis for the prevention of mine water damage and the design of coal mine drainage system.

1. Introduction

The Taran Gale Mine Field is located at the northwestern edge of the Dongsheng Coalfield and belongs to the Yashitugou-Taoli Temple Sea Subsystem in the Molin River-Saline Sea Stream Flow Subsystem of the Cretaceous Clastic Fracture Aquifer System of the Ordos. The groundwater hydrodynamic conditions of the Cretaceous aquifer in the area are controlled by factors such as climate, topography, geomorphology and lithology, while the groundwater hydrodynamic conditions of the Middle Jurassic aquifer are mainly controlled by the occurrence and lithology.

The elevation of the area is generally around 1200~1600m. The middle part of the terrain is higher and gradually decreases toward the north and south sides. The “Dongshengliang”, which extends east-west along the Nalin-Dongsheng-Duoguijiahan line, has an elevation of 1400~1500 m, which constitutes a regional natural surface watershed in the area. The area is adjacent to the Kubuqi Desert in the north, with strong erosion of water flow, development of gullies, and features of erosive hills and aeolian deserts.

The Jurassic Mesozoic (J_2) lithology where the main coal seam of the mine is located is light yellow, blue-gray medium-grained sandstone, pebbly coarse-grained sandstone, purple-red, variegated siltstone and mudstone and sandy mudstone in the minefield. The inside is widely distributed, and the thickness is large and stable. The Jurassic Zhongtong (J_2) aquifer and the Jurassic Middle and Lower Yan'an Formation (J_{1-2y}) are mainly grayish-gray, gray-white medium-grained sandstone, gray, dark gray sandy mudstone, followed by fine-grained sandstone, siltstone, etc., containing coal seams, the whole area exists, widely distributed. The thickness of the aquifer is 143-203m, with an average of 174.20m, the groundwater depth is 124-204m, the water level is +1337.14-1343.69m, the unit water inflow is $q=0.03-0.2$ L/s•m, and the permeability coefficient $K=0.0154\sim 0.2327$ m/d; the water-rich is weak to medium, the water conductivity is medium, the groundwater recharge conditions and runoff conditions are poor, and the hydraulic connection with the overlying aquifer and atmospheric precipitation is poor. The aquifer is a direct aquifer and a main aquifer in the well.

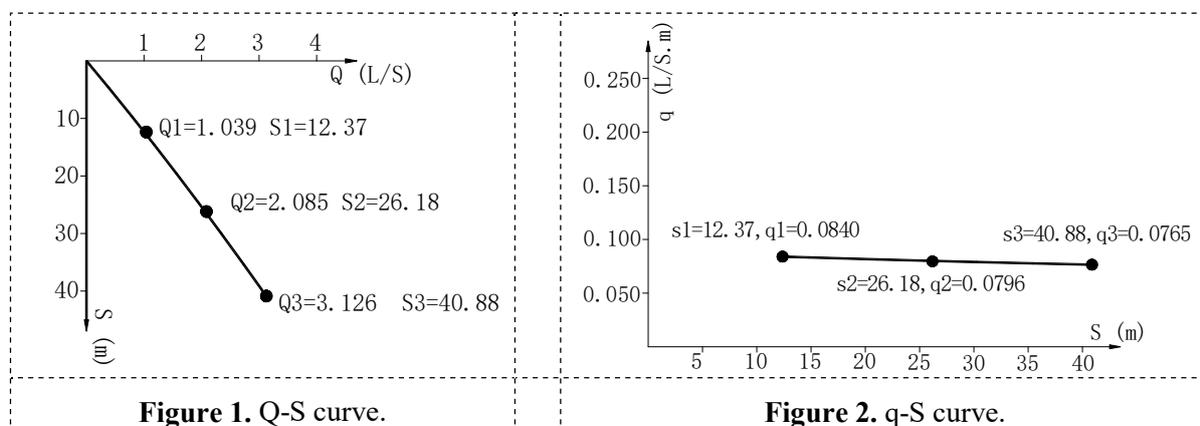


Combined with previous data: the characteristics of the confined aquifer of the 3-1 coal seam floor to the 4-2 coal seam roof sandstone fracture are as follows:

The lithology is mainly gray-white medium-grained sandstone with fine-grained sandstone. The top layer of the coarse-grained sandstone is relatively developed. The average thickness of the aquifer is 16.69m. It exists in the whole area and is widely distributed. The groundwater level is +1419.00m. The water volume is $Q=0.165\text{L/s}$, the unit water inflow is $q=0.0062\text{L/s}\cdot\text{m}$, the permeability coefficient is $K=0.0211\text{m/d}$, and the aquifer is rich in water.

2. Single hole pumping test data processing

According to the observation data of pumping test, the permeability coefficient and the influence radius are calculated according to the complete well formula of confined aquifer and the empirical formula of confined aquifer, and the Q-S and q-S curves are drawn (as shown in Figures 1 and 2).



The K- Permeability coefficient calculation equation was used:

$$K = \frac{0.366 \times Q \times \log \frac{R}{r}}{M \times S} \quad (1)$$

According to the following formula, the water volume of the unit is 91mm, and the water level of the pumping water is 10m.:

$$Q_{91} = Q_B \left(\frac{1gR_B - 1gr_B}{1gR_{91} - 1gr_{91}} \right) \quad (2)$$

where Q_{91} , R_{91} , r_{91} are Water inflow, radius of influence and drilling radius of boreholes with a bore diameter of 91 mm. Q_B , R_B , r_B are Water inflow, influence radius and drilling radius of borehole with aperture r.

3. Porous pumping test data processing

According to the water injection test data, the relationship graph (Fig. 2) is drawn, and the values of the parameters a and b of the trend line and the linear equation are obtained by the least squares method. The characteristic time is calculated using equation (3):

$$\ln(H_t / H_0) = at - b \quad (3)$$

the permeability coefficient is calculated according to formula (4):

$$K = \frac{0.0523r^2}{ATo} \tag{4}$$

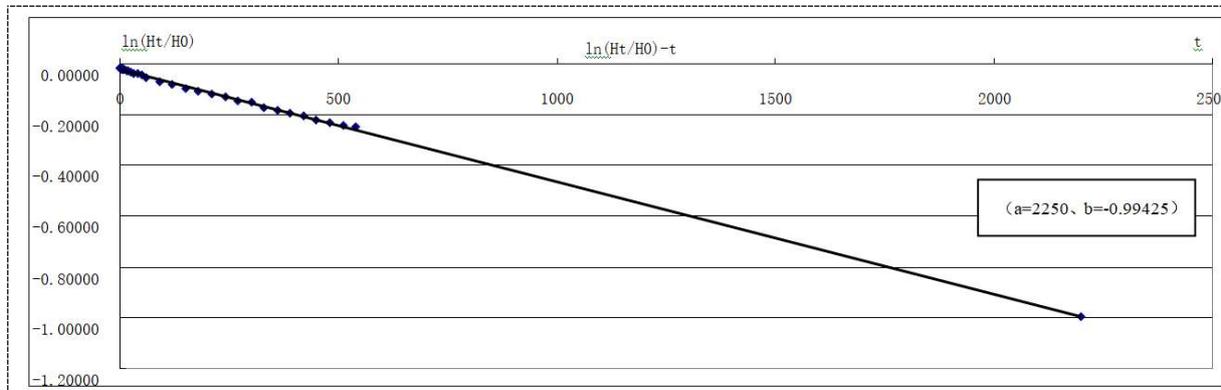


Figure 3. Water injection hole injection test ln(Ht / Ho) - t relationship curve.

4. Discussion on mine water intrush

In the porous pumping test, the main hole was pumped, and the observation hole observed the water level change at the same time. The observation data is processed using an unsteady flow calculation method. Draw the deepening duration curve, as shown in Figure 4. Match the Tess curve according to the Tess formula, as shown in Figure 4.

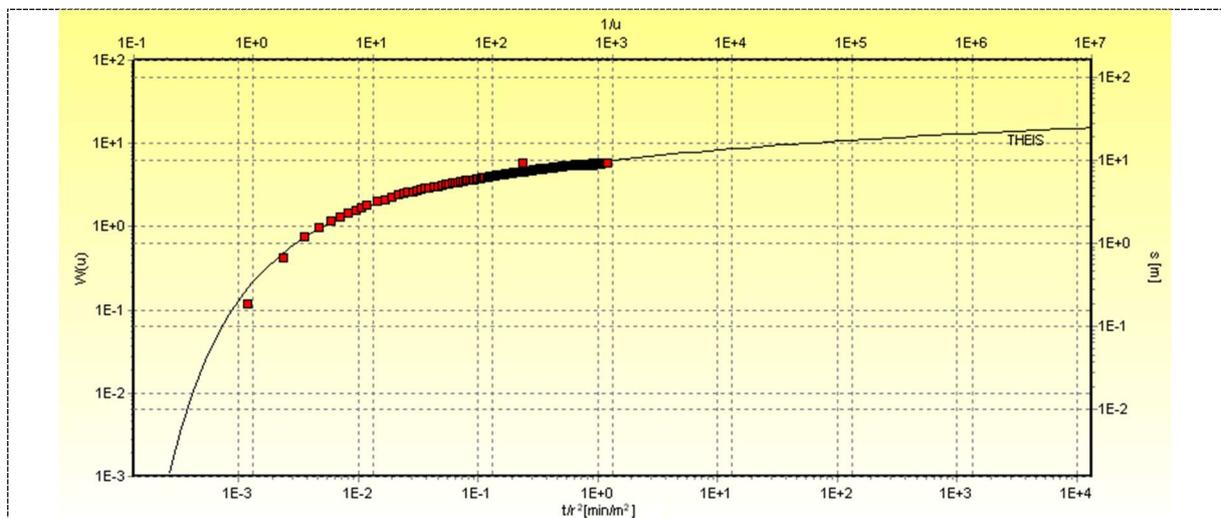


Figure 4. Observed hole depth deep tes curve matching map.

Unsteady flow calculations can obtain more hydrogeological parameters, including permeability coefficient K, water conductivity coefficient T, and elastic water release coefficient S.

5. Conclusion

This hydrogeological supplementary exploration has carried out special work for the prevention and control of water in future mining, and has achieved more abundant and reliable results than before, mainly in:

- 1) The amount of water pumped in a single hole is much larger than that in the previous pumping test. In the previous data, the pumping volume during the pumping test of the lower aquifer section was

less than $2\text{m}^3/\text{h}$, and the single-hole pumping volume during the pumping test of this supplementary exploration was $3.74\sim 16.34\text{m}^3/\text{h}$;

2) The amount of water influx in the lower aquifer is much larger than the existing value. In the past, the unit water inflow in the aquifer was only $q=0.00389\sim 0.00558\text{L}/\text{s}\cdot\text{m}$, so the aquifer water content was extremely weak; and the unit water inflow obtained in this section was $0.039\sim 0.23\text{L}/\text{s}\cdot\text{m}$. The previous value is 10 to 41 times, and the water-rich state is weak to moderate. And this results in a qualitative change in the water-rich water content of the aquifer;

3) Similarly, the permeability coefficient of the lower aquifer obtained this time has also changed greatly from the past. The permeability coefficient k obtained in the past is 0.0051 to $0.00325\text{m}/\text{d}$, and the permeability coefficient obtained this time is 0.0154 to $0.2327\text{m}/\text{d}$, which is 10.2 to 71.6 times of the previous value;

4) The water level of the aquifer changes significantly. According to the observation results of this supplementary exploration pumping test, the water level elevation of the Baidan system Zhidan Group conglomerate aquifer (upper aquifer) is $+1341.711\sim 1349.127$; the Jurassic Zhongzhi Zhiluo Formation to the Jurassic Middle Lower Yan'an Formation The water level elevation of the conglomerate aquifer (lower aquifer) is $+1337.14\sim +1343.687$.

The reason for the above significant differences may be that each of the key technical links is strictly controlled during the hydrogeological supplementary exploration process, and the quality of the project is high, especially the comprehensive well washing and bridges such as CO_2 well washing, piston washing, submersible pump washing and so on. The use of the filter ensures the quality of the pumping test and thus obtains more accurate hydrogeological parameters.

Changes in hydrogeological parameters also explain the reasons for major changes in hydrogeological conditions and expected wellbore construction.

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References

- [1] J.Dupuit, *Etudes. Theoriques et Pratiques sur le Mouvement des Eaux dans les Canaux de Couverts et Traverses Terrains Permeables*[M]., Dunod, Paris, 1863.
- [2] CV Theis. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground water storage[J]. *Trans Am Geophys Union* 2:519-524.
- [3] Cooper, H.H. and C.E. Jacob. A generalized graphical method for evaluating formation constants and summarizing well field history[J]. *Am. Geophys. Union Trans.*, 1946.vol. 27, pp. 526-534.
- [4] Hantush M S, Papadopoulos I S. Flow of ground water to collector wells. *Proc Am Soc Civil Engrs* [C]. *J Hydraulics Division*, 1962, HY5: 221-244.
- [5] Rosa A J, Carvalho R de S. A mathematical model for pressure evaluation in an infinite-conductivity horizontal[J]. *SPE Formation Evaluation*, 1989, 4(4): 559-566.
- [6] Casasent D, Wang Y C. "A hierarchical classifier using new support vector machines for automatic target recognition." *Neural Networks*, vol. 18, pp.541-548, May 2005.
- [7] Yang Yongguo, Huang Fuchen, "Water source determination of mine inflow based on nonlinear method," *Journal of China University of Mining and Technology (Natural Science)*, vol. 36, pp. 283-286, March 2007.
- [8] Hao P Y, Chiang J H, Tu Y K, "Hierarchically SVM classification based on support vector clustering method and its application to document categorization," *Expert Systems with Applications*, vol. 33, PP. 627-635, March 2007.
- [9] J. Annan, L. Bing, "Particle swarm optimization support vectors machine method of identifying standard components of ions of groundwater," *Journal of China Coal Society*, vol. 31, pp. 310-

- 313, March 2006.
- [10] T. Lian-sheng, W. Si-jing, “Progress in the study on mechanical effect of the chemical action of water-rock on deformation and failure of rocks,” *Advance in Earth Sciences*. vol. 14, pp. 433–439, May 1999.
- [11] L. Ning, Z. Yun-ming, S. Bo, et al, “A chemical damage model of sandstone in acid solution,” *International Journal of Rock Mechanics and Mining Sciences*, vol. 40, pp. 243–249, May 2003.
- [12] F. L J, “Effect of chemically active solution on shearing behavior of sandstone,” *Tectonophysics*, vol. 175, pp. 159–176, July 1990.