Prediction Mine Water Inrush by Set Water Corridor Method and Comparison Method

Chen Shi1,2,*

1 College of Water Resources and Architectural Engineering, Northwest A&F University, Yanglin, Shaanxi, 712100, China
2 Key Laboratory of Agricultural Soil and Water Engineering in Arid and Semiarid Areas, Ministry of Education, Northwest A & F University, Yanglin, 712100, China

*Corresponding author’s e-mail: aliphonse@gmail.com

Abstract. Set water corridor method and comparison method have been used for predict the mine water inrush in coal mine mining widely. In this paper, these two methods were used to calculate the water inrush from the first mining face of the Taran Gale coal mine.

1. Introduction
The Taran Gol Coal Mine is under the responsibility of Shenhua Hangjin Energy Co., Ltd. and is the key project of the National Eleventh Five-Year Plan.

The Taran Gol Coal Mine uses vertical shaft development. The three wells of the main, auxiliary and wind wells have a water inflow of 118 m³/h during the construction of the wellbore, and the maximum water volume of the drilling and drainage holes exceeds 200 m³/h. The amount of water in the wellbore construction process far exceeded expectations, indicating that the hydrogeological conditions in the minefield are seriously inconsistent with the existing understanding. It is foreseeable that the future 3-1 coal mining will also be threatened by roof water. Therefore, it is necessary to predict the amount of water inflow from the mine, formulate a mine water prevention plan based on the predicted results, and design a mine drainage system.

2. Mine water-filled aquifer and aquitard
Terrestrial clastic rocks mainly developed in the area, semi-cemented rocks and loose rocks in the Cenozoic zone. According to the different water-bearing characteristics of groundwater, the regional water-bearing rock group can be divided into three categories: loose rock pore water Rock group, semi-cemented rock-like pore water-bearing rock group.

The recharge channel of groundwater in the Lower Cretaceous aquifer group is mainly atmospheric precipitation, and its runoff and discharge conditions are obviously controlled by topography, landform and stratum structure. Influenced by the top beam of the Shililiang-Yanchi area and the local beam geomorphology of the central Husband, the runoff direction of the groundwater is divided into northward and southward runoff by the total flow direction of the geologically. The excretion method is mainly spring. Forms are exposed, forming surface runoff or replenishing other aquifers. In the south, the confined water passes through the "skylight" to support the upper part of the diving, and finally...
discharges the surface in the low depression of the terrain, forming a long-term lake Muir (such as Chahan, Bahan, Olympus, etc.).

There are two ways to recharge groundwater in the Middle Jurassic water-bearing rock group, one is atmospheric precipitation, and the second is recharge of the upper Lower Cretaceous aquifer. Atmospheric precipitation recharge is limited by the exposure range of the stratum. In the northern margin of Husliang, some groups of the Middle Jurassic are exposed, which can directly accept the recharge of atmospheric precipitation. The recharge of the upper Lower Cretaceous aquifer is mainly indirectly received by the aquifers of the Middle Jurassic in the basin. In the interval between the upper and lower aquifers, the amount of recharge is large, and the recharge effect is strong, so that the groundwater in the aquifers of the Middle Jurassic is rich in water. Since the upper aquifer is relatively stable, the overlying Lower Cretaceous aquifer has little effect on the recharge of the lower aquifer in the lower Zhiluo Formation.

The controlling factors of groundwater movement in the Middle Jurassic aquifer are mainly the distribution of river sedimentary sand bodies and the occurrence of strata, in other words, the spatial distribution of reservoirs of underground (water) fluids and the occurrence and accumulation of reservoir space. Deep control of the distribution and migration of groundwater; the overall flow from the northwest to the southeast runoff, but due to the smaller dip angle, the hydrodynamics are relatively weak, the runoff is slow; in the southeast to the Ulanmulun river basin with exposed conditions The area is excreted and eventually drained to the Yellow River.

The groundwater in this area is finally replenished to the Yellow River. The sedimentary rocks in the region are rich in muddy and organic matter, the fault structure is low, the pores of clastic rocks are poorly developed, and the groundwater runoff conditions are poor. The groundwater recharge source is mainly atmospheric precipitation. The Quaternary loose aquifer is directly recharged by atmospheric precipitation. The bedrock aquifer can accept atmospheric precipitation and recharge in the shallow part, and receive lateral runoff recharge in the deep.

The runoff of the submarine is controlled by the topography and generally flows along the valley. The confined water runoff is controlled by the overall structural form of the area, generally along the rock stratum, that is, the southwest runoff, and then discharged outside the area.

3. Set water corridor method prediction

According to the water collection corridor method, the mine water inflow is estimated as follows:

$$Q = BK \frac{(2H - M)M - h_0^2}{2R}$$  \hspace{1cm} (1)

where $Q$ are predicted mine water inflow; $K$ are permeability coefficient (m/d); $H$ are water column height (m); $B$ are roadway length; $h_0$ are the height of the remaining water column of the aquifer (m), $M$ are aquifer thickness (m).

When calculating $B$, take the working face length: take 5000m in the west area, 5500m in the east area, 1000m in the test mining area, and take the value of 10500m in the east and west areas. The calculation is shown in Figure 1. The mine water inflow is expected to be shown in Table 1.

**Table 1.** Calculation result of water inrush under the condition that the aquifer is completely drained.

| Aquifer | Normal mine water inflow | Maximum mine water inflow |
|---------|--------------------------|---------------------------|
|         | (m$^3$/d) | (m$^3$/h) | (m$^3$/d) | (m$^3$/h) |
| Separate mining  | 7845 | 327 | 9414 | 392 |
| Mining one east alone | 8630 | 360 | 10356 | 431 |
| Test face | 1569 | 65 | 1883 | 78 |
| Mining two east and west mining areas at the same time | 16475 | 686 | 19770 | 824 |
4. Comparison method prediction

There are many mines under construction and production in the vicinity of Taran Gol, among which the Gaotou kiln coal mine is 50~60km away from the Taran Gale coal mine, as follows:

The resources of the Gaotou kiln coal mine are 2 billion tons, and the coal seams of the Yan'an Formation in the Middle and Lower Jurassic systems are mined. The mine design scale is 8.0 Mt/a and has recently been put into production.

Mine water inflow: At present, the mine water inflow is 84 m$^3$/h (2000 m$^3$/d), and the first working face is only 17 m$^3$/h (400 m$^3$/d). The Gaotou kiln well stratum and mining coal seam are basically the same as the Taran Gol mine, and the hydrogeological conditions are similar. Based on this, the hydrogeological conditions can be used to predict the water inflow from the Taran Gale mine. Comparison conditions: according to the production surface water-rich coefficient method. Calculate the water-rich coefficient according to the formula:

\[ K_p = \frac{Q_c}{P_c} \]  

Where \( K_p \) are water-rich coefficient (m$^3$/Mt); \( Q_c \) are the amount of water inflow on the working surface (m$^3$/a), take 400 m$^3$/d = 146000 m$^3$/a; \( P_c \) are raw coal production (Mt/a), take 4Mt/a.

Gaotouyao Coal Mine is calculated according to 4.0Mt/a of each working face, and its water-rich coefficient is 36500 m$^3$/Mt, comparative calculation:

\[ Q = K_p \times P = 36500 \text{ m}^3/\text{Mt} \times 10.0 \text{ Mt/a} = 365000 \text{ m}^3/\text{a} = 1000 \text{ m}^3/\text{d} = 42 \text{ m}^3/\text{h} \]

5. Conclusion

In view of the fact that the ‘set water corridor method’ can not calculate the width of the mining area, the method predicts that the mine water inflow has its inherent defects. It is expected that the mine water inflow cannot reflect the change of the mine water inflow with the mining, and according to the current The exploration and release of water from the downhole actually reveals that the aquifer in the roof has a certain water-rich condition. At present, it is more suitable to use the water inflow from the Gaotou kiln coal mine to compare the expected water inflow from the Taran Gale mine. In the future, if
necessary, an independent drainage system for the mining area can be established in the new mining area, and the mine water can be directly discharged to the ground through the direct drilling.

The ‘set water corridor method’ is expected to have a large change in the amount of water inflow from the mine and the amount of water inflow expected in the analogy method. The main reason is that the hydrogeological supplementary exploration has carried out a large amount of single-hole and porous pumping tests, which is more accurate. The hydrogeological parameters are obtained, and the hydrogeological parameters obtained are significantly larger than in the past. The mine drainage system design should be based on the mine water inflow expected from this hydrogeological supplementary exploration.

Acknowledgments
This research was supported by projects from national natural science foundation of China (NO.41602254), and Special Funding Project for Basic Scientific Research Business Fees of Central Universities (2452016179), Double-class discipline group dry area hydrology and water resources regulation research funding project (Z102021853).

References
[1] Park E, Zhan H. Hydraulics of a finite-diameter horizontal well with wellbore storage and skin effect [J]. Adv Water Resources, 2002, 25(4): 389-400.
[2] Chen, C., Wan, J., and Zhan, H., Theoretical and experimental studies of coupled seepage-pipe flow to a horizontal well[J]. Journal of Hydrology, 281(1/2), 159-171, 2003.
[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, Papadopulos 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] N Samani, M Kompani-Zare, H Seyyedian. Flow to horizontal and slanted drains in anisotropic unconfined aquifers [J]. Developments in Water Science, 2004,55 (1): 427–440.
[12] PR Tsou, ZY Feng, Stream depletion rate with horizontal or slanted wells in confined [J]. Hydrol. Earth Syst. Sci. Discuss., 2010(7): 2347–2371.