Hydro-geological Conditions and Mine Inflow Water Forecast of the Western Long Beach in Junggar Coalfield

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Abstract

Gushing water is harmful to underground coal mine safety. Jungar coalfield is the major coal base in the Chinese Midwest, and coal-bearing strata are mainly Shanxi Formation and Taiyuan Formation. Coal seams can be mined in the western long beach are 3\textsuperscript{a}, 5\textsuperscript{a}, 6\textsuperscript{a}, 9\textsuperscript{a}. This paper analyzed regional geological conditions, hydro-geological conditions in the western Long Beach of Jungar coalfield, and water-filled factors, predicted mine water discharge, based on the prediction, and proposed prevention and treatment measures of coal mine water.

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Keywords: the western Long Beach of Jungar coalfield; hydro-geological conditions; mine water discharge

1. Introduction

Junggar Coalfield is located in Ordos with syncline northeast of North China platform, and the terrain is from northwest to southeast. Elevation is 1050m ~ 1250m. The average rainfall in many years is 408mm, and the annual total evaporation is up to 1824.7mm ~ 2204.4mm. Yellow River flows through the eastern and the southern edge of the coalfield, which is the largest surface water body around the coalfield, and the minimum basic erosion level of coalfield. The general construction was uplift in east and western depression. Move from south to north, and the monoclinic structure is formed by west tilted. And occurrence is gentle, generally <10°. Sub-structure is the main-relief folds, and faults developed not...

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well (Shown in Figure 1). Groundwater storage and transport are controlled by the overall structure shape and secondary relief folds [1, 2].

![Fig. 1 Sketch map and Study Area (Gray).](image)

**Table 1**

| Age              | Rock                          | Distribution                          | Thickness                      | Hydrological characteristics                                      |
|------------------|-------------------------------|---------------------------------------|--------------------------------|---------------------------------------------------------------|
| Quaternary       | Aeolian sand                  | Kongdui Ditch, Dalu Ditch, Wulanbula  | Different with the topography   | Permeable but not containing water                            |
| Holocene         |                               |                                       | Different                      | With pore water                                               |
| Quaternary       | Alluvial layer                | Lama Bay, Mashan                      | Different                      | Good water permeability                                       |
| Holocene         |                               |                                       | 0.00~150.00m                   |                                                               |
| Quaternary       | Loess layer, yellow, brown    | Regional distribution                 | Different                      | Impermeable layer                                             |
| Pleistocene      | yellow                       |                                       |                               |                                                               |
| Tertiary red soil | Red clay and loam            |                                       |                               |                                                               |
| Cretaceous       | Variation in lithology        | Northern and northwestern edge of the| 4.00m~20.00m                   | Uneven rich water                                             |
|                  |                               | coalfield                             |                               |                                                               |
| Triassic         | Sandstone and mudstone        | Southwestern coalfield                | More than 165m                 | Poor rich water                                               |
| Permian          | Sandstone, sandy mudstone,    | Western coalfield                     | Uncertain                      | Sandstone porosity, fractured, permeable layer; mudstone as   |
|                  | mudstone, mudstone            |                                       |                               | impermeable layer                                             |
| Carboniferous    | Sandstone, mudstone, marl,    | eastern, central and southern         | Uncertain                      | Impermeable layer of coal stable                              |
|                  | aluminum soil mudstone        | coal field                            |                               |                                                               |
| Ordovician       | Limestone                     | eastern and southern edge of coalfield| Uncertain                      | Karst fissure developed well with better rich water           |
| Cambrian         | Silty shale, siltstone, fine  | East of the Yellow River              | 330m                           | Fractured, good water-rich                                    |
|                  | sandstone with purple - purple gray |                                       |                               |                                                               |
2. The Region Lithology and Hydrological Characteristics of the Coalfield

The mined coal layers are 5\textsuperscript{th}, 6\textsuperscript{th}, 9\textsuperscript{th} in the coalfield. The region lithology and containing water characteristics in the Coalfield are shown in Table 1. The direct water-filled aquifers in major mining coal seams are Shanxi Formation sandstone fractured aquifers in Permian and Taiyuan Formation sandstone fractured aquifer in Carboniferous. The coalfield is less rainfall with small recharge area and large undulating topography, and valleys are cutting deeply without a good catchment topography\textsuperscript{[3]}. Overall structure is the west-dipping with undulating monocline, which is unfavorable for the enrichment of groundwater storage. The recharge of direct water-filled coal aquifer is extremely small with poor-rich water, and hydro-geological conditions are simple.

3. Hydrological and Geological Conditions of Coalfield

The direct water-filled rock group with coal-water of the mined layer 3\textsuperscript{th}, 5\textsuperscript{th}, 6\textsuperscript{th}, 9\textsuperscript{th} is sandstone fractured aquifer in Shanxi Formation. Taiyuan Formation has mostly changed to sandy mudstone, and can not constitute continuous water-bearing rock group. Shanxi Formation is formed by sandstone, and cracks are developed to vary degrees. Connectivity is better, and the top generally has 1 or 2 layers mudstone. Sandy mudstone strata are separated by impermeable layer and the overlying strata. The water depth is 99.98m, head elevation is 1055.47m, permeability coefficient is 0.001m/d, and unit water discharge is 0.00144L/s•m. Sandy mudstone and mudstone layers are the better impermeable in upper and lower stone box, which play a good role in blocking the direct precipitation infiltration recharge water-filled water rock group. The supply source of direct water-filled rock group is from the atmospheric precipitation, which is supplied by coal-bearing strata outcrop or hidden under a layer of overlying loess outcrop. Recharge area is small, the distribution is not concentrated, and very little precipitation determines the supply is limited with poor-rich water.

The fractured of Cambrian, Ordovician limestone, dolomite karst under the coalfield is very uneven, and rich-water is very different. Pressure head elevation of region Cambrian, Ordovician karst fissure is 860m ~ 870m, which is higher 352.68m than the lowest floor elevation of 6\textsuperscript{th}. 500m head pressure is equivalent to about 5.0Mpa. Cambrian, Ordovician karst fissure confined aquifer and the coal-bearing strata are separated by stable impermeable layers in Benxi Formation. Rock mechanics testing has shown that uniaxial compressive strength with natural state of sandy mudstone exposing in the lower part of Taiyuan Formation is 42.9Mpa. The intensity values have safety coefficient to barrier 5.0MPa water pressure. It is possible that gushing water could occur in mining when water head elevation is lower than 860~870m in Cambrian, Ordovician limestone karst fissure. Rock group of direct water-filled aquifer in coal mining layers is sandstone water-filled cracks. The unit water discharge is less than 0.1L/s•m and easy dewatering, and hydro-geological conditions are simple.

4. Analysis of Water-filled Deposits

The coalfield is located in the Loess Plateau, which has wide thicken loess, poor consolidation, vertical joint development, large undulating terrain, valleys cutting deep. Precipitation is easy to form flood and concentrated into the Yellow River with little into the ground. There are no surface water bodies, but have the valleys with water. The Yellow River flows through the eastern edge (from the east about 25km) and the southern margin (from the southern boundary about 28km) of the outer coalfield. The bank of the Yellow River around the coalfield cut Cambrian, Ordovician strata, which only contact water power with the above strata. The stable impermeable layers in Benxi Formation are existed between Cambrian, Ordovician karst fissure and coal-bearing strata.
In the recovery area of coal mine, water range is unknown, the series relationship is complex, the volume of water is large with strong acidic and head pressure is great, which is very harmful. To probe hydrocele in the old mine well is the primary mean to prove recoverable water boundaries and keep safe mining.

The main water-filled channels in coalfield are caving zone and fracture zone formed in mining process. The water-filled resource is from the groundwater in sandstone fissures of Shanxi Formation. Direct water-filled aquifers of mined coal seams are fractured sandstone aquifers in Shanxi Formation.

5. Mine Water Discharge Forecasts

Use “Virtual Large Diameter Well “to predict water discharge in roadway system of 6#. In the projection, the principles to determine the parameters are as the following[4~6]:

a. Permeability coefficient (K): Measured and calculated result is \( K = 0.001 \text{m/d} \).

b. Aquifer thickness (M): The measured average thickness of the sandstone fractured aquifer in Shanxi Formation is 107.02m.

c. Reference radius of influence (R): According to the empirical formula: It is measured by \( R = 2S\sqrt{HK} \) and the measured data R is 2158m.

d. Initial water head value (H):

The difference between the arithmetic mean of pre-drilling exploration sites in the base elevation of Shanxi Formation and the water level elevation values of the hydrogeology hole in the purposed construction section.

e. Roadway system (“Big Well”), Reference radius (r0) (shown in Figure 2):

Pre-mining location is rectangle, and according to the reference radius calculated formula, the result is:

\[
r_0 = \sqrt{\frac{a + b}{4}} = 1.144 \times \frac{8940 + 2310}{4} = 3217.50 \text{m};
\]

Suppose if direct water-filled rocks in roadway system of pre-mining sites are homogeneous, isotropic, infinitely aquifer with the same thickness, and suppose if the complex roadway system in pre-mining sites is an area equivalent to the "big well", a formula could get to predict water discharge, when the pressure switch to non-pressure with mathematical model of analytical method with a steady flow[7~10]. The formula is
\[ Q = \frac{1.366K[(2H - M)M - h^2]}{\log \frac{R_0}{r_0}} \] ........................(1)

Dynamic water level: h = 0 (The distance is from moving water to the aquifer, 6#, dewatering to the bottom of Shanxi Formation, so it is 0);
Groundwater landing radius: \( R_0 = r_0 + R = 3217.50m + 2158m = 5375.50m \).

The relationships are shown in Figure 1. The corresponding parameters are put into Equation (1), it is achieved: \( Q = 799m^3/d \).

6. Conclusions

Through the analysis of regional geological conditions and hydrological and geological conditions in western Long Beach of Jungar coalfield and the prediction of water discharge in 6#, the following conclusions are achieved:

1) The surface water is lack in the coalfield. Direct water-filled aquifer in coal seam is sandstone cracks water rock group in Permian of Shanxi Formation. Precipitation is the main supply source. The overall trend in the coalfield structure is NNW, and tends to SWW, which is not conducive to the enrichment of groundwater.

2) Unit water discharge in water-filled sandstone cracks aquifer is less than 0.1L/s•m. Water discharge in 6# is 799m\(^3\)/d, which is the normal water discharge of the final stage of the exploitation in the pre-mining location.

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References

[1] Chu KZ. Characteristics of Coal Layer and its Sedimental enviroment in Junggar Coalfield. Inner Mongolia Science Technology & Economy 2008; 3:12-16.
[2] Zuo GG. Multimesure of the Late Paleozoic Coal Mine Layers in Junggar Coalfield, Inner Mongolia. Coal Geology of China 1999; 1:13-16.
[3] Cao DY, Zhang SR, Mu XS, et al. Study on Control Factors of Deformation of Coal Measures in China. Journal of China University of Mining & Technology 1999; 1:25-28.
[4] Zhou YH, Zhao KQ, Liu ZG, et al. Devastating laws of overlying strata with fissure under high hydraulic pressure. Journal of China Coal Society 2009; 6:3-7.
[5] Hua JM. Questioning on Mine Water Inflow "Virtual Large Diameter Well" Method Prediction. Coal Geology of China 2009; 21:45-47.
[6] Du MM, Deng YE, Xu M. Review of Methodology for Prediction of Water Yield of Mine. Acta Geologica Sichuan 2009; 1:73-76.
[7] Li CH, Teng WF, Gao C, et al. Analysis of Hydrogeological Characters and Forecast of Inflow in One Mine. Safety and Environmental Engineering 2009; 6:100-104.
[8] Liu Y and Zhang YZ. Forecast Method for Water Inflow from Working Face in Shallowly Buried Coal Seam. Journal of Mining & Safety Engineering 2010; 27:116–120.
[9] Xiao YC, Zhang XC, Gu ZM. Grey Model for Predicting and Forecasting the Amount of Gushing Water in Shallow Coal Layer. *China Safety Science Journal* 2004; 5:97-103.

[10] Zhang YJ. Grey Model for Predicting and Forecasting the Amount of Gushing Water in Shallow Coal Layer. How to prepare an electronic version of your article. *Journal of China Coal Society* 2009; 5:36-39.