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Forecasting water disaster for a coal mine under the Xiaolangdi reservoir

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Abstract: Xin'an coal mine, Henan Province, faces the risk of water inrush because 40% of the area of the coal mine is under the surface water of the Xiaolangdi reservoir. To forecast water disaster, an effective aquifuge and a limit of water infiltration were determined by rock-phase analysis and long term observations of surface water and groundwater. By field monitoring, as well as physical and numerical simulation experiments, we obtained data reflecting different heights of a water flow fractured zone (WFFZ) under different mining conditions, derived a formula to calculate this height and built a forecasting model with the aid of GIS. On the basis of these activities, the coal mine area was classified into three sub-areas with different potential of water inrush. In the end, our research results have been applied in and verified by industrial mining experiments at three working faces and we were able to present a successful example of coal mining under a large reservoir.

Key words: coal mining under surface water; water flow fractured zone; water inrush of coal mine; effective aquifuge; forecasting model

1 Introduction

There are over 2.5 billion tons of coal resources under surface waters in China. In some mines, coal under surface water, has been successfully excavated because of the existence of an effective aquifuge, such as in the Jining coal mine under the Weishan Lake and in the Huainan mining area under the Huaihe River. On the other hand, there are also many disasters as the result from surface water in cases where the aquifuges were damaged by mining[1–4].

The Xiaolangdi Reservoir is a large scale reservoir at the bottom of the main bed of the Yellow River. After water impoundment, its water level reached +275 m and 40% of the Xin'an coal mining area and more than 80 millions of tons of coal resource became submerged. Therefore, coal mines in this area are at the risk of water inrush. It is necessary to be able to predict the possibility of water inrush as a basis for decision making.

Water flow fractured zones (WFFZ) are formed by rocks cracking during coal mining. It will be the main flow channel for water inrush, which occurs if the thickness of the aquifuge between the water infiltrating interface and the top interface of the water flow fractured zone is insufficient. Previous studies have demonstrated the form of overburden rock failures and water conduits by mining activities and carried out massive investigations, proposed a delineation methods for a range of rock failures, derived rules of distribution of the three zones, presented emperical formulas to calculate the height of rock failures as well as technical safety measures for mining under water bodies[5–9]. Current prediction methods for water flow fractured zones can be summed up as field measurements, simulation experiments (physical simulation and numerical simulation) and theoretical analyses. But all these methods have their own limitations[6]. Therefore, based on the demand for safe mining under the Xiaolangdi reservoir, we used a related theory of mine hydrogeology and selected numerical simulation and comprehensive field measurements to discuss the rules of a rising water flow fractured zone after coal mining and then provided the Xin'an coal mine with some important parameters and technological support for a rational design of ways of mining under the Xiaolangdi reservoir.

We deal with three key scientific problems to present the water disaster forecasting results: features of groundwater field evolution after water impoundment of the reservoir to determine the lower limit of surface water seepage, rules for overburden rock crack-

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ing during coal mining to calculate the height of the water flow fractured zone and the methods to build the forecasting model of water inrush. A safe area for mining under water was determined with the use of GIS. Three working faces have been successfully excavated as a result.

2 Geological background of Xin'an coal mine

The Xin'an coal mine is located in the western part of Luoyang, Henan Province, with an area of 53.58 km^2. The major coal seam to be excavated is No.21 in the Shanxi Group of the Permian System, with a thickness ranging from 0 m to 18.8 m, with an average of 4.2 m. The rock overburden consists of mudstone, sandstone and coal. The fold is well developed, but no fault in the area, submerged by water of the reservoir, was found. After water storage of the reservoir, the surface water infiltrates into an un-solidified aquifer of the Quarternary (Fig. 1).

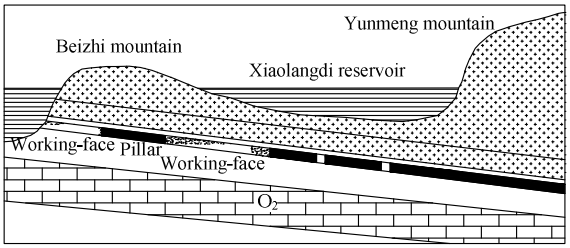

Fig. 1 Sketch map of Xin'an coal mining under Xiaolangdi reservoir

3 Effective aquifuge

The effective aquifuge is an impermeable seam which can prevent surface water from infiltrating into the coal mine. The first effective aquifuge from top to bottom determines the infiltration limit interface of the surface water. In most cases, the impermeable clay layer of the Quarternary can be regarded as an effective aquifuge of surface water. But in this area, surface water can percolate into some sandstones due to by-pass flow through rock outcrops. In order to make sure of the reliability of the infiltration limit interface, a rock-phrase analytical method was applied and data from all boreholes were analyzed. As a result, the impermeable mudstone of the lower Shihezi Group of the Permian system, was determined to be an effective aquifuge (Fig. 2).

After that, the water level and its dynamic change of surface water in the reservoir, as well as groundwater in aquifers in both the upper and lower Shihezi Grounp were monitored for a hydraulic year. The result shows that the water level in the aquifers above the effective aquifuge (in the K1 hole) range from about 240 m to 260 m and change in response to the water level of the reservoir (Fig. 3). However, no ground water was found in the rocks below the aquifuge, indicating that the effective aquifuge is reliable.

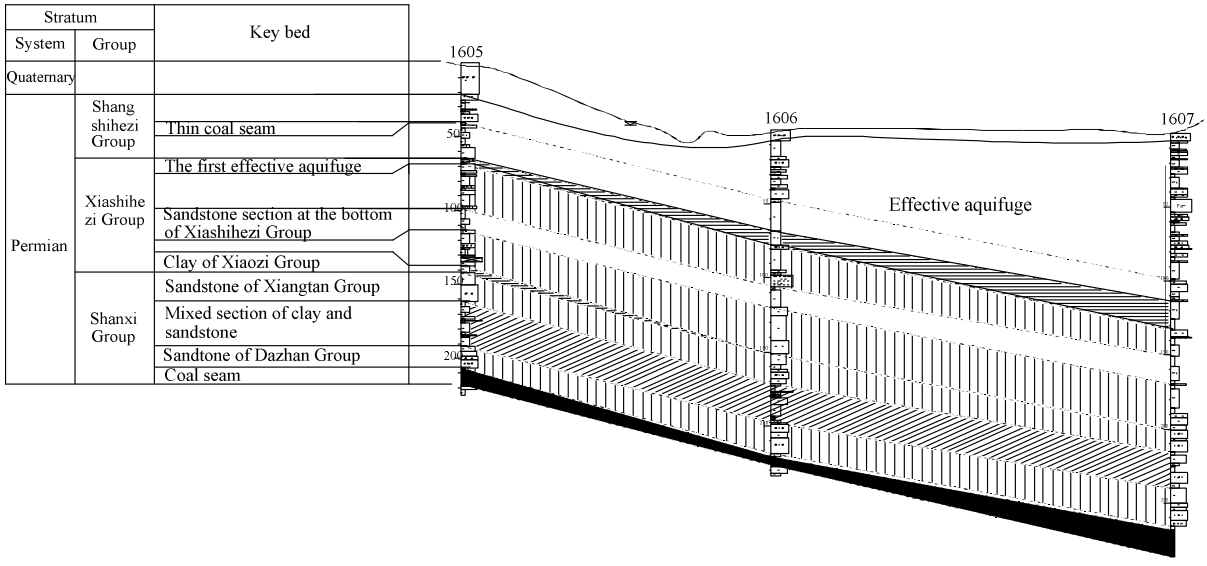

Fig. 2 Effective aquifuge as infiltration limit interface of surface water

4 Water flow fractured zone

To obtain reliable data of the height of the water flow fractured zone, we first established a numerical simulation model and calculated the heights of the WFFZ of the entire mining area, with reference to other studies[10–13]. Secondly, field observations were used to verify the calculated results and to acquire more data of the WFFZ.