Occurrence of coal seam as main aquifer

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Abstract

Hydrogeologically coal seam is always viewed as aquifuge. However, the upper minerable coal seams of the Ordos Jurassic Coal Basin were actually disclosed as the main flooding aquifer of the coal mines. To investigate the occurrence of the coal seams as the main aquifer, a comprehensive method is adopted, which includes geological analysis, coal seam fractures survey, underground stress measurement, rock constituent analysis, and mechanical tests of the roof and floor rock. The results show that (1) the neo-tectonic survey indicated an overall shift of stress field, where the maximum principal stress changed from the E-W to the N-S direction and the minimum principal stress shifted from the N-S to the E-W direction; (2) the underground stress tests proved that the in-situ measured maximum and minimum principal stress was 200≈206°∠7° and 111≈117°∠7° in strike respectively, which were agree with the regional tectonic movement; (3) water in the coal seams was observed releasing from and flowing along two groups of water-conducting fractures with the strike of 10≈20° and 285≈295°, which were consistent with the regional neo-tectonic movement and stress field; (4) the sandstone of the roof and floor formations is mainly composed of grains of feldspar and lithic and clay fillings, which makes the fractures in the roof and floor strata almost closed and the whole roof and floor even serve as aquifuge; and (5) the unusually high strength, hardness and brittleness of coal seams makes it generate a large amount of open fractures. The effective water control measures involved pre-water-availability exploring and dewatering of the coal seam aquifer and the coal mines had kept safe mining so far.

Keywords: Coal seam, main aquifer, cause, neo-tectonic movement

Introduction

Hydrogeologically coal seam is always viewed as aquifuge. However, the upper mineable coal seams of the Ordos Jurassic Coal Basin were actually disclosed as the main flooding aquifer of the coal mines. To investigate the occurrence of the coal seams as the main aquifer, a comprehensive method is adopted, which includes geological analysis, coal seam fractures survey, underground stress measurement, rock constituent analysis, and mechanical tests of the roof and floor rock.

Proofs of the coal seam as an aquifer

It was convinced that the water violently bursting into the central intake and venting shafts under construction was running out from the No. 2 coal seam at X coal mine. When digging the central intake and vent shafts and just approaching the No. 2 coal seam, one routine explosion accidently induced such a big water inrush of 82 m^3/h with high water pressure of 2MPa that the shafts being digging were flooded then.

Further exploratory drilling revealed that the No. 2 coal seam was functioning as a typical aquifer. In order to salvage the flooded shafts, the ingates of the shafts had to be elevated by 23 m and then a series of hydrogeological exploratory boreholes were drilled. From October of 2011 to December of 2012, seven boreholes were drilled at the maingate towards the underlying No.2 coal seam. It showed that (Table 1) the inrush of water into the boreholes occurred when drilling reached 0.7-6.7m above the coal seam, then violently increased to the its peak flow after drilling 0.2-1.7m into the coal seam, and finally didn't go up any more even till the borehole fully penetrating the coal seam. Hence it indicated that the coal seam here is a typical and main aquifer, especially its medium and bottom section, to flood the coal mine. Based on the following underground pumping tests, the coal seam was assessed as a medium water-bearing aquifer with a specific capacity of 0.52 ≈ 0.82 L/(m·s).

The afterwards occurrence of water inrush as excavating the roadways, maingates, tailgates, etc. fully proved that the No.2 coal seam was functioning as the main flooding aquifer. In April 6, 2012, when the return return roadway came across the No. 2 coal seam, coal seam water burst into at an initial rate of 90m^3/h and the inrush still increased with the further disclosing the coal seam. On Aril 26, 2012, the peak inrush went up to 540m^3/h. As shown in Figure 1, high dip fractures with a common strike of North-South, where the water was running out, widely and intensively occurred in the No.2 coal seam, which further proved that the coal seam itself was the main flooding aquifer instead of other overlying or underlying weak aquifer.

Geogetic analysis

The neo-tectonic survey indicated an overall shift of stress field, where the maximum principal stress changed from the E-W to the N-S direction and the minimum principal stress shifted from the N-S to the E-W direction. Two in situ stress test were conducted via (Table 2), the results showed (Table 3) that the underground stress tests proved that the in-situ measured maximum and minimum principal stress was 200≈206°∠7° and

Table 1. *Comparison table of construction results of water probe hole constructing*

Boreholes	1#	2#	3#	4#	5#	6#	7#
Level of drill floor (m)	914.1	914.6	913.2	901.9	897.3	907. 7	907.5
Initial water level (m)		896.8	897.5	893.4	891.8	899.6	896.2
Level of inrush obviously increasing (m)	894.9	895.9	894.3	892.3	891.4	894.5	895.7
Level of coal seam roof (m)	891.0	892.4	891.9	891.1	891.1	892.2	894.9
Level of inrush re-abruptly increasing (m)	890.2	891.9	891.6	890.3	890.9	890.6	894.7
Level of coal seam floor (m)	not yet seen	891.5	not yet seen	889.4	not yet	889.8	894.4
End of the boreholes (m)	889.7	888.5	890.9	889.3	seen	889.78	894.1
Flow rate(m^3/h)	>40	20	>93	29.4	890.6	45	flooded
water pressure (MPa)	2.6	2.5	2.6	2.4	>60		

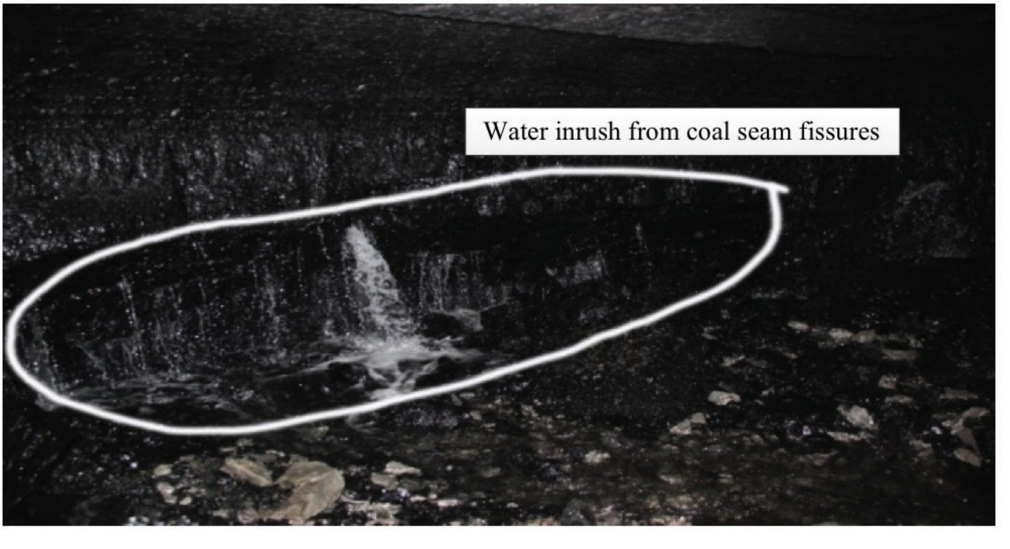

Figure 1 *N-S to fractured water in the alley gang coal seam of the return ventilation roadway*

Table 2. Drilling of in situ stress measurement at the X coal mine

Measuring sites	Depth (m)	Location	borehole		
			length (m)	Azimuth (°)	Dip (°)
Point 1#	327	Right side of central air intake shaft	9.6	1	3
Point 2#	325	Left side of central air intake shaft	8.4	55	4

Table 3. Test results of in-situ stress in X coal mine

Measuring sites	Principal stress				Vertical stress (MPa)
	Principal stress	Value (MPa)	Azimuth (°)	Dip (°)	
Point 1#	σ1	10.74	200.55	6.69	
	σ2	8.95	58.98	81.48	8.97
	σ3	7.96	111.17	-5.25	
	σ1	11.25	206.06	-10.65	
Point 2#	σ2	9.12	60.82	-77.11	9.19
	σ3	8.93	117.41	7.18	

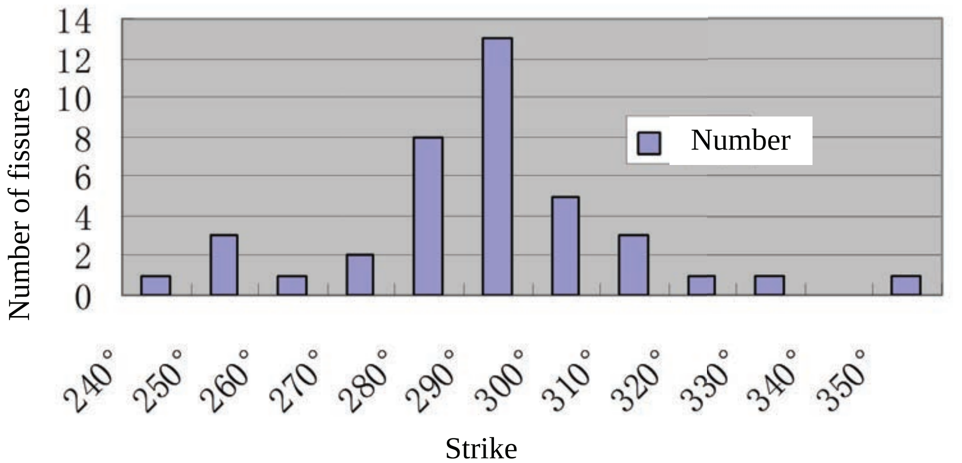

Figure 2 *Observation statistics of effluent cracks in 11203 return airway*

111≈117°∠7° in strike respectively, which were agree with the regional tectonic movement;

The fracture observation and statistics along the tailgates of Face 11203, as shown in Figure 2, indicated that inrush released from and flowed along two groups of water-conducting fractures with the strike of 10≈20° and 285≈295°, which were consistent with the regional neo-tectonic movement and stress field.

The sandstone of the roof and floor formations is mainly composed of grains of feldspar and lithic and clay fillings, which makes the fractures in the roof and floor strata almost closed and the whole roof and floor even serve as aquifuge (Figure 3). However, the unusually high strength, hardness and brittleness of coal seams makes it generate a large amount of open fractures.

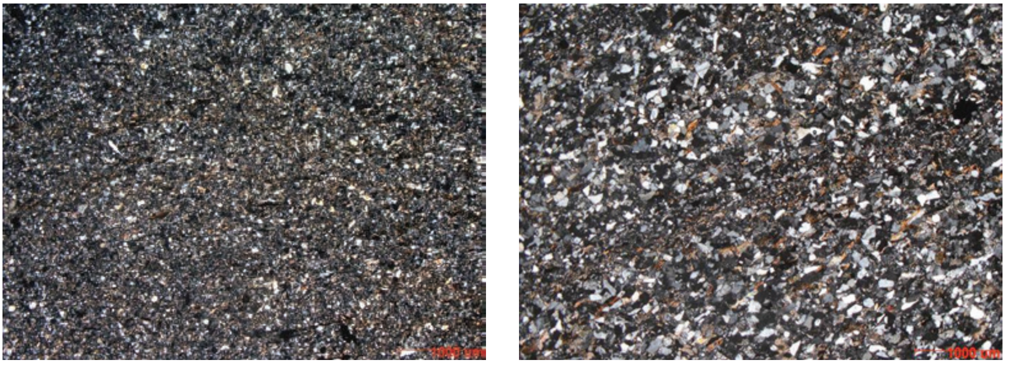

Fig. 3 *Overlying clayey siltstone (left) and fine-grained lithic feldspar sandstone (right)*

Conclusions

Methods of geological analysis, coal seam fractures survey, underground stress measurement, rock constituent analysis, and mechanical tests of the roof and floor rock were adopted to investigate the occurrence of the coal seams as the main aquifer. Coal seam aquifer mainly contained water in its popular N-S direction fractures, which were consistent with the regional neo-tectonic movement and stress field in the Ordos basin. The features of unusually high strength, hardness and brittleness of coal seams makes it an aquifer. The effective water control measures involved hydrogeologically exploring and dewatering of the coal seam aquifer.

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