Application of directional borehole grouting technology to structural complex floor reinforcement in deep underground coal mine

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Abstract Water inrush from coal floor constitutes one of the main disasters in mine construction and mine production, which always brings high risks and losses to the coal mine safe production. As the mining depth of coal fields in North China gradually increased, especially in the complicated structural region, the threat posed by limestone karstic water of coal floor to the safe stoping of mines has become increasingly prominent. In this paper, the Taoyuan coalmine was taken as an example, for which, the directional borehole grouting technology was utilized to reinforce the coal seam floor prior to mining. Also, the factors affecting the grouting effect were analyzed. These were the geological structure, the crustal stress and the range of slurry diffusion. The layout principle of grouting drilling was put forward and the directional drilling structure was designed. The water level observations in the end hole indicated that the target stratum was accurate and reliable. The effect of grouting was validated through the audio frequency electric perspective method and the holedrilling in the track trough. The results demonstrated that the effect of grouting in third limestone and the rock stratum above the third limestone of coal seam floor was apparent. Simultaneously, no water inrush occurred following the actual mining of the working face, which further demonstrated that the grouting reinforcement effect was apparent. The research findings were of high significance for the prevention and control of floor water disaster and water conservation in deep complex structural areas.

Keywords Complicated structural region · Directional drilling · Grouting reinforcement · Coal floor · Karst aquifer

1. Introduction

China is globally the producer and consumer of the highest amount of coal. A high number of disasters occur in the coalmines of China every year, in which water inrush is one of the major disasters. According to statistics, since 2000, more than 750 coal mine water inrush accidents occurred in China, while more than 3800 people died, resulting in direct economic losses, exceeding tens of billions of dollars (http://www.chinacoal-safety.gov.cn/mkaj/). As the mining depth of coal fields in North China gradually increases, the risk of water inrush in deep mines increases due to the effects of excavation disturbance and the inaccuracy of invisible water conducted structure exploration (For example, the detection rate of the collapse column can only reach to approximately30%) (Sui et al. 2011; Li and Chen 2016; Sun et al. 2017). In particular, the lower-group coal mining in the North China coalfield, which is threatened by the karst water of the coal floor limestone, often causes catastrophic water inrush accidents as a result of the strong conducting-water structure zone (collapse column and concentrated fracture zone of structure) (Meng et al. 2009; Hu et al. 2014; Shi et al. 2017; Yang et al. 2017).

At present, the main methods for the prevention and control of limestone karst water in coal mines include drainage to lower water pressure and grouting reconstruction (Ge and Wang 2007; Wang et al. 2012; Cheng et al. 2013; Hao et al. 2014; Li and Du 2014; Tian et al. 2015; Sun et al. 2015). The drainage to lower water pressure method refers to the drainage of the aquifers in the floor prior to coal mining. This method is easily restricted by the water content of the aquifer, the condition of recharge, the thickness of floor aquiclude, the pressure and the drainage capacity of the mine, causing high amounts of groundwater waste. Conventional grouting reconstruction is mainly conducted through grouting in the underground tunnel or ground drilling, the plugging of fractures of the floor rock stratum and the tensile strength increase of the floor, to overcome the pressure of confined water and prevent water inrush from the working face. This method is difficult and inefficient due to underground grouting construction, while its effect is versatile. In addition, for ground drilling grouting, due to the high depth of Ordovician limestone, the cost is usually higher (Dong et al. 2014; Xu et al.

2014).

To solve the problem of water inrush from coal floor as well as the shortage of conventional drilling grouting, in this paper, the Taoyuan coalmine was taken as an example. The directional borehole grouting technology was utilized to reinforce the coal seam floor prior to mining, to prevent and control the karst water disaster of the floor limestone. The layout principle and structure of the directional drilling were studied. The grouting effect was verified through geophysical prospecting and holedrilling in the track trough. The research findings were of high significance for the prevention and control of floor water disaster and water conservation in deep complex structural areas.

2 Study Area

The Huaibei coal mine district is located in the northern part of Anhui province. It lies at the intersection of the four provinces of Jiangsu, Shandong, Henan and Anhui, where as the geotectonic position is in the southeast margin of the North China plate. The east-west direction of the mining area is approximately140km.The north-south direction is approximately110km, while the entire area is approximately 15400km^2.The coal resources in the mining area are abundant and the coal quality is good. The entire region constitutes an important coal gathering area of the Carboniferous Permian system in China (Fig. 1).

The fault structures in the mining area have developed (More than 600 faults were found, of which, 170 exceeded 100m in drop height), while the mining geology and hydrogeological conditions are complex. The lower-groups of coal (6thand 10th) seams are mainly threatened by the thin limestone group (first limestone to fourth limestone) in the upper part of the Taiyuan formation and the deep Ordovician aquifer. The limestone of Taiyuan formation is mainly a medium - thin layer limestone, mainly with fractured karst water and the water-abundance is quite uneven. Most regions are characterized by high pressure and water-abundance as the depth increases. The distance between the coal seam and the Ordovician limestone is approximately 100 to 200m. In general (when the floor is relatively complete), the mine will not demonstrate karst water inrush from the Ordovician limestone during the mining of lower-groups. In the vertical invisible water conducting structure zone, with high-sized faults, collapse column and fracture zone, a hydraulic connection between Ordovician limestone water and thin limestone water exists. At present, three dimensional seismic exploration and other technologies are still difficult to accurately detect and determine the locations of water conducted structure zones. As the mining depth increases (beyond

520m), the water pressure increases, easily causing the high-sized Ordovician limestone water inrush into the mine, leading to mine disasters and major losses. In mines such as Yangzhuang, Taoyuan and Zhuzhuang, similar water inrush accidents have occurred.

Taking the Taoyuan coalmine as an example, the directional borehole grouting technology was utilized to reinforce the coal seam floor prior to mining, to prevent and control the karst water disaster of the floor limestone. The Taoyuan coalmine is located in the south of the Huaibei mining area (Fig. 1). The structural complexity of the study area was medium, presenting 12 faults at the drop height of beyond or equal to 10m, while the low-sized structures of the study were developed.

The third limestone in the study area was the thin limestone aquifer with the highest water abundance in the first limestone to the fourth limestone of the upper part of the Taiyuan formation, also constituting one of the main direct discharge aquifers for the 10th coal seam (Fig. 2). The grouting to reinforce third limestone could directly fill the thin layer limestone karst fracture. The third limestone had a high amount of fractures and strongly pourable. Consequently, it was easy to achieve the expected grouting reinforcement effect. Therefore, the third limestone was selected as the target layer for grouting reinforcement.
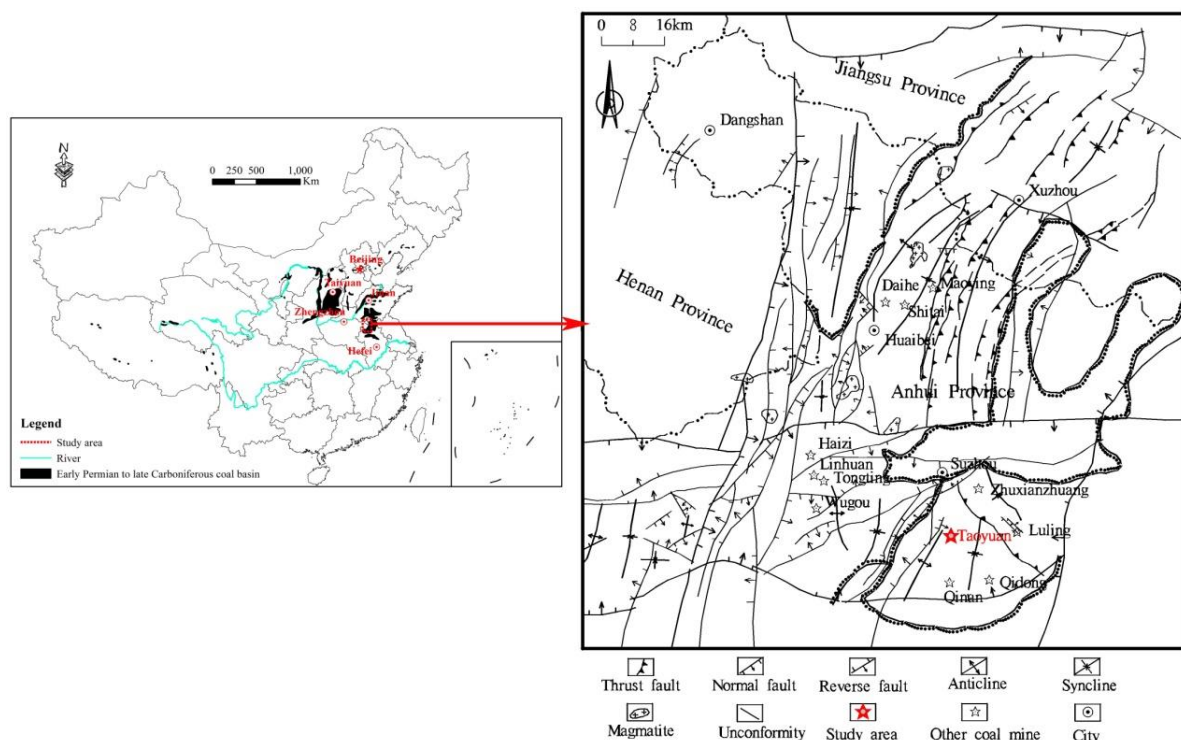

Fig. 1 Structure outline map of Huaibei Coalfield and location of study area

Strata			Core columns	Thickness (m) Min~Max / Average	Lithology
System	Series	Formation			
Permain	Lower Permian	Shanxi Formation		2.2~4.0 / 3.7	10th coal seam
				56.0~59.8 / 57.9	Combination of mud rock and sandstone interbedded
				2.1~3.0 / 2.6	First limestone
				3.9~5.0 / 4.5	Sandy mudstone
Carboniferous	Upper Carboniferous	Taiyuan Formation		3.0~4.8 / 3.9	Second limestone
				5.8~6.5 / 6.2	Combination of mud rock and sandstone interbedded
				6.5~13.1 / 9.8	Third limestone
				3.2~5.0 / 4.1	Mudstone
		Benxi Formation		3.5~8.7 / 6.1	Fourth limestone
				59.2~61.3 / 60.3	Combination of mud rock and sandstone interbedded
Ordovician	Middle Ordovician	Baitu Formation		>500	Ordovician limestone

Fig. 2 Comprehensive typical strata column of coal seam floor for study area

3 Directional borehole design

3.1 The layout orientation of grouting drilling

3.1.1 Effect of geological structure on drilling orientation selection

The fractures, the faults, the water rich zone and the vertical water conducting structure zone of the third limestone in the coal seam floor were the object of the ground directional borehole grouting. Especially, the vertical water fault and the fold axis crack were the key points for the prevention and control of water inrush from the floor. Faults and their sides are usually accompanied by many structural fractures, forming tectonic fracture zones. Due to the strong interlayer shear in the formation of folds, the bedding joints of the limbs were developed. The lateral side of the turning end was subjected to tension and mainly distributed to tension joints. The core of the fold was strongly extruded, while the main distribution of the axial plane was cleavage.

The effects of fault and fold axis should be fully taken into account when the layout orientation of grouting drilling was designed. For the fissure-cavern limestone, between the transverse and longitudinal directions significant differences were displayed. If the horizontal section of a single drill is set along the vertical fissure strike, it will penetrate fewer cracks,

which will be unfavorable for the grouting reconstruction to the water plugging. If the horizontal section of a single drill is set along the vertical fissure tendency, it will penetrate more cracks, which will be favorable for the slurry diffusion (Fig. 3). Therefore, the directional drilling locus should be highly intersected with the faults and other fractures.
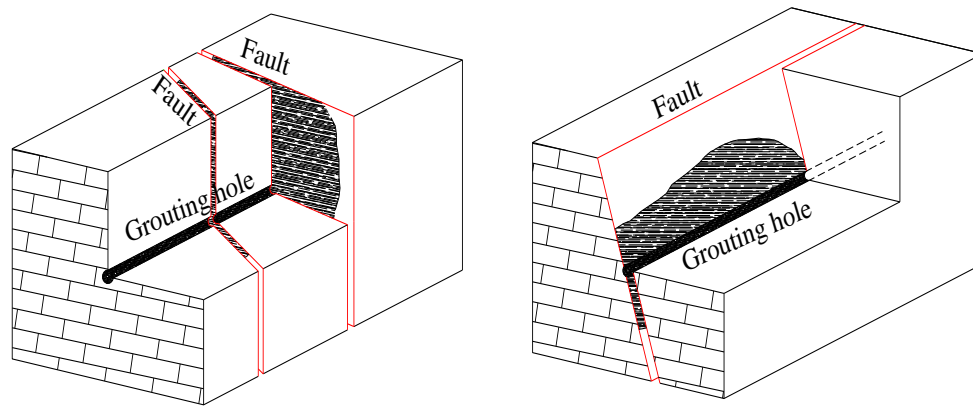

Fig.3 Sketch of grouting effect at different angles of drilling orientation and fault

3.1.2 Effect of crustal stress on drilling orientation selection

The orientation of directional drilling of horizontal section under the condition of complex stress distribution has a high effect on the direction of the induced grouting crack produced by high pressure splitting, which determines whether the fracture zone produced by the high-pressure grouting can be better connected to the natural fissure or not. Therefore, the stress distribution condition is an important basis for the orientation optimization of directional drilling of the horizontal section. For the initiation direction of splitting grouting, it is generally considered that the splitting plane is perpendicular to the minimum principal stress direction. This means that the initial crack is along the direction of the maximum principal stress (Lo and Kaniaru 1990; Zhou and Chen 2002). If the directional horizontal drilling is in accordance with the maximum horizontal principal stress direction, a longitudinal crack parallel to the drilling direction is produced. If the drilling is perpendicular to the direction of maximum horizontal principal stress, a transverse crack perpendicular to the drilling locus is produced (Fig. 4).

The longitudinal cracks are single and distribute along the maximum principal stress direction, while the splitting range is low. The transverse cracks are perpendicular to the

horizontal drilling locus, while the splitting range is higher. The latter is more conducive to the diffusion of the slurry with high pressure splitting. Therefore, the vertical direction of maximum principal stress direction is the dominant position of the horizontal drilling locus.
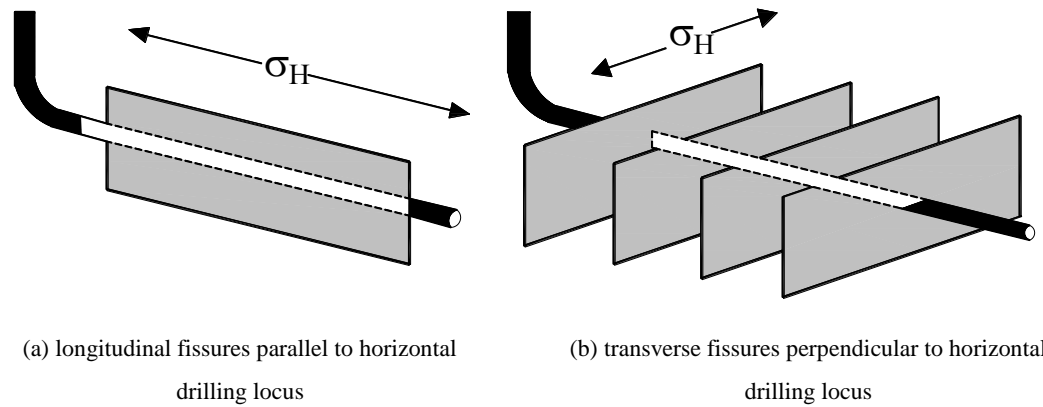
(a) longitudinal fissures parallel to horizontal   (b) transverse fissures perpendicular to horizontal
drilling locus   drilling locus

Fig. 4 Sketch of relationship between horizontal drilling locus and splitting fissure orientation

3.2 Grouting simulation of fractured rock mass

In the process of slurry flow, the slurry pressure will cause the rock mass deformation, while the latter will also affect the slurry diffusion distance size and the final grouting effect. In this study, the geological and hydrogeological conditions of the study area were analyzed. The effective diffusion radius of the grouting slurry of third limestone was simulated with a two dimensional realistic failure process analysis code (RFPA2D-Flow) (Tang et al. 1998).

(1) Numerical calculation model and parameters

According to the geological survey data of the study area, the numerical model was designed (Fig. 5). The size of the model was 300m×150m and the elevation of the 10th coal floor was approximately -420m. The top and the floor were sandstone and mudstone, respectively. The third limestone water pressure was approximately 4MPa and the dip angle of the fault was approximately 60 degrees. The grouting drilling diameter was 152mm.

Based on the measured results of the crustal stress, the applied stress on the left boundary of the model was 9MPa. The upper boundary of the model as applied to the self-weight load of the overlying rock and soil (approximately10MPa). The displacements of the right boundary and the lower boundary were fixed, whereas the upper and lower boundaries of the model were impermeable boundaries. The first step was to make the model stable and the

second step to simulate grouting. The grouting drilling was set to be conducted at the middle of the third limestone, while two steps were set to simulate the normal rock layer (first segment) and fault (second segment) grouting. The length of the grouting section was 60m for each step. The diffusion rules of the slurries under the four grouting pressures of 4MPa, 8MPa, 10MPa and 12MPa were simulated. The model parameters of numerical simulation are presented in Table 1.
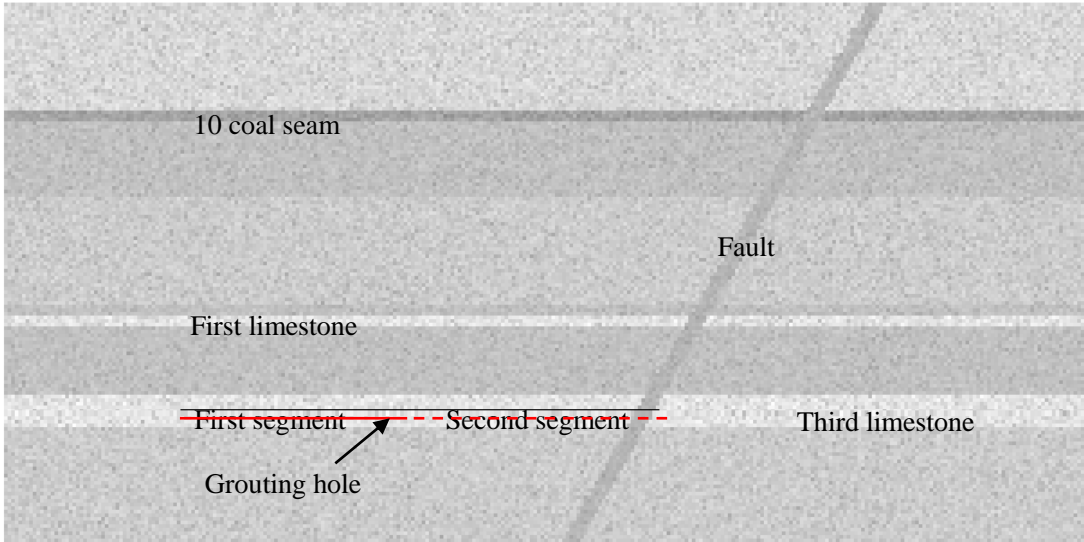
Fig. 5 Geological numerical model

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Table 1 Model parameters of numerical simulation

Model materials	Thickness (m)	Elastic modulus (GPa)	Compressive Strength (MPa)	Friction angle (°)	Poisson's ratio	Density (kg/m³)	Permeability coefficient (m/d)		Porosity	Homogeneity
							Vertical direction	Horizontal direction		
Roof of coal seam	30	8	33	30	0.25	2500	0.001	0.001	0.01	10
10th coal seam	3	3.5	10	30	0.30	1800	0.001	0.001	0.01	10
Floor of coal seam	22	6	33	36	0.25	2500	0.05	0.05	0.01	10
	33	7	27	34	0.25	2500	0.05	0.05	0.01	10
First limestone	2	11	70	35	0.30	2800	0.001	0.001	0.01	10
Floor of first limestone	17	6	28	32	0.25	2500	0.05	0.05	0.01	10
Third limestone	9	11	71	38	0.3	2800	2	2	0.1	5
Floor of third limestone	34	7	40	32	0.25	2500	0.001	0.001	0.01	10
Fault	4	4	10	30	0.25	2200	10	10	0.2	5

2

3

4   (2) Simulation results and analysis

5   The results of numerical analysis are presented in Figure 6. It could be observed

6   from Figure 6 that when the grouting pressure as 4MPa, the slurry as mainly filled

7   with natural fractures in the aquifer, while the grouting section was partially diffused

8   to the third limestone roof. Also, the diffusion radius was approximately 13m. When

9   the grouting drilling penetrated the fault, the slurry mainly diffused along the fault and

10   the diffusion distance was approximately 60m.

11   When the grouting pressure increased to 8MPa, the diffusion distance of the slurry

12   gradually increased. Moreover, under the action of grouting pressure, the weak

13   structural plane began to expand, especially the bedding, the fault zone and the

14   contact zone. Also, the slurry diffusion radius was approximately 30m.

15   As the grouting pressure continued to increase (10MPa), the stress and tensile

16   strengths of the weak part of the aquifer were exceeded. The splitting formed along

17   the plane perpendicularly to the main stress plane, while the direction of the crack was

18   the same as the direction of maximum principal stress. As the slurry was filled, the

19   aquifer was strengthened further, while the radius of slurry diffusion was

20   approximately 50m.

21   When the grouting pressure increased to 12MPa, the original and split cracks were

22   filled to a relatively high level. As the pressure increased, the filling became dense

23   and the diffusion radius did not increase significantly, while the radius of diffusion

24   slurry was approximately 55m. Adversely, the contact flow between the fault and the

25   coal seam increased.

(a) grouting in rock mass   (b) grouting in fault
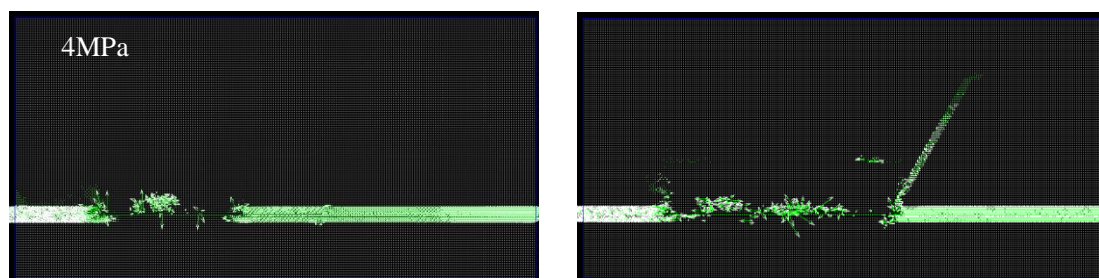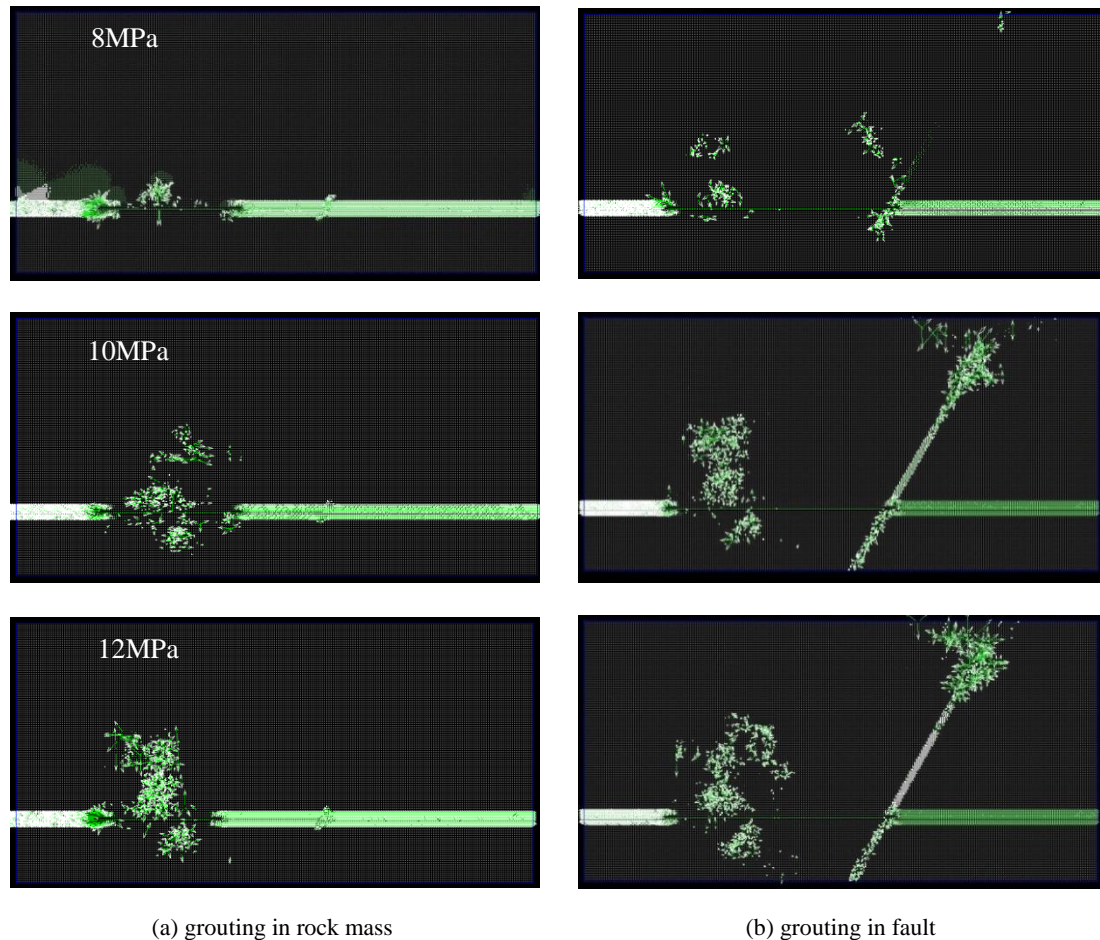
Fig. 6 Results of numerical analysis

26

27   The aforementioned simulation results demonstrated that the higher the grouting

28   pressure was, the higher the radius of slurry diffusion was, but the diffusion radius

29   increase was not apparent when the grouting pressure reached to a certain pressure

30   value. When the grouting pressure was10~12MPa, the diffusion distance of the slurry

31   changed slightly to approximately 50~55m. On one hand, the diffusion range of the

32   slurry was related to the grouting pressure. On the other hand, the diffusion range of

33   the slurry was related to the dominant direction of fracture. The slurry often diffused

34   along the dominant channel with good permeability and easy splitting of the weak

35   structural planes.

36   **3.3 Drilling structure design**

37   The ground directional borehole grouting was mainly through the near horizontal

38   drilling unit to enter the third limestone prior to mining, as well as to seal the cracks

39   with high pressure grouting. The borehole unit was arranged by the main drilling as

40   well as the multiple first-level branches and secondary branch drilling, which had

41   fan-shaped distribution. The distance in-between branch drillings was 50~110m. The

42   drilling structure design is presented in Figure 7.

43   The drilling consisted of three segments. The first segment was the straight drilling

44   (0~120m). The borehole diameter was 311mm. The size of casing was 244.5mm,

45   putting the casing down to 20m below the bedrock. Cementing was used to isolate the

46   quaternary surface soil layer. The second segment was directional deflecting drilling.

47   The borehole diameter was 216mm, and the size of casing was 177.8mm, putting the

48   casing down to 30m below the floor of 6th coal seam and close to the bedding. The

49   third segment was directional bedding drilling of 152mmin diameter. During driling

50   along the third limestone bedding, all branches sustained directional drilling in the

51   third limestone bedding.

(a) Plane structure of drilling   (b) Section structureof drilling
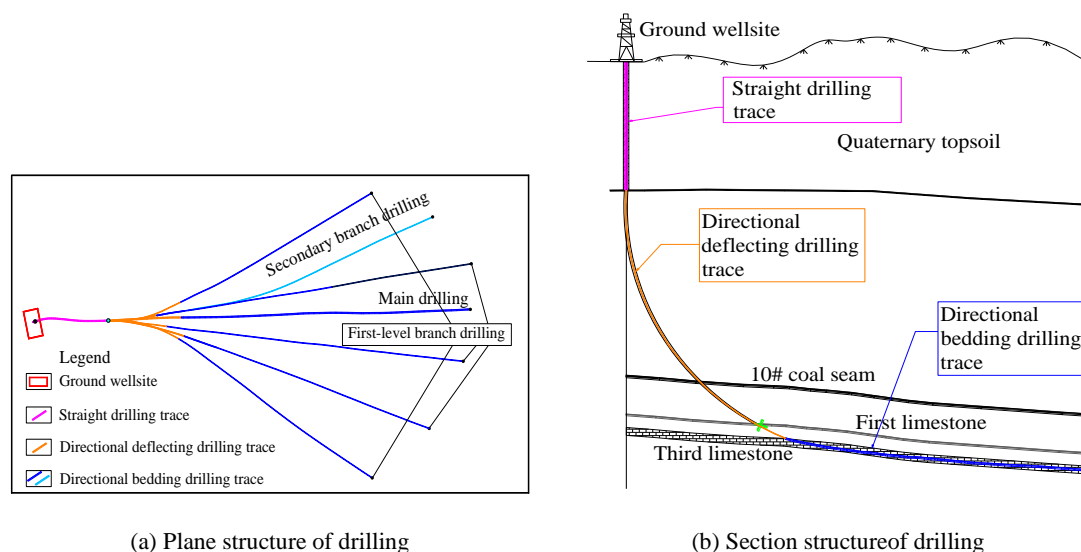
52   **Fig. 7** Sketch of drilling structure design

53   **3.4 Layout of grouting drilling in study area**

54   Combined with the aforementioned analysis, it was determined that the orientation

55   and spacing of branch drilling should be based on the following principles:

56   (1) The branch drilling should be intersected with the large angle of fault and folds

57   axis as high as possible, also through the faults and folds.

58   (2) In order to ensure the complete filling and plugging of third limestone aquifers

59   and fault fracture zones, the distance between the branch drilling should not exceed

60   twice the diffusion radius. Simultaneously, the high efficiency and economic

61   rationality should be taken into consideration. The drilling spacing should exceed the

62   single drilling grouting diffusion range. Therefore, the distance between branch

63   drillings should be between 50~110m.

64   (3) The scope of drilling grouting diffusion should cover the entire treatment area

65   as far as possible.

66   According to the layout principle of the latter grouting drilling, the directional

67   grouting drilling of II1027 and II1029 working faces in the study area was designed

68   and is presented in Figure 8.

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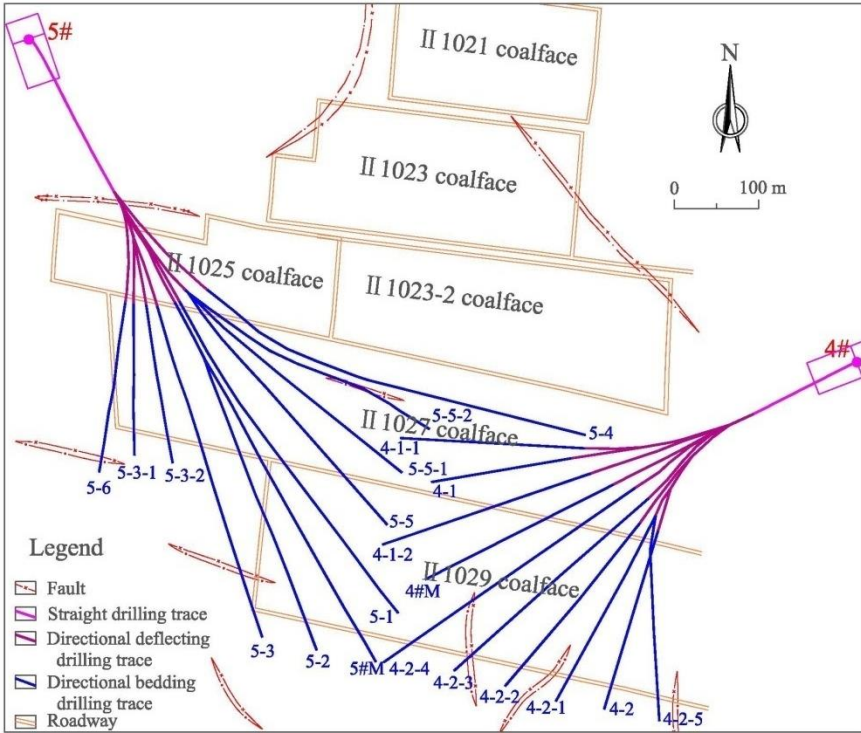
70   **Fig. 8** Layout of grouting drilling in study area

71   **4 Grouting and verification of grouting effect**

72   **4.1 Grouting process**

73   The directional drilling grouting of this study was carried out through downward stage

74   grouting and orifice-closed grouting methods (Li and Du 2014), which consisted of

75   two stages: filling grouting and high pressure grouting.

76   (1) Filling grouting: When high-sized cracks or karst caves exist in the limestone,

13

77   the high concentration cement slurry with a specific gravity of

78   approximately1.5~1.7t/m^3 is injected with the large displacement grouting pump of

79   260~600L/min to quickly fill the fissure or cave.

80   (2) High pressure grouting: In order to increase the diffusion distance and fill the

81   fine fissures, the high pressure grouting is used to spread the residual gap and

82   low-sized fissure in the rock mass to increase the reinforcement effect.

83   According to the "coal mine prevention and control water regulations" (State

84   Administration of Work Safety 2009), the grouting pressure should be twice the

85   maximum hydrostatic pressure (4MPa) of the injected aquifer, while the termination

86   pressure of the grouting drilling must not be lower than 2.5 times of the water

87   pressure. Due to the particularity of the grouting project, the construction could be

88   adjusted according to the actual situation in the field. The hydrostatic pressure of third

89   limestone was approximately 4MPa.Consequently, the final pressure of grouting

90   was10~12MPa. Finally, the grouting absorption capacity was generally 40~60L/min

91   and the stability time was 20~30 min.

92   **4.2 Verification of grouting effect**

93   The water level plays a guiding role in drilling grouting. Through the analysis of

94   the water level and combined with the pressure water testing, the development degree

95   of the fracture, the connection between adjacent aquifers, the existence of abnormal

96   water pressure area, as well as the existence of faults and collapse columns could be

97   determined. Table 2 presents the water levels of each drilling in the II1027 and II1029

98   working faces. In this area, the third limestone water level elevation was usually

99   -180~-230m. It could be observed that the water level of most drillings belonged to

100   the third limestone water level elevation, which demonstrated that the target location

101   of drilling was accurate and reliable, meeting the design requirements.

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105 **Tbale 2** Statistics of water level for each drilling

The drilling unit	Drilling number	Grouting section (m)	Groundwater elevation (m)	The drilling unit	Drilling number	Grouting section (m)	Groundwater elevation (m)
	4#M	785.22-1128	Not detected		5#M	800.62-980	Not detected
	4-1#	758.22-1191.92	-223.6		5-1#	865-1427	-215.4
	4-1-1#	785-1222.2	-197.6		5-2#	909-1424	-193.4 (Instability)
	4-1-2#	861.5-1272	-256.6		5-3#	817-1368.63	-217.3
	4-2#	785-1177	-263.6		5-3-1#	820-1140.78	-81.4 (Instability)
4#	4-2-1#	1177-1230	-153.6	5#	5-3-2#	849-1155.7	-4.1 (Instability)
	4-2-2#	909-1260	-173.9		5-4#	815-1331	-226
	4-2-3#	870-1290	-193.4		5-5#	815-1328	-56.6
	4-2-4#	840-1348.2	-111.1 (Instability)		5-5-1#	892-1297	-193.9
	4-2-5#	800-1242.34	-164.6		5-5-2#	800.62-1188	-203.4
					5-6#	807-1158.8	-216.4

106

107   Following the completion of grouting, the audio frequency electric perspective

108   (AFEP) method (Zhang et al. 2013) was utilized to detect the grouting face (II1027

109   working face). The results demonstrated that the apparent conductivity was uniformly

110   distributed in most areas of the working face, while the apparent conductivity of the

111   40~70m range below the floor was low. Also, only two relative anomalous regions

112   existed, reflecting the improved effect of the aquifer reconstruction of the floor

113   limestone.

114   Through the drilling of holes in the track trough, the relative anomalous regions of

115   AFEP, the structural fracture development and the abnormal grouting areas were

116   verified. The end position of each drilling was designed as the grouting target layer

117   (middle and lower part of third limestone). The layout of each drilling is presented in

118   Figure 9.

119   Each drilling was conducted with a 133mm drill, while the casing was put down to

120   2~5m. Consequently, the drill size was changed to 94mm and the casing was put

121   down to 25m. At the end, the 75mm drill was driven to the bottom of the hole. Only

122   six drillings (D2#, D3#, D5#, D8#, D9#, D12#) sent water up in all test drillings,

123   while the amount of water only was 0.5~2.0m^3/h. In addition, the D5#, D9# and D12#

124   drillings sent water up at the third limestone, while the water amounts were 0.5m^3/h,

125   1.0m^3/h and 0.1m^3/h, respectively. The D3# drilling was first limestone with effluent

126   water, while the D#2 andD#8 were second limestone with effluent water. From the

127   aforementioned situation, it could be observed that the third limestone and above the

128   limestone aquifer grouting reconstruction effects were apparent. The first to third

129   limestone could be regarded as the equivalent aquiclude. The grouting sealing was

130   carried out subsequently to the drilling construction, which is referred to Table3.

131   In addition, through actual mining verification, no water inrush occurred during

132   mining, which indicated that the grouting reinforcement effect was apparent.

133   **Table 3** List of drilling construction

| Drilling number	Azimuthal angles (°)	Pitch-down angle (°)	Drilling depth (m)	Water inflow (m^3/h)	Position of water inflow	Final position of drilling	Grouting flow (t)	Grouting pressure (MPa)
D1#	222	33.5	78	/	/	Fourth limestone	0.8	10
D2#	240	33.5	74.5	2	Second limestone	Third limestone bottom	2	10
D3#	290	41	65	0.5	First limestone	Third limestone	0.6	10
D4#	290	42	46	/	/	Third limestone	0.6	11
D5#	274	30	66	0.5	Third limestone	Third limestone	0.8	10
D6#	315	49	48	/	/	Third limestone	0.5	11
D7#	278.5	44	55	/	/	Third limestone bottom	0.35	10
D8#	80	52	74	1	Second limestone	Third limestone	1	10
D9#	261	25	73	1	Third limestone	Third limestone	1.4	9
D10#	283	66	50.6	/	/	Third limestone bottom	0.7	9
D11#	290	33.5	64.2	/		Third limestone	1.2	10
D12#	305	15	90	0.1	Third limestone	Third limestone bottom	1.2	10

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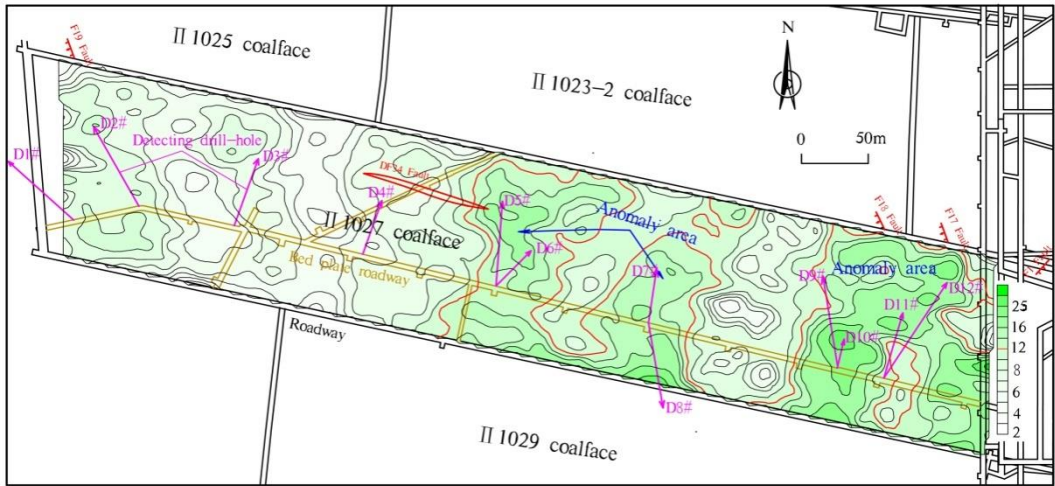
136   **Fig. 9** Result of AFEP and layout of holedrilling in track trough.

137   **5 Conclusions**

138   The directional drilling technology and grouting technology were utilized to

139   reconstruct the floor of the typical working face in the deep complex structure mining

140   area of North China.The layout principle of the directional drilling was studied. The

141   borehole unit was arranged through main drilling as well as multiple first-level

142   branches and secondary branch drilling, which had fan-shaped distribution. The

143   geological structure, the crustal stressand the slurry diffusion range were the main

144   factors for the layout consideration of the drillings. The branch drillings were as much

145   as possible through the faults and folds. The spacing of the branch drillings should

146   exceed the single drilling grouting slurry diffusion range, whereas the scope of

147   drilling grouting diffusion should significantly cover the entire treatment area. During

148   grouting in the working faces of the study area, the water level of the grouting branch

149   drilling demonstrated that the target layer of drilling was accurate and reliable, which

150   conformed to the design requirements, indicating that the directional drilling

151   technology was reliable. The AFEP method was utilized to detect the grouting

152   working face. The results demonstrated that the apparent conductivity was uniformly

153   distributed in most areas of the working face, while only two relative anomalous

154   regions existed. Through holedrilling in the track trough, the relative anomalous

155   regionsof AFEP, the structural fracture development and the abnormal grouting areas

156   were verified. The results demonstrated that only certain drillings sent water up,

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157 which indicated that the grouting effects of third limestone and above the limestone

158 aquifer in the study area were apparent. Through actual mining, it was also verified

159 that the grouting reinforcement effect was good. Directional drilling grouting

160 technology had solved the problem of water disasters in the thin aquifer of deep

161 complex structure coal mines, through which, safe mining was realized.

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