Formation Mechanism and Prevention Technology of Mine Water Disaster under Complex Conditions

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Abstract: With the continuous westward shift of China's coal production center, the western mining areas will play an increasingly important role in ensuring national energy security. It is urgent to extract coal economically and efficiently and realize scientific mining under the premise of ensuring the safe and environmental capacity. This paper systematically summarizes the research progress of coal seam separation water disaster at home and abroad, and elaborates the problem of coal seam separation water disaster from four aspects: formation mechanism of coal seam separation water, disaster-causing mechanism, prediction and early warning of water disaster and key prevention and control technologies. This paper summarizes the research on mining overlying strata separation and the formation mechanism of overlying strata separation water, and summarizes the formation of coal seam overlying strata separation water into three basic conditions: water separation, the existence of recharge water around the separation bed, and the separation space lasting long enough. However, the prevention and control of coal mine water disaster under complex geological conditions is an important problem restricting coal mine safety at present. The water damage prediction of overlying strata separation is summarized from three aspects: prediction of the location of available water separation, prediction of the periodicity of water inrush and prediction of the amount of water inrush, according to the development characteristics of bed separation. In this paper, the water damage prediction of overlying strata separation is summarized from three aspects: prediction of the location of available water separation, prediction of the periodicity of water inrush and prediction of the amount of water inrush. According to the development characteristics of bed-separation and the location of bed-separation water, the main prevention and control methods of bed-separation water damage, such as diversion hole, advance drain hole and ground direct pump hole, are proposed.

1 Introduction

Therefore, water disaster is one of the five major disasters affecting the safe production of coal mines. At present, the main types of water hazards in China are surface water hazards, old void water hazards, direct roof plate water hazards, and geological tectonic water hazards such as faults, folds, and karst collapse holes. The main types of water hazards include top plate water hazards (fall zone, fissure zone, bending and sinking zone), water hazards of burnt rock, water hazards of bottom plate, water hazards of old hollow area, etc. The water hazards are mainly caused by the water conduction of top and bottom plates. Groundwater is poured into the underground mining space in the form of sudden surges with the help of water conduction channels of the roof and bottom slabs, which has caused great casualties and property losses. With the center of gravity of coal production moving westward, the western mining area will play an increasingly important role in guaranteeing national energy security, and there is an urgent need to economically and efficiently extract coal under the premise of guaranteeing safety and environmental capacity, and realizing scientific mining [1]. One of the key scientific issues to realize scientific mining is the prevention and control of flooding and the protection and utilization of water resources [2-3].

In 1983, German scholar H.K ratzsch proposed the concept of off-layer for the first time in his book "Mining Damage and Protection" [4]; in 1984, American scholar S.S Peng proposed that: the off-layer and damage of mining overburden occur in the pressure arch, the roof overburden is divided into three zones vertically after the face mining, and the phenomenon of off-layer occurs in the rift zone [5-6]; in 1986, Polish scholar J. In 1986, Polish scholar J.Palarski proposed that the surface subsidence should be controlled by the method of off-layer grouting, and predicted that off-layer grouting could reduce the amount of surface subsidence by 20-30% [7]; in 1990, Russian scholar B.J.Самарин focused on the formation of off-layer zones, the location of the development of the zones and their influencing factors by taking the mining under the water as the object of his research; and S. Lin analyzed the dislocation of the composite roof level. S.LIN analyzed the discontinuity of displacement and the change of stress at the composite
roof level [8]; Gregory Molinda observed the composite roof plate delamination in the field and proposed the method of grouting to strengthen the roof plate [9]. Gregory Molinda proposed the method of grouting to strengthen the roof slab [10].

Scholars in China have done a lot of research work on the stress and fissure evolution of overburden rock in the process of coal seam mining. Cheng Zhiheng et al. [11] investigated the distribution and evolution characteristics of stress and fissure in the overburden rock under the influence of double mining for both the protective and protected seams by similar material modeling tests. Wang Xinfeng et al. [12] studied the dynamic evolution characteristics and spatial-temporal coupling law of mining stress, overburden rock transport, and fracture distribution in deep quarry. Li Chunyuan et al. [13] investigated the fracture extension mechanism in the end effect zone under dynamic disturbance and the zone of water-surge channel development under unloading effect in stages by unloading rock theory, and found that the intensity of dynamic disturbance determines the extension of the bottom plate fracture and infiltration effect. Zheng Jianweif et al. [14] analyzed the dynamic evolution characteristics of the spatial structure of overburden rock under time and space conditions during the mining process through the overburden rock structure model established in the whole life cycle of the quarry, and divided the whole life cycle of the quarry into the occurrence period, the development period and the stabilization period. Xie and Ping [15] simulated the vertical and horizontal stresses in front of the longwall working face through coal rock mining dynamics experiments, and obtained the mining dynamics behavior of the whole process of coal body destruction under different mining conditions. Wen et al. [16] established a flow stress damage model and its fissure expansion criterion based on the Mohr-Coulomb criterion, and simulated the deformation and destruction of the overburden rock and water-conducting fissure zones in the process of mining using FLAC3D software. damage and the evolution of water-conducting fissure zone during the mining process.

Qiao Wei [17] and others systematically organized and summarized the research progress on coal mine overburden water damage at home and abroad, and elaborated on the problem of coal overburden water damage from four aspects, namely, the formation mechanism of coal mine overburden water, disaster-causing mechanism, prediction and early warning of water damage, and the key prevention and control technology. Zhu Qingwei et al. divided the evolution of overburden rock breakage into three stages, and established the corresponding mechanical model [18]. Zhang Xin et al. studied the development location and spatial size of deep quarry. Li Chunyuan et al. [13] studied the dynamic evolution of water-conducting fissure zone during the mining process using FLAC3D software. damage and the amount of water.

2 Prediction of water damage in the overlying rock outcrop

Stratified water damage is characterized by strong destructiveness, short duration, complicated disaster-causing mechanism and great difficulty in investigation. The prediction of off-layer water damage is the prediction of the location of water-off-layer, the periodicity of breakage and the amount of water.

Key Layer Discriminant Off-Level Equation:

\[ q_{n+1} = \frac{E_1h_1(\rho_1h_1 + \rho_2h_2 + \ldots + \rho_nh_n)}{E_1h_1 + E_2h_2 + \ldots + E_nh_n} \]  \tag{1}

Where E1, E2, ..., En is the elastic modulus of each layer; h1, h2, ..., hn is the thickness of each layer; \( \rho_1 \), \( \rho_2 \), ..., \( \rho_n \) is the density of each layer; n is the number of rock layers in the group. If \( q_{n+1} > q_{n+1} + 1 \), it means that the n+1 layer does not exert load on the first layer, which proves that the delamination occurs between the nth layer and the n+1th layer.

Zhang Wenzhong derived the formula under the consideration of the buoyant support force of the water body as

\[ L = h \sqrt{\frac{2gR}{q - \rho gh}} + 2 \left( \sum h + (n+1)h \right) \cot \theta \]  \tag{2}

Where, h--thickness of stratification of overhanging rock layer, m

R – ultimate tensile strength of the base top in the aquifer; and

q—load on the upper part of the basic roof in the aquifer; and

g—Gravity acceleration;

h---Collapse thickness of overburden rock, m;

\( \theta \)—Collapse angle of rock formation.

The field monitoring and statistics on the development of the off-seam fissures in mining have concluded that there is a positive relationship between the volume of off-
seam fissures $V$ and the volume of the coal seam mined back $V_c$, i.e.

$$V = \gamma V_c$$ (3)

Where, $\gamma$ - scale factor, %, determined by regression statistics based on existing off-stratum fracture monitoring data from similar mines or workings.

For the mines with periodic outbursts of water, it is possible to predict the next outbursts of water through the observation data of the previous outbursts of water and the correlation between the outbursts of water and the advancement of the working face; in addition to this, it is also possible to predict the outbursts of water at the working face through the situation of the outbursts of water in the neighboring areas that have already been mined.

### 3 Coal-rock properties and damage characteristics under complex geological conditions

In order to investigate the effect of water on the physical and mechanical properties of coal and rock samples under complex geological conditions, indoor experimental means, through the coal for field sampling, specimen preparation into a cylindrical shape, specimens are generally 50mm in diameter and 100mm in height, to carry out the coal and rock samples in the natural, water-saturated state of the indoor rock mechanics test coal and rock samples using displacement control, coal samples loaded at a rate of 0.8mm/s, the loading rate of rock samples for 1.0 The loading rate of coal samples is 0.8mm/s and rock samples is 1.0mm/s.

Coal samples under uniaxial compressive loading mainly produce X-shaped conjugate oblique shear damage, single oblique shear damage and tensile damage. Fig. 1 shows the macroscopic damage pattern of coal samples in the natural state under uniaxial compression loading. In the natural state, the coal samples are mainly damaged by shear, and the loaded damage of the coal samples is mainly concentrated on a strip on the surface of the coal samples, with a large damage scale, and the fine cracks are mainly concentrated in the vicinity of the large and obvious uni-slope damage strips, and the damage is monotonous; it can be seen in Fig. 2 that, in the saturated state, the loaded damage of coal samples is not only limited to a strip on the surface of coal samples, but also multiple parallel ruptures through the coal samples, and the rupture scale of coal samples is smaller with more cracks. Comparing the damage forms of the complete coal samples in the natural state and the water-saturated state, it can be found that the damage forms of the water-saturated state coal samples are more complicated, and the rupture scale decreases and the number of cracks increases. This is due to the fact that when the coal samples are saturated with water, the internal microfissures of the coal samples are easier to develop and penetrate during the loading process, so that more cracks are formed on the surface of the coal samples with more development. This indicates that the presence of groundwater can change the damage mode of coal rock and make the damage form more complicated. Under the same mechanical environment, in the area affected by groundwater, the internal cracks of coal rock are more likely to develop and penetrate, and are more likely to be destabilized.

By analyzing the test data, it was found that the stress-strain curves of coal samples in the same state differed significantly.

As can be seen from Fig. 3, the full stress-strain curves of uniaxial coal samples in both natural and water-saturated states can be divided into the following stages:

1. **Compaction stage**: the curve is concave in the natural state and waterlogged state, and the slope of the tangent line at each point can be found to be increasing, which is reflected in the microscopic pore area ratio gradually...

![Figure 1](image1.png)

**Figure 1.** Failure characteristics of coal samples in natural state.

![Figure 2](image2.png)

**Figure 2.** Failure characteristics of coal samples in the state of water immersion.

![Figure 3](image3.png)

**Figure 3.** Stress-strain curves of coal samples in two states.
decreasing, and the macroscopic mechanical properties are shown as the uniaxial compressive elasticity modulus gradually increasing, which is due to the fact that there are inevitably a lot of defects such as microcracks and pores in the coal samples, i.e., the initial pore area; when the samples are loaded, the initial pore area will be gradually reduced by closure.

It can be clearly seen from the comparison image that the duration of the compacting stage of the coal samples in the water-saturated state is obviously more than that of the natural state, which reflects the softening effect of water on the compacting stage of the coal samples, increasing the initial pore space and making the duration of the compacting stage grow.

Linear elasticity stage: the curve of this section in the natural state and water-saturated state is approximately an oblique straight line, which can be interpreted from the microscopic point of view that the microcracks and pores are no longer reduced after closing to a certain degree, and the increase of external load is not enough to produce new cracks, and it can be considered that the microscopic pore area of this stage stays unchanged or grows very slowly; the macroscopic mechanical properties of this section of the curve are that the stress and strain are in good linear relationship, i.e. the modulus of elasticity increases, which makes the compacting stage increase in duration. The macroscopic mechanical properties of this section of the curve show a good linear relationship between stress and strain, i.e., the elastic modulus is a constant value.

Through comparing the images, it can be clearly seen that the slope of the linear elasticity stage curve of the coal samples in water-saturated condition is obviously smaller than that of the natural condition, which reflects the softening effect of water on the linear elasticity stage of the coal samples and reduces the elasticity modulus calculated in the linear elasticity stage, so that the slope of the curve of the linear elasticity stage curve of the water-saturated condition samples is slowed down.

Yield stage: In the natural state condition, from a certain stage before the peak strength, the material with lower strength inside the material is destroyed firstly, new fissures start to form, the damage of the specimen accumulates gradually, and the surrounding material is also destroyed gradually due to higher stress, the fissures evolve and expand, and the coal sample shows a weakening phenomenon. The stress-strain relationship is nonlinear, and it can be assumed that the elastic modulus of the coal samples at this stage decreases with the increase of strain. The yield stage is not obvious in the case of water-saturated state, and it starts directly from the peak strength point, the lower strength material inside the material is destroyed, new cracks begin to form, the damage of the specimen accumulates gradually, and the surrounding material is also destroyed gradually due to higher stress, the cracks evolve and expand, and the coal samples show the phenomenon of weakening. The stress-strain relationship is nonlinear, and it can be assumed that the elastic modulus of coal samples in this stage decreases with the increase of strain.

Destruction stage: After the weakening stage, the coal sample reaches the ultimate stress it can bear in the natural state, the crack inside the sample penetrates through, the material is destroyed instantly, and the stress decreases rapidly; with the continued loading, the stress remains unchanged, showing the residual stress intensity. After the weakening stage, the coal samples under water-saturated condition reach the ultimate stress that can be withstood, the internal cracks of the samples are penetrated, the material is destroyed more slowly, and the stress decreases more slowly; with the continued loading, the stress remains unchanged, and the residual stress intensity is presented.

The damage pattern of coal samples under the influence of water body is derived, which is characterized by the decrease of rupture scale and the increase of the number of cracks. Water saturation deteriorated the mechanical properties of the coal samples, reducing the uniaxial compressive strength by 26% and the modulus of elasticity by 24%. The water-saturated coal samples had a longer stress fall time and appeared to have curves showing a concave bimodal change, experiencing two such processes before reaching the stage of participating strength.

The internal cracks in the water-saturated coal samples are more prone to multiple penetrations, showing X-type conjugate shear damage, with two large and distinct cracks running together through the rock samples, and fine cracks along a slightly smaller, but increased number of cracks. Water-saturated still softens the mechanical strength of the rock samples, reducing the uniaxial compressive strength by 23%, water-saturated rock samples climb directly to the peak strength after the initial compression-density stage, while natural rock samples experience two linear climbs with different slopes, and the post-peak damage stage, with a longer stress fall in water-saturated samples compared to the natural state coal samples.

4 Numerical Simulation of mine overburden stress evolution characteristics

4.1 Modeling

The model was built according to the actual geological situation, and the boundary conditions used in the model are as follows: horizontal stress linearly increasing with depth is applied at the left and right ends of the X-direction; gravity is applied in the Z-direction, and the bottom of the model is controlled by speed; the mechanical parameters of the coal and rock seams are assigned according to the results of the experiments of the rock mechanics and on-site geological investigations; and the dimensions of the whole model are 350.0m×150.0m×350.0m, which is a good example of how the model can be used in the field of geology.

4.2 Analysis of Simulation Results

Fig. 4, 5 and 6 show the cloud diagrams of the stress distribution in the vertical direction of the working face after the model excavation of 10.0m, 40m, 70m and 100m
as well as the change of stress at different distances from the working face.

From the image of stress change with distance from the working face in Fig. 4(a), the maximum value of stress occurs at 10.0m from the working face, and its stress concentration coefficient is 1.24, and then the stress begins to decrease and converges to a straight line, and it can be seen that 80.0m from the working face is the affected area of the rock layer in Fig. 6(a).

Fig. 4(b) shows the vertical stress distribution of the working face after the model 40.0m, and it can be seen from the figure that the maximum stress is still distributed in the coal pillar on the right side of the working face when it advances to 40.0m, and it starts to extend upward to the fine sandstone in the direct top in the vertical direction, and the distribution of the stress continues to be extended on the basis of the original foundation, and the stress is concentrated in the middle of the coal pillar, and the maximum stress value is 10.95 MPa. The arch-shaped area of stress concentration formed in the top and bottom plates of the working face continues to spread and the stress is increasing, while the stress distribution in the vertical direction of the upper rock layer shows a pattern of extending from the two sides to the middle, extending to the siltstone in the old roof, and the maximum stress extends to the coarse sandstone in the direct roof. From the image of stress change with distance from the working face when advancing 40.0m in Fig. 6(b), the maximum stress is reached at 22.0m from the working face, and the maximum stress on the coal body behind the working face at this time is 8.72MPa with the stress concentration coefficient of 1.25, and then the stress gradually tends to a straight line, and at the same time, it can be seen that in the range of 80.0m from the working face is the area of the rock stratum affected, influence area.

As shown in Fig. 4(c) for the model 70.0m after the vertical direction of the working face stress distribution, as can be seen from the figure, advancing 70.0m when the stress with the distance from the working face changes in the image, in the distance from the working face at 24.0m to reach the maximum value of the stress, at this time, the coal body behind the working face was subjected to the maximum stress of 11.14MPa stress concentration coefficient of 1.27, and then began to gradually converge to a straight line at the same time it can be seen that its stress gradually converge to a straight line at the same time it can be seen that its decrease decreases and finally tends to be in equilibrium or has the tendency to tend to be in equilibrium.

![Figure 4. Variation of vertical stress at different distances from working face.](image)

As shown in Fig. 4(d) for the working face vertical stress distribution after the model 100.0m, it can be seen from the figure, advancing 100.0m when the stress with the distance from the working face changes in the image, in the distance from the working face at 24.0m to reach the maximum value of the stress, at this time, the coal body behind the working face was subjected to the maximum stress of 14.12MPa stress concentration coefficient of 1.32, and then began to gradually converge to a straight line at the same time, and then began to gradually converge to a straight line of stress, and at the same time can be seen in the range of 80.0m from the working face is the area affected by the rock. The stress gradually converges to a straight line while continuing to extend the curve, which can be seen in the range of 80.0m from the working face is the affected area of the rock layer. The overall change of the vertical stress distribution of the working face after excavation of the four groups is shown in Fig. 5, which can be seen intuitively that the longer the advancing distance, the higher the peak stress in the vertical direction of the working face, and the four curves of the stress change trend is basically the same, both are rapidly rising and then decreasing, and the magnitude of the decrease decreases and finally tends to be in equilibrium.

![Figure 5. Comparison diagram of vertical stress changes at different distances from working face.](image)

![Figure 6. Stress change nephogram.](image)
From the stress change cloud diagram in Fig. 6, it can be seen that the maximum stress is mainly distributed in the coal pillar on the right side of the working face and the rock layer of the bottom plate on the left side of the working face after the face is advanced for 10.0m, and the maximum stress is 8.47MPa. The top plate and the bottom plate of the working face are the areas where the tensile stress is concentrated, and the top plate is affected by the fine sandstone and siltstone above the face; the maximum stress is still distributed in the coal pillar on the right side of the working face after the face advances for 40.0m. The maximum stress is still distributed in the coal pillar on the right side of the working face, and it starts to extend upward to the fine sandstone in the direct top in the vertical direction, and the stress distribution continues to extend and the stress concentration in the middle part of the coal pillar is the maximum stress value of 10.95MPa. The stress concentration arch formed in the top and bottom plates of the working face continues to spread and the stress increases, while the stress distribution of the upper rock stratum in the vertical direction shows a general pattern of a tensile stress concentration in the top and bottom plates. The stress distribution in the upper rock layer in the vertical direction shows a pattern of expanding from both sides to the middle, extending to the siltstone in the old top, and the maximum stress extends to the coarse sandstone in the direct top; when advancing to 70.0m, the maximum stress is still distributed in the coal pillar on the right side of the working face, and the area of stress concentration shrinks, and the maximum stress is 14.24MPa, and the stress distribution and the top of the model are connected to form a saddle-shaped stress distribution and a saddle-shaped stress distribution in the vertical direction. The maximum stress is 14.24MPa, and the stress distribution in the vertical direction and the top of the model are connected to form a saddle-shaped stress distribution and expand widely to both sides. When the excavation reaches 100.0m, the maximum stress is still distributed in the right coal pillar of the working face, and the stress concentration area continues to be narrowed down, with the maximum stress being 20.3MPa, and the distribution of the vertical direction and the top of the model are connected to form a saddle-shaped stress distribution and continue to be expanded widely to both sides. At 70m and 100m of excavation, the arch-shaped stress distribution area on the working face is mainly in the coarse sandstone, fifteen coals, fine sandstone and siltstone layers, which extends rapidly upward to the junction of coarse sandstone and mudstone of the overlying layers, and the stress area formed below the working face extends to the bottom mudstone area and distributes nearly the whole area along with the deepening of excavation with the angle of 135° from the horizontal.

5 Techniques for the prevention and control of delaminated water

For the coal seam roof water release is mainly divided into three basic ways: surface release, underground release and joint release. There are 4 basic conditions of off-seam water damage: water can be accumulated off-seam - off-seam space is "closed"; there is a recharge water source around the off-seam; a certain long time off-seam space is filled with water; and there is a water conduction channel. Mining roof off layer water release hole can be divided into downhole conduit hole, interceptor holes and ground through the type of water release holes. Accumulation of water away from the location of the layer from the lower face closer, can be used downhole release hole management.

The breeding and development of off-layer water damage is characterized by "dynamic water source" and "dynamic channel". The so-called "dynamic water source" means that the water body is not a natural aquifer, but the mining space in the coal seam overlying rock is recharged by the natural aquifer and filled with water, so the prediction of the formation of the water body of the formation of the off-seam location, timing is one of the difficult points. The difficulty of "dynamic channel" is that it is difficult to grasp the combination point of water body and mining water-conducting fissure, after the formation of water body, if the water-conducting fissure (belt) can't be passed through it, then it can't form the water of the off-seam surge; if the water-conducting fissure communicates with the water body of the off-seam above the air-mining area, then the harm strength of the water of the off-seam surge will be weaker; if the water-conducting fissure communicates with the off-seam above the air-mining area, then the harm strength of the water of the off-seam surge will be weaker. When the water-conducting fissure communicates with the water body above the roof-control area, or communicates with the water body above the air-mining area, but the water flow is introduced into the working face by the water-conducting fissure, the water damage of the off-layer is often formed. Mining roof off layer water release holes can be divided into downhole guide hole, interceptor holes and ground through the type of water release holes. When the location of the water off the layer is close to the lower face, it can be managed by the underground relief hole; for the coal mine water off the layer of the development of the location of the higher, downhole upward construction difficulties, it can be used on the ground through the type of water relief hole for the release of water off the layer.

Influence hole: Its purpose is to release the overburden water before it affects the working face, so as to reduce the influence of the overburden water on the working face during the period of mining. The downhole water diversion holes should be directed to the off-lying space, and the final holes should be located in the off-lying water accumulation area, as shown in Fig. 7.

![Diagram of diversion hole](image-url)
Excessive discharge hole: its purpose is to release the off-lying recharge aquifer and block its recharge to the off-lying space, so as to reduce the amount of recharge gained from the off-lying space, thus reducing the impact of the off-lying water on the working face. Among them, the interceptor holes end up in the off-lying recharge aquifer and point to the outside of the working face. The interception holes of off-stratum water must be constructed and drained before the face is mined back, as shown in Fig. 8.

Figure 8. Schematic diagram of lead drain hole.

Ground straight pumping holes: Mainly applicable to coal mine high level off-seam water damage, because of its off-seam and the lower working face between most of the mudstone layer, underground construction is difficult, you can use the ground straight-through relief holes on the roof of the quarry off-seam water release. The role of the straight-through drain hole is the same as the role of the off-layer water diversion holes, both of which are to release the water in the space of the off-layer in advance, in order to minimize the impact on the lower working face during the mining period. For the straight-through drain hole, it should point to the off-layer space, and the final hole is at the top of the fallout zone, as shown in Fig. 9.

Figure 9. Schematic diagram of ground direct pumping hole.

In addition to the method of drilling and releasing, the necessary conditions for the formation of water-deposited seams can be destroyed by controlling the mining height and advancing speed, so as to prevent the formation of water-deposited seams. The duration of the roof off-seam space is inversely proportional to the advancement speed of the coal seam mining, therefore, accelerating the advancement speed of the working face can shorten the duration of the off-seam, so as to minimize the impact of the roof off-seam water on the lower part of the quarry.

6 Conclusion

The difficulty of preventing off-seam water damage is that it involves hydrogeology, engineering geology, mining rock mechanics and mining technology and equipment. First of all, the engineering geology and hydrogeology conditions of the overburden rock should be analyzed in depth, the regional prediction of off-seam water damage should be carried out, and the danger area of off-seam water damage should be divided, so that the prevention and control of water damage can be "targeted". The research on mining rock overburden seams and the formation mechanism of rock overburden seams water is summarized, and the formation of coal seam rock overburden seams water is summarized into three basic conditions: water can be accumulated in the seams, there is a recharge water source around the seams, and the duration of the seams space is long enough. However, the prevention and control of water damage in coal mines under complex geological conditions is an important problem that restricts the safety of coal mines at present. The prediction of water hazards in overburden outcrops is summarized from three aspects: prediction of the location of waterlogged outcrops, prediction of the periodicity of outcrop water surges, and prediction of the amount of water surging from outcrops. According to the development characteristics of the off-seam and the location of the off-seam water, the main off-seam water damage prevention and control methods are proposed, such as inflow holes, over-discharge holes, and three kinds of discharge holes of the ground direct pumping holes.

Reference


15. Xie Heping, ZHOU Hongwei, LIU Jianfeng, et al. Study on the behavior of mining dynamics under different mining conditions [J]. Research on the behavior of mining dynamics under different mining conditions [J].


