

**Opinion**

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Progress of Strata Control in Safe and Green Mining of Large Shallow Coalfield in Western China

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Opinion

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China's coal production output ranks first in the world and is the world's largest coal mining country. Shenfu and Dongsheng coalfield is one of the largest coalfields in the world. The coal seams are shallow buried and close seams group. The practice shows that the ground pressure in the working face of shallow coal seam is violent, and the mining has a significant impact on the ecological environment, which has become a major issue of coal mining. In the early 1990s, based on the pre mining simulation of the first working face of Daliuta coal mine in Shenfu coalfield, the phenomenon of "step subsidence" of the roof was found. Through years of research, it was found that the single and double key strata of thin bedrock roof were the main indicators of the definition of shallow coal seam [1], and the mechanism of "short voussoir beam" evolving

into "step voussoir beam" [2], and it was also found the large and small periodic weighting of roof was caused by synchronous and asynchronous movement of double key strata [3]. The structural model of "step voussoir beam" was established, which reveals that the mechanism of large dynamic roof weighting of shallow coal seam is the sliding instability of step voussoir beam structure. Based on the field measurement and physical simulation, the "asymmetric three hinged arch" structure in the first roof weighting was proposed [4], and the coefficient of friction and squeezing at of rock block corner of roof structure were measured [5]. Thus, the quantitative calculation of support load of the first and periodic weighting in coal face is realized [6], and the basic theory of rock strata control in shallow coal seam is formed.

Another reason for the strong roof weighting of shallow coal seam mining face is that there is thick sandy soil layer on the thin bedrock. The load transfer phenomenon of sandy soil layer was measured, and it was found that the sandy soil layer forms a temporary unloading arch structure with small load at the beginning movement of key blocks, and later evolves into inclined rock column with large load [7]. Therefore, the mechanism of rapid advance and decompression of working face is revealed. With the emergence of large mining height, the crushing expansion of geological immediate roof is not enough to fill the mined space, some adjacent geological main roof is difficult to hinge and are in caving state, which becomes "equivalent immediate roof" [8]. The articulated roof of the main roof moves upward to form a "high step voussoir beam" structure. The "step voussoir beam" structure is more common in large mining height face. The equivalent immediate roof increases

the proportion of static load of support, and it reveals the mechanism of continuous high roof weighting in large mining height face [9].

With the large-scale mining of shallow coal seams, the surface water level has decreased significantly, and the contradiction between coal mining and environmental protection has become increasingly prominent. After 2004, with the support of the Ministry of education and the national foundation, the research on the mining water resistance of the aquiclude was carried out for green mining. Through innovative solid-liquid coupling simulation of the water conservation mining, it was revealed that the mining overburden was not only affected by the traditional “upward crack”, but also found that the “downward crack” also had important impact on the aquiclude [10]. Therefore, the stability criterion of the aquiclude was established, and the classification of “natural water conservation mining”, “limited height water conservation mining” and “special water conservation mining” were put forward in shallow coal seams. Since 2012, according to the conditions of shallow coal seams, high sand filling materials have been developed, and the flexible strip filling water conservation mining method has been proposed [11]. Through this method, the filling and water conservation mining of shallow coal seam can be organically combined with surface sand control and farmland making, and a road of green development can be found [12].

Since 2015, with the lower coal seam mining under goad of the shallow coal seams group, the problems of underground coal pillar stress concentration and surface crack development have become prominent due to repeated mining in close coal seams. Through research, a classification method of close coal seams group is proposed, which is characterized by the key strata of the interval strata and the ratio of interval strata thickness to mining height as the main index. For the “very close coal seam” with no key strata in the interval strata, the roof weighting of coal face is mainly affected by the activation structure of the roof of the upper coal seam. For the single key seam close coal seam, the roof weighting is mainly affected by the “step voussoir beam” structure of the interval strata, spacer and the activation structure of the upper coal seam. For the close coal seam with double key strata, the roof of coal face mainly forms the combined structure of lower “step voussoir beam” and upper “voussoir beam”, which will cause the large and small periodic weighting. Based on this, the calculation method of support load determination is established, and the rock strata control theory of shallow close coal seam are developed [13]. It is also found that the surface fissures and coal pillar concentrated stress of coal seam group mining are derived from the uneven subsidence caused by the coal pillars [14]. The coupling control of underground stress concentration reduction and surface damage reduction can be realized by reasonable staggering arrangement in upper and lower coal faces mining [15].

At present, coal mining is developing towards green and intelligent mining. The research on intelligent rock stratum control has

just started and has a long way to go. Revealing the basic behavior and mechanism of ground pressure is still an important support for intelligent mining development.

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Conflict of Interest

No conflict of interest.

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