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A novel land subsidence control technique for "green mining"

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Abstract: Land subsidence caused by mining is increasingly severe. A novel land subsidence control technique for coal mining is proposed in this paper. Two longwall panels are offset on ends of each panel by adjusting panel layout which eliminates conventional coal pillars. Therefore, no wavy deformation occurs on the land surface which protects land and constructions on the ground surface. A case study is given. It shows that by using the novel technology, a better subsidence control result is obtained, coal recovery ratio is higher, drilling work load is less and less future potential secondary subsidence hazards. The technology is significant for "green mining" by protecting land.

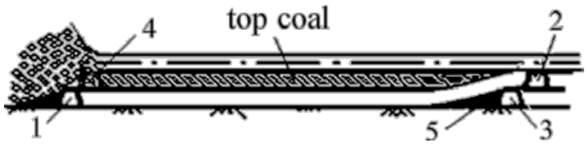
Keywords: Land subsidence, green mining, wavy deformation, coal pillar.

1. Introduction

Many underground engineering projects lead to land subsidence, coal mining, in particular, has a huge influence on reshaping topography. Many mining methods leave pillars to control land subsidence, such as room-and-pillar method, longwall mining with chain pillars, etc. However, pillars turned out to be potential hazards in the future due to the time-dependent characteristic of stability of the pillars: they will eventually fail. Coalbrook disaster in 1960 was caused by cascading pillar failure over an area covering 324 hectares and 437 people were killed [1]. In Lanark in Scotland, room-and-pillar mining had ceased 118 years before sandstone beds collapsed abruptly over workings [2]. Orchard and Alien (1965) noted that 9 percent of total potential subsidence occurred during a 6-year period after a 166-m-deep longwall face advance stopped at Peterlee in the United Kingdom [2]. Many coal mines in South Africa also has many such pillar failure problems [3]. In view of these problems, many researchers carried out a multitude of studies. Tong [4] notes that before construction projects on land surface, subsidence ratio should be determined, and suggested that activation of abandoned mines and subsidence be accelerated before the land of interest is going to be used making sure that no future subsidence occurs. Hu [5] studied the residual deformation after coal extraction and confirm that residual subsidence will influence the structures on the land surface. A lot of subsidence control method were proposed in addition to leaving pillars such as stowing, overburden grout injection, etc. which are very effective yet costly [6]. Therefore, if all coal pillars are able to be extracted in a safe manner, the surface subsidence associated with pillar failure would be eliminated. And no secondary subsidence and potential damage to structures on the ground due to elimination of pillars [7].

2. The new technique

The novel surface subsidence control method through longwall mining layout in flat or nearly flat thick coal seam is shown in Fig. 1 termed "Longwall mining with split-level gateroads" (LMSG) [8]. As shown in Fig. 1, gateroads on both ends of the middle panel are located in different levels (split-level) with the headgate 1 driven along the floor while the tailgate 2 driven along the roof forming a gradually elevated section 5 on the right end of the panel. This section is elevated by adjusting the inclination of mining machines. Headgate 3 of the successive panel is driven along the floor, and under the edge of the mined-out area after the excavation of the middle panel in the same manner how the headgate 1 is driven. Corresponding operations for LMSG are unique and termed "triple sections mining technology" (TSMT) [9], as shown in Fig. 2.



1—Headgate; 2—Tailgate; 3—Headgate of successive panel; 4—Tailgate of previous panel; 5—Triangular pillar.

Fig. 1 The system of a typical LMSG top coal caving in a flat or nearly flat coal seam

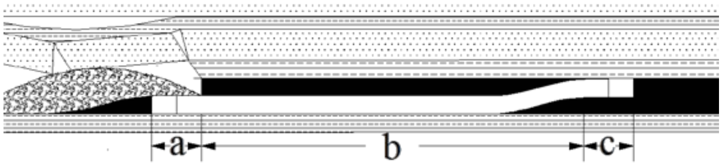


Fig. 2 Triple sections mining technology (TSMT) of top coal caving of LMSG

Working of section "a" is performed under artificial roof which is underlain by steel wire mesh that paved when mining upper level of the same part of previous panel. So tunneling work of headgate is done under this artificial roof. The headgate is supported by steel sets with wire mesh on top to prevents caved rocks from falling. Operations in section "b" are the same with that in conventional longwall top coal caving. The working of section "c" is the same with multi-slice longwall mining, the shields here equipped with mesh-lying device in order to form artificial roof for the next section "a" of the successive panel. All workings of the three sections constitute a working cycle for one panel.

The new method is very effective in ameliorating land deformations, thus reducing the damage to surface structures. According to characteristics of the land surface movements and deformations, chain pillars in conventional longwall mining would induce a deformation of a wave pattern above multiple isolated panels. While in LMSG, since the conventional large pillars are eliminated, and two panels are overlapped on each ends, only a tiny triangular coal loss left which has little impact on deformation of surface. Comparing the two pictures in Fig. 3, we can see that a continuous surface basin is developed above adjacent LMSG panels while for conventional method, the subsidence is nonuniform.

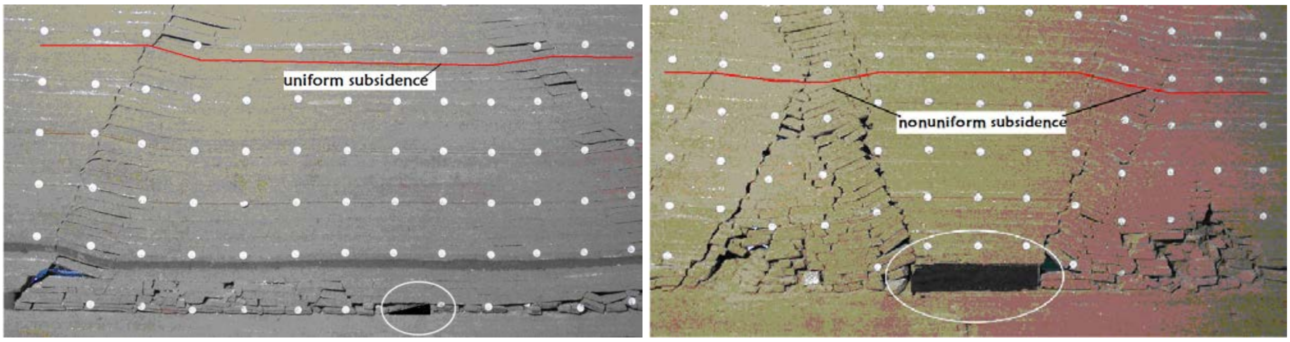


Fig. 3 Characteristics of the subsidence of LMSG and its comparison

With additional protective measures for structures on the ground, satisfactory results would obtain for surface structures protection. Especially in depth, the mined-out area generally can't reach the critical size, which means there is no flat bottom on the surface subsidence trough. By employing LMSG, the isolated panels are joined together thus avoiding wavy deformations on the surface. As a result, LMSG is favorable for coal mines where subsidence is allowed such as when there are no water tables within overburden, no water resources on the surface or there are no structures need to be protected. Because surface subsidence is sufficient and complete employing LMSG which eliminates the potential secondary subsidence, so the future construction activities after extraction of LMSG panels are sound and safe.

On top of that, for cases that there are water tables within overburden strata or water resources on the surface or structures need to be protected, overburden grout injection couple with LMSG is also an effective and economical way to prevent or control the subsidence within allowable magnitude.

Fig. 4 and 5 show comparison between the overburden grout injection coupled with two methods. As we can see, at least one borehole is needed for each independent overburden separation, while for the novel technology, only one borehole is needed for the continuous separation. In addition, volume of separation shown in Fig. 5 is much larger than the sum of independent separations which means larger amount of grout leading to better subsidence reduction result.

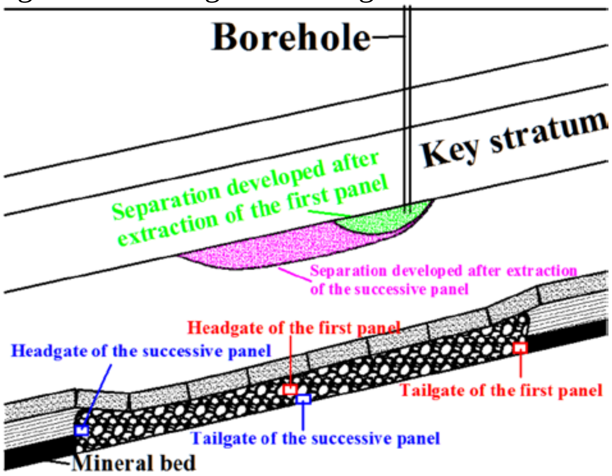


Fig. 4 Independent overburden grout injection

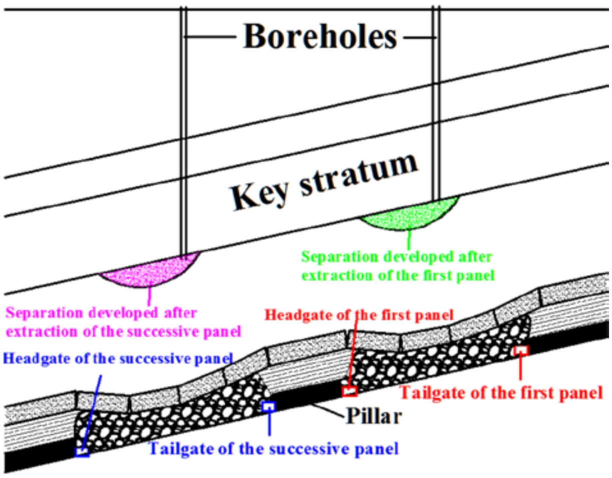


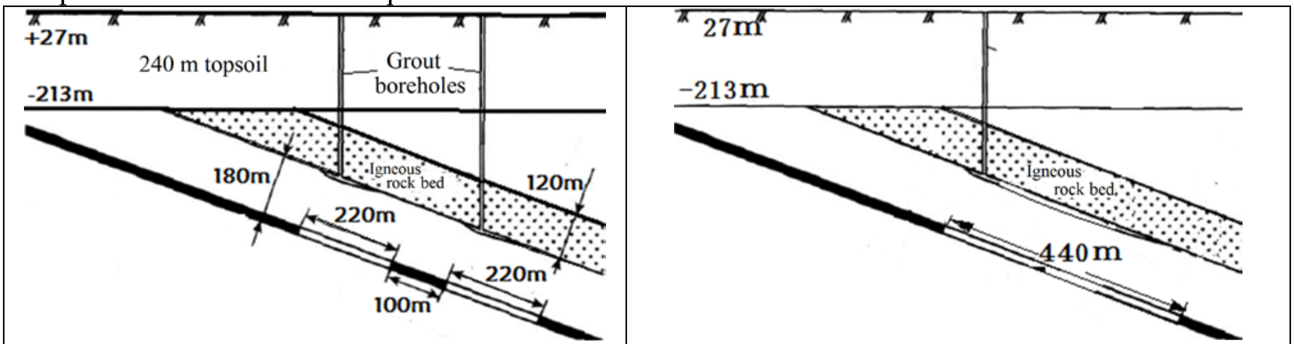
Fig. 5 Continuous overburden grout injection

3. Case study

4# coal seam is the main seam of Huafeng coal mine under management of Xinwen bureau. Average thickness of the coal seam is 6.2 m, average inclination is 32°. The ultra-thick conglomerate stratum is 150 away from coal seam on average and is the main key strata which controls the movement of all the strata above it. Since the Quaternary topsoil is thin, only 0-4 m, while tertiary conglomerate stratum is thick with better integrity. Therefore, the movement of the surface reflects the movement of conglomerate stratum. In the past, separated overburden grout injection was conducted for combined 1407 and 1408 panels and injection elevation was right under the conglomerate strata.

From the past situation of separated overburden grout injection in Huafeng coal mine, following problems exist including: (1) short face, which caused insufficient overlying strata movement in the dip direction thus leading to limited supporting effect on conglomerate strata; (2) boreholes were laid out along the dip. In order to realize separated overburden separation grout injection, according to field data, the angle of draw were 65° and 70° respectively for each sides, therefore a pillar of 170 m had to be left which is evidently very demanding in view of current reserve.

Now Huafeng coal mining is mining 1411 panel, in order to prevent surface breaks and rock bursts from occurring, overburden grout injection coupled with LMSG was employed. Fig. 6 shows the comparison of the two techniques.



(a) Independent overburden grout injection (b) The new technology

Fig. 6 Comparison between the two methods

First, since two LMSG panels overlap, critical width of panel is reached which means more separation develops, and there are no wavy deformation occur on the surface. Second, subsidence reduction ratio is 44.6% which is better than that of 15%-20% under sub-critical conditions. In addition, since there is no coal pillar between panels, much larger amount of coal can be recovered. What’s more, total length of borehole is about 850 m employing the new method, while for conventional method it was 2080 m, thus 1230 m of drilling work was saved.

4. Conclusions

A novel surface subsidence management technique for coal extraction is proposed int his paper. In the technology, by adjusting panel layout, two panels are overlapped on one end and no conventional coal pillar exists, so the wavy deformation of the suface is eliminated. What’s most important is that the threat of secondary subsidence caused by failure of coal pillars are avoided which benefits safe future use of the land above LMSG panels. So it is recommended that the novel surface subsidence management technique be priority when choosing coal mining methods for suitable geological conditions. The technology is significant not only for the sustainable development of coal mining industry but also for environmental and land issue.

5. Acknowledgments

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