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Design concerns of room and pillar retreat panels

Ted M. Klemetti[*], **Morgan M. Sears**, and **Ihsan B. Tulu**
Mining Engineer Ground Control Branch NIOSH, Office of Mine Safety and Health Research, Pittsburgh, PA, USA

Abstract

Why do some room and pillar retreat panels encounter abnormal conditions? What factors deserve the most consideration during the planning and execution phases of mining and what can be done to mitigate those abnormal conditions when they are encountered? To help answer these questions, and to determine some of the relevant factors influencing the conditions of room and pillar (R & P) retreat mining entries, four consecutive R & P retreat panels were evaluated. This evaluation was intended to reinforce the influence of topographic changes, depth of cover, multiple-seam interactions, geological conditions, and mining geometry. This paper details observations were made in four consecutive R & P retreat panels and the data were collected from an instrumentation site during retreat mining. The primary focus was on the differences observed among the four panels and within the panels themselves. The instrumentation study was initially planned to evaluate the interactions between primary and secondary support, but produced rather interesting results relating to the loading encountered under the current mining conditions. In addition to the observation and instrumentation, numerical modeling was performed to evaluate the stress conditions. Both the LaModel 3.0 and Rocscience Phase 2 programs were used to evaluate these four panels. The results of both models indicated a drastic reduction in the vertical stresses experienced in these panels due to the full extraction mining in overlying seams when compared to the full overburden load. Both models showed a higher level of stress associated with the outside entries of the panels. These results agree quite well with the observations and instrumentation studies performed at the mine. These efforts provided two overarching conclusions concerning R & P retreat mine planning and execution. The first was that there are four areas that should not be overlooked during R & P retreat mining: topographic relief, multiple-seam stress relief, stress concentrations near the gob edge, and geologic changes in the immediate roof. The second is that in order to successfully retreat an R & P panel, a three-phased approach to the design and analysis of the panel should be conducted: the planning phase, evaluation phase, and monitoring phase.

Keywords

Room and pillar; Retreat mining; Deep cover; Safety; Multiple seam

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[*] Corresponding author. Tel.: +1 412 386 5240., TKlemetti@cdc.gov (T.M. Klemetti).

Disclaimer

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

1. Introduction

During an evaluation of unexpected conditions experienced at an eastern Kentucky room and pillar retreat mine that was conducted as part of a NIOSH research effort, it became evident that several factors associated with stress redistribution were involved. The initial efforts and results were published in the past two International Conference on Ground Control in Mining (ICGCM) proceedings by Tulu et al. [1,2]. These two publications concluded that topographical changes and multiple-seam interactions were the cause of the unexpected conditions leading to the difficulties experienced in panels L6 and L4.

While visiting the mine and evaluating the unexpected conditions to determine the most likely causes, it became apparent to NIOSH researchers that this study would provide insight into a new research effort being developed to investigate the stress redistribution resulting from full extraction mining. This eastern Kentucky R & P mine provided an opportunity to evaluate the interactions between depth of cover, topographic changes, and multiple-seam interactions at a full extraction mine. This paper describes the field observations, instrumentation, and numerical modeling of four consecutive room and pillar panels retreated at the mine. The results of this study should provide additional factors to include in future designs and assessments both in the planning stage and prior to retreat mining.

2. Mining and geotechnical parameters

The Darby Fork No. 1 mine is operated by Lone Mountain Processing, Inc., and is located in Harlan County, KY. The mine produces bituminous coal from the Darby and Kellioka coal beds by the retreat room and pillar mining method. The operator has been mining the Owl, Darby, and Kellioka coal beds for at least the last 20 years. This paper focuses on mining in the Kellioka Seam, located below workings in the Owl and Darby coal beds. The majority of the mining layout and geotechnical parameters for the study areas were published in previous papers [1,2]. Two particular parameters to be expanded upon in this paper are the multiple-seam mining geometry and the variable geology encountered in these four panels.

2.1. Multiple-seam mining geometry

The Kellioka, Darby, and previously mined Owl panels have been stacked vertically so that the panel edges and barrier pillars between panels are superimposed. In all of the seams, the panel widths were subcritical, included 5 entries, utilized slab cuts during retreat, and included barrier pillars between the subsequent panels. The overmining conducted in these four consecutive R & P retreat panels varied as mining progressed to the west. For the L6, L5, and L4 panels, both the Darby and Owl seams were fully extracted above the Kellioka Seam prior to mining. Above the L3 panel, the Owl seam was developed, but not retreat mined, while the Darby seam was fully extracted. The interburden between the Kellioka and Darby seams ranges from 9 to 15 m within this area, while the interburden between the Darby and Owl seams ranges from 15 to 18 m. In general the interburden between the Kellioka and Darby seams decreases as the mining progressed from the L6 to the L3 panel. Over the same area the depth of cover increases from a minimum of 244 m to a maximum of 518 m. The previously discussed multiple-seam mining geometry is graphically represented in Fig. 1.

2.2. Geological conditions

The typical geology in the area of interest consists mainly of interbedded shales, siltstones, and sandstones (Fig. 1). In general, the interburden between the Kellioka and Darby seams consists of a medium strength dark shale that is relatively massive. A sandstone may be present in the interval, but the thickness is variable and ranges from 3 to 6 m over the L7 panel to less than 0.6 m over the L1 and L0 panels. The sandstone is not thought to be within the reach of installed roof support. However, thicker sandstone is reported to result in improved rood stability in the Kellioka Seam.

The immediate roof of the Kellioka Seam is described as a dark grey shale that is somewhat massive but can delaminate into thin slabs during buckling and cutter formation. Laboratory and field tests were conducted to determine the relative strength variations that could be expected during mining. The typical roof shale has a uniaxial compressive strength (UCS) varying between 51.7 and 103.4 MPa and an average Brazilian tensile strength of 7.6 MPa. From field analysis, the coal mine roof rating (CMRR) can vary between 35 and 55 while the majority of the roof encountered in this area is about 45 and dents when struck by a ball peen hammer. Visual observations of the immediate roof in areas of extended height included highly fossilized shales, sandstones, massive shales (both grey and black), and occasionally coal streaks or rider seams, as seen in Fig. 2. However, there are considerable differences in the description of the roof strata that do not always indicate a difference in strength.

3. Field observations and instrumentation

The primary techniques utilized to evaluate the conditions and potential elevated stresses observed in the four R & P retreat panels were visual observation and instrumentation. During the progression of mining from the L6 to the L3 panel, the visual observations included condition mapping and photographs to document the observed conditions. The results of the visual observations of the L6, L5, and L4 panels from the initial study were discussed in publications presented at the 33rd and 34th ICGCM by Tulu et al. [1,2]. In general these panels experienced poor conditions in the #5 entry were whenever the entry was not shifted further towards the center of the overlying gob. Although there were localized poor conditions encountered in all entries, entries #1–#4 experienced much better conditions than #5 in all three panels. The most interesting observations from the L6-L4 panels in relation to this new study included the following:

1. Anytime the #5 entry was not shifted, conditions quickly worsened and required the mine to shift the entry back;
2. The multiple-seam interactions were readily observable and were where expected;
3. The poor conditions observed included ragged, high, and slickensided roof areas, roof cutting along riblines, roof sag in entries and crosscuts, open fractures in the roof, floor heave, joint sets, and rolls;
4. The conditions in the #5 entry appeared to worsen as the rider seam came closer in proximity to the immediate roof;

5. The gob generally formed quite rapidly and the roof did not hang for extended distances.

3.1. Visual observation

In this paper, the focus is on the observations during development and retreat of the L3 panel. The observations of the L3 panel produced similar results for the #2, #3, #4, and #5 entries (see Figs 3 and 4). In general, the #2, #3, and #4 entries experienced relatively good conditions and only experienced difficulties while passing an overlying gob solid boundary or remnant pillar. On occasion, these entries did encounter very weak immediate roof that caused less than ideal conditions. The #5 entry experienced poor conditions relative to the other entries similar to those of the previous 3 panels. The #1 entry appeared to have an increased occurrence of poor conditions in comparison to the previous three panels observed (see Fig. 5). Although they were not as extreme or continuous, the conditions were less desirable than those experienced in entries #2, #3, and #4. This entry did not experience the frequency nor the severity of the conditions observed in the #5 entry.

In addition to the surface evaluations, several test holes were evaluated for cracking and shifting in all 5 entries near the instrumentation site when the pillar line was approximately ten, two, and one row(s) inby the instrumentation site. The test holes in entry #1 and #5 had the highest prevalence of both cracking and shifting and tended to increase as the pillar line approached the holes. Shifting was prevalent in the #1 entry test holes while cracking was most common in the #5 entry.

It was also observed that poor conditions generally coincided with rolls, roof sag, open fractures in the roof, and roof strata changes. There was no apparent elevated loading or condition deterioration attributable to the pillar extraction. It appears that aside from time-dependent deterioration, the conditions tend to remain the same during retreat as they were during development. The time-dependent deterioration was most frequently encountered well in advance of the pillar line resulting in some pillars or partial pillars being left due to poor conditions, increased cribbing, and previous roof falls.

3.2. Instrumentation

While mining was underway in the L4 panel, an instrumentation plan was developed to investigate the interaction between primary and secondary supports for the L3 panel. The instrumentation actually produced rather interesting results in relation to the loading experienced due to the topography, multiple-seam interactions, and geological setting. The instrumentation plan included one 4-point roof extensometer, two 8-point roof extensometers, and four load cells installed on the 3.66 m two-piece superbolts (75 grade 19 mm). The 4-point extensometer had anchors located 4.9, 3.7, 2.7, and 1.2 m above the roof line while the 8-point extensometers had anchors located 2.7, 2.4, 2.1, 1.8, 1.5, 1.2, 0.9, and 0.6 m above the roof line. The instruments were located in the #2 entry at crosscut 13 and mid-pillar between crosscuts 12 and 13, as shown in Fig. 6. The instrumentation was installed during development of the panel in an attempt to capture as much movement and loading as possible. Data acquisition from the instruments in the intersection was terminated during the course of mining after extraction inby crosscut 13 and prior to extraction outby.

However, the instrumentation located mid-pillar captured all retreat mining surrounding the instrumentation location and is detailed below.

Both locations showed little to no roof movement or superbolt loading prior to the extraction of pillars inby the instrumentation locations as can be seen in Figs. 7–10. The mid-pillar location began experiencing roof movement and superbolt loading upon extraction of the pillars inby crosscut 12. Prior to the removal of the data logging system for the mid-pillar site, the roof in the #2 entry still had not collapsed for at least one break inby the pillar line. The superbolt loading was greater on the gob side cells and began earlier on the inby cells. The inby cells showed an abrupt load increase followed by a period of minor load increase and then another abrupt load increase. The outby cells did not show the “stepping” in the readings, possibly due to the timing of instrumentation removal. The cells closer to the gob showed a greater increase in load than those closer to the solid coal side. The average of the inby load increase was approximately 75.62 kN and the outby load increase was approximately 26.6 kN. The 4.9 m roof extensometer showed a maximum roof sag of 3.48 cm with the majority of the sag occurring in the first 1.2 m of the roof. The 2.7 m roof extensometers showed an average maximum roof sag of 1.09 cm with very little movement above the 1.8 m horizon.

The timing, rates, and maximum values of roof sag and loading were fairly consistent among most instruments. All of the instruments that were installed slightly closer to the previous panels’ gob showed greater load increases or roof sag, indicating a preferential loading of the entry on the gob side. The instruments showed that the roof was most active during mining of the same entry that the instruments were in. During mining of the furthest entries from the instrumentation site, there was little additional change in the roof sag or superbolt load.

4. Numerical modeling

After the initial visual observations were conducted it became apparent that the addition of numerical model simulations would provide more insight into the mechanisms at work in this multiple-seam mining scenario. Two different numerical modeling programs were used to study the responses to the mining conducted in the four R & P retreat panels: LaModel 3.0 and Rocscience Phase 2. The primary focus of the numerical modeling efforts was to assess the stress redistribution due to the topographical relief, multiple-seam interactions, and full extraction mining. The LaModel simulations will be described first to discuss the purely vertical loading evaluation of the four panels. Unlike the LaModel simulations, Phase 2 incorporates horizontal stress and strain while limiting the model to two-dimensional space.

4.1. LaModel analysis

The widely used boundary element program, LaModel was used to simulate the vertical stresses and displacements experienced during both development and retreat mining of the L6-L3 panels [3]. To incorporate as much of the mining district as possible, the three seams were discretized using 1.5 m elements and the overburden was discretized using 15.2 m elements. This resulted in seam grids of 1380 × 1600 elements and an overburden grid extending 305 m beyond the mine grid.

4.1.1. Input parameters—The critical input parameters for calculating accurate stresses and pillar loads are the overburden stiffness, gob stiffness, and coal strength [4]. To accentuate the multiple-seam stresses in this particular model, the rock mass modulus and lamination thickness were kept at the default 20.7 GPa and 15.2 m values, respectively [5]. The gob stiffness for each panel was calibrated independently such that the average gob stress matches that of the empirically suggested 21° abutment angle as used in the ALPS and ARMPS programs [6,7]. Finally, the default 6.2 MPa insitu coal strength was used along with the Mark-Bieniawski pillar strength formula to create the coal seam material properties. Elastic-plastic coal materials were chosen because pillar failure was not explicitly being simulated [8].

4.1.2. Development mining stresses—Prior to mining, the panels of interest are located in a state of decreased in situ stress which is defined by the overlying gob characteristics (stiffness) and the overburden load applied to them. The average overburden stress and in situ (pre-development) stress across the AA cross section for each panel can be seen in Fig. 11. Panel L6 was initially driven on 25.9 m centers when problems were encountered. The #4 and #5 entries of panels L5-L3 were mined on 19.8 m centers reducing the panel width by 9.1 m, and consequently the vertical stress on the right half of the panel [1,2]. The L3 panel is not only deeper, but is also only overmined in one seam, resulting in higher vertical in situ stress on the active seam when compared to panels L4 and L5.

The development loading experienced by the pillars as each successive panel is mined, as is depicted in Fig. 12. One can observe that the total vertical stress on the developed workings is elevated in areas under the overlying barrier pillars, which is widely published and accepted. However, the focus of this paper is the conditions encountered under the overlying stress shadow. Total vertical stresses simulated on the pillars in this region range from less than 3.45 MPa (the white areas) to stresses of as much as 6.9 MPa in the L3 Panel and 10.34 MPa in the widened portion of the L6 panel.

Retreat mining of the L3 panel was also simulated in the area of the instrumentation site at the mid-pillar location between crosscuts 12 and 13. A comparison with the single-seam case, calibrated using the LaModel deep cover pillar retreat calibration technique, is seen in Fig. 13 [9].

The total vertical stress distributions across the pillar line at crosscut 13 for the multiple-seam case show a steep increase in stress along the front abutment that dissipates rapidly as the instrumentation location is neared. This is equivalent to an abutment extent of about 15.2 m and closely relates to the timing of increased load on the roof bolts and associated roof sag. In contrast, the single-seam case simulates a much smoother transfer of the abutment stresses and results in an abutment extent of about 61 m (two pillar rows) near the center of the panel. As expected, both the magnitude of the stresses and the abutment extent for the single-seam model are drastically larger than those observed in the L3 panel both on development and during retreat.

4.2. Phase2 stress analysis

In order to determine the total stress distribution induced by overburden and multiple-seam stress conditions, the Phase 2 numerical model that was previously used by Tulu et al. [10]. It was updated to improve the estimate of the horizontal stress due to tectonic loading and the depth across the four R & P retreat panels [11]. The analysis was conducted by modeling different cross sections across the panels, capturing the topographic effect of the mountains and a stream valley. The model simulated vertical stress due to gravity, and the tectonic stress was modeled with the locked-in stress option in the Phase 2 model. The updated model results in in situ horizontal stresses and K-ratios that are consistent with expectations based on stress measurements in the Appalachian coal region [1,10]. The multi-seam effect caused by the full extraction of the panels in the overlying Darby and Owl coal beds as modeled prior to entry development in the Kellioka seam. The gob in the Owl and Darby panels was modeled as a soft material that attracted loads similar to what would be predicted by an abutment angle of 21°. The elastic modulus of each gob is calibrated separately to give the expected 21° abutment angle loading. Heights of the gobs in the Owl and Darby panels were selected as 4.6 and 6.1 m based on the experience at the mine.

4.2.1. Horizontal and vertical stresses—The average horizontal stress, vertical stress, and strength factors for the as-mined location of each of the entries in the Kellioka Seam were queried from the Phase 2 model and are presented in Table 1. Model results indicate that for all panels, stress concentration around the entries between #5 and #1 were destressed (Fig. 14). Since the #5 entries of panels 3, 4, and 5 were shifted 9.1 m to the east of the planned position, the strength factors for these entries are higher than the corresponding #1 entries. The #5 entry of the L6 panel has a lower strength factor than the #1 entry of the same panel.

5. Discussion

Visual observations throughout these studies have provided the most insight into the actual conditions, causes, and potential mitigation techniques. The instrumentation and numerical modeling efforts provided significant support to the results of these visual observations. The LaModel results showed that there was a significant reduction in development load, front abutment load, and front abutment extent in comparison to a panel without the overlying gob. This was apparent in the lack of stress-related rib deformation across all of the observed panels and was confirmed with the instrumentation measurements in the L3 panel.

Similar results were produced using Phase 2, where emphasis was placed on modeling the horizontal stress impact on the outside entries of the L3 panel. This horizontal stress orientation was apparent in the roof and floor deformation observed in these entries as well as the prevalence for cutter formation along the inside rib. This horizontal stress field is the primary cause of the poor conditions experienced in the #5 entry throughout this mining district as previously ascertained [1,2]. The effect of the topographical relief on the stresses across the panels continues to be evident; however it is less pronounced that it was in panel L6. This is most likely due to the applied mitigation technique of shifting the #4 and #5 entries as well as a general smoothing of the topographic stress as the panels get deeper.

The conditions observed along each entry showed considerable variability even though the predicted stresses were very consistent along the length of the panel. This implies that the geology encountered plays a significant role in the stability of the mine openings. This mechanism is best described as a stress-driven, geologically constrained failure. That is, the observed roof deterioration is caused by the encountered stress field, but failure of the roof beam is limited to areas of substandard geology. Roof deterioration in this area of the mine was mostly constrained by the proximity of the rider seam and the prevalence of a joint set running roughly perpendicular to the mined headings. Generally speaking, as mining progressed from the L6 panel to the L3 panel, the depth of cover increased, the interburden thickness decreased, the distance to the rider seam decreased, and the strength of the immediate roof decreased.

The instrumentation study was initially designed to provide some insight into the interaction of primary and secondary support. Due to the fact that the initiation of the loading on the superbolts and the associated roof sag occurred just prior to the removal of the data loggers, there is limited data available to assess these interactions. In addition, the relative strength of the roof strata in the vicinity of the instrumentation in combination with reduced abutment extent and stress did not provide an adequate test of the roof support in this entry prior to gob formation.

6. Conclusions

Based on the results of this study, the following four factors appear to be significant and should be considered during R & P retreat mine planning and execution:

1. Topographic relief across panels can lead to very different conditions than those associated with relatively flat overburden.
2. An overlying gob can relieve a large portion of the overburden pressure, as evidenced from the four panels observed.
3. As the entries get closer to the overlying gob solid boundary, the entries appear to encounter higher stresses leading to more roof and rib deterioration.
4. Geological changes in the immediate roof can significantly affect the condition of the entries resulting in stress-driven, geologically constrained failure.

Furthermore, based on the study outcomes and discussions with mine operators, successful retreat mining in increasingly difficult ground conditions requires a three-phased approach. Planning, evaluation, and monitoring should be conducted throughout the mining cycle. The approach to each phase is a mine-specific and evolving process subject to change based on prevailing conditions, changes in mining techniques, or changes in the geology from one area of the mine to another. To date, the majority of research and design recommendations fall into the planning phase where pillar design is a factor of importance. However, relatively little exists in the form of guidelines for the evaluation and monitoring phases (MSHA “Roof Control Plan Approval and Review Procedures”).

The planning phase should rely heavily on sound engineering design procedures. These procedures should evaluate the expected loading, displacement, and timing of the planned mining. Factors of importance include: pillar design, panel layout, depth of cover, topographic relief, roof support design, the potential for multiple-seam influence, and geologic setting. Numerous techniques for pillar design, roof support design, and rock mass classification have been developed to assist in this type of mine planning. Pillar design programs such as ARMPS, AMSS, and LaModel based on the Mark-Bieniawski pillar strength formula have gained nearly industry-wide acceptance. Other techniques such as those used by Salamon and Munro, Obert and Duvall, Wilson, Baron and others have seen usage in the US and abroad [11]. Roof support design techniques such as ARBS, STOP, reinforcement density index (RDI), tensioned bolt design charts, suspension calculations, and numerical models such as FLAC when combined with past experiences have been used with varying degrees of success. The coal mine roof rating (CMRR) was developed from several rock mass classification systems (RQD, RMR, URCS, Q, etc.) and provides a quantitative method to identify geologic factors affecting the quality of the mine roof [12]. The CMRR is the most widely used rock mass classification system in US coal mines and can be incorporated in all three design analyses.

The evaluation phase should be conducted prior to retreat mining and rely more heavily on assessment of the prevailing conditions of the area(s) to be mined. This pre-retreat mining evaluation phase should assess the amount of loading, deterioration, and deformation on the roof, rib, floor, and installed supports that have occurred due to development, multiple-seam, and abutment loadings. A re-evaluation of the pillar design should be completed if the as-mined input parameters differ from those used in the planning phase. The prevailing geologic setting, transition zones, and geologic anomalies that are encountered can be assessed at any time during development. Common geologic considerations include: joints and fractures, faults, seam rolls due to differential compaction from sand channels, rider seams, slickensides, location of strong and/or weak beds in the roof, ground water inflow, etc. Logically, focus should be applied to those conditions, which have caused problems in the past as well as those which are rarely encountered. At this point, a judgement must be made on the appropriate course of action such as increased monitoring, installation of additional support, or leaving a partial pillar or pillars or the entire pillar or pillars.

The monitoring phase should be conducted during retreat mining and should rely on observation and evaluation of the change in conditions as retreat mining progresses. Increased monitoring of ground conditions on the working section should be considered with emphasis on increased roof, rib, and floor deformations and excessive support loading. Additional consideration should be placed on conditions that are unexpected or differ significantly from those encountered in prior experience, particularly in areas identified with potential hazards prior to retreat mining. Again, as conditions dictate, the final decision to continue monitoring, install additional support, or leave a partial or entire pillar or pillars can be made.

Research efforts moving forward can probably have a more significant effect on the safety of miners if they focus on the monitoring phase of the hazard assessment using methods similar to those implemented in Australia. What type, frequency, and detail of evaluations would provide the most valuable assessment of potential failures that may lead to injuries and fatalities in underground coal mines? What skills are necessary and who would be responsible for performing those hazard assessments? These are two fundamental questions whose answers would improve the safety of underground coal miners.

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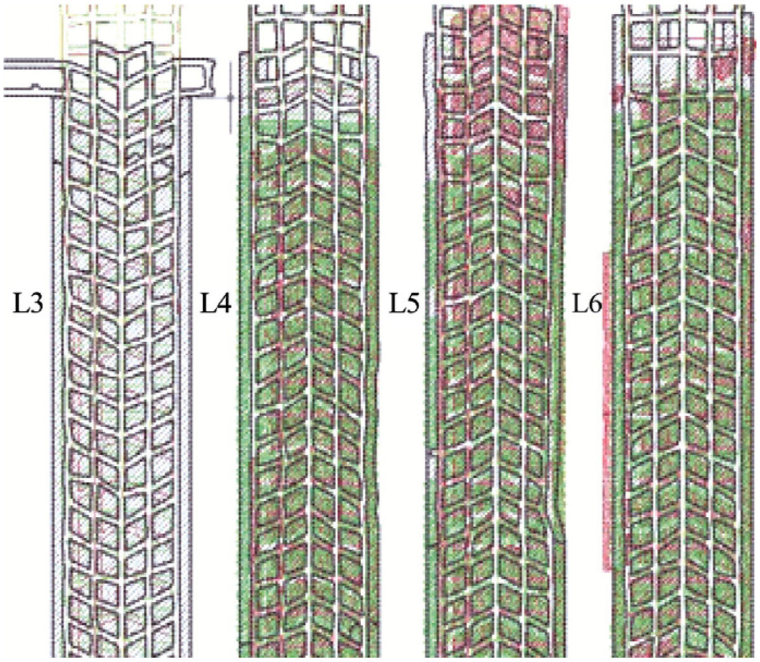

Fig. 1.

General layout of the panels in the area of interest (showing previous mining above the current seam).

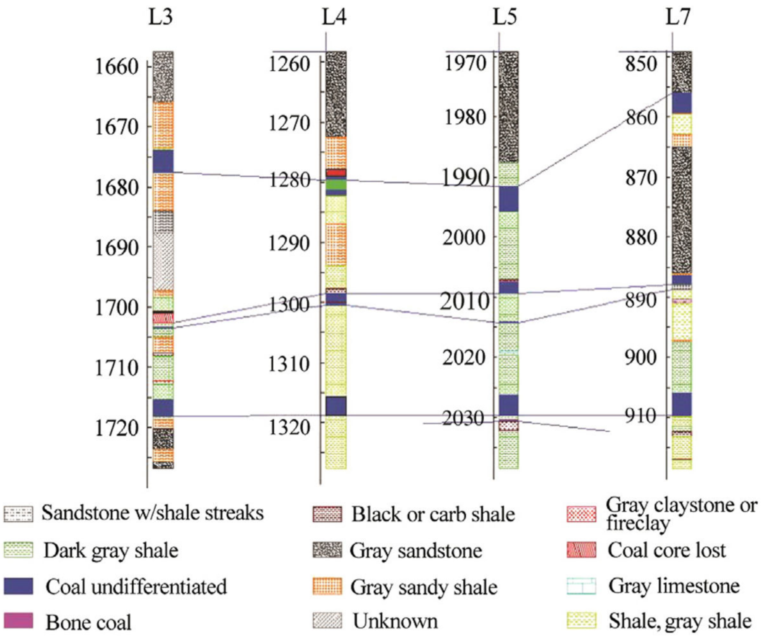

Fig. 2.

Geological core logs from the L7 to L3 panel area, showing significant changes in the immediate roof, floor, and interburden strata at the mine.

Fig. 3.
Entry #4 panel L3 exhibiting good conditions, common to all panels observed.

Fig. 4.

Entry #5 panel L3 showing heavily cribbed area due to roof deterioration, pillar spalling, and floor heave, common to all panels observed.

Fig. 5.

Entry #1 panel L3 exhibiting poor conditions: floor heave, minor pillar spalling, and cutter roof.

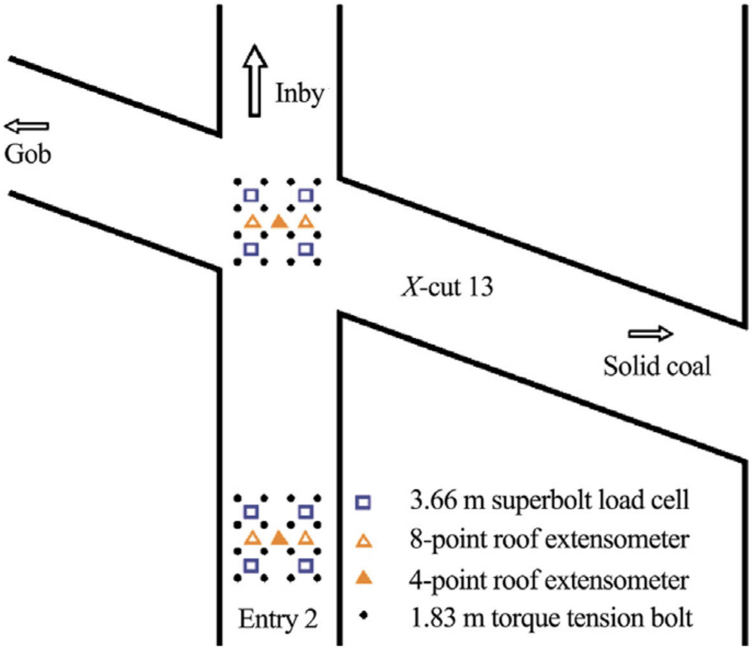

Fig. 6.

Instrumentation site showing location of roof extensometers and load cells.

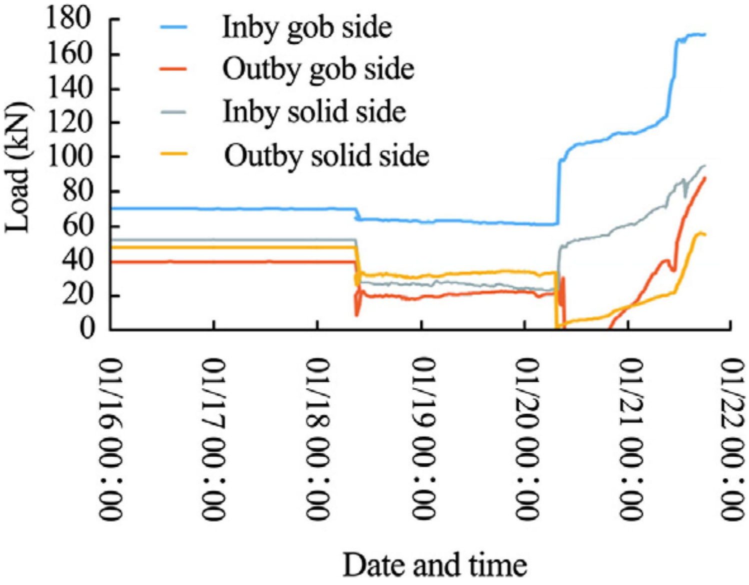

Fig. 7.

Superbolt loading response to R & P retreat.

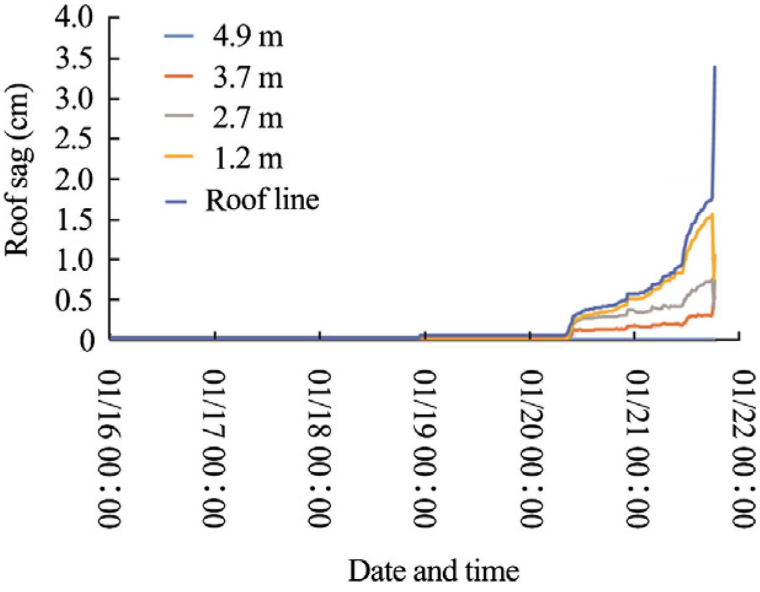

Fig. 8.
4.9 m extensometer data in response to R & P retreat mining.

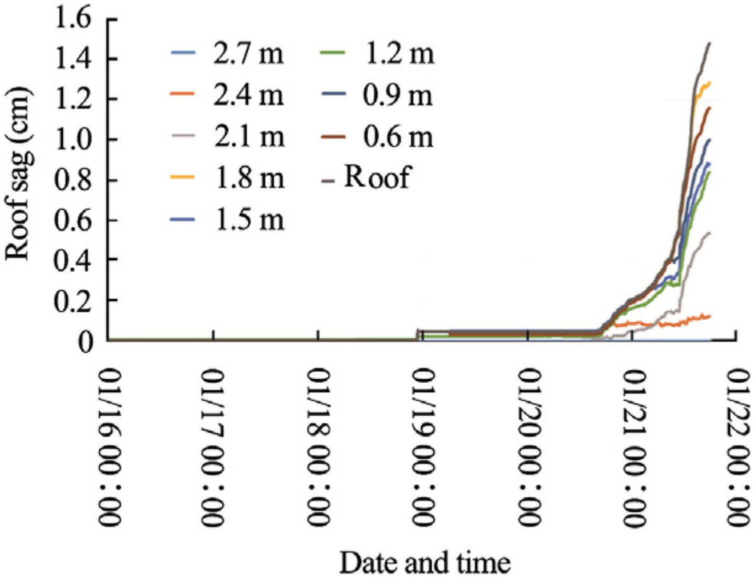

Fig. 9.
2.7 m gob side roof extensometer reading in response to R & P retreat mining.

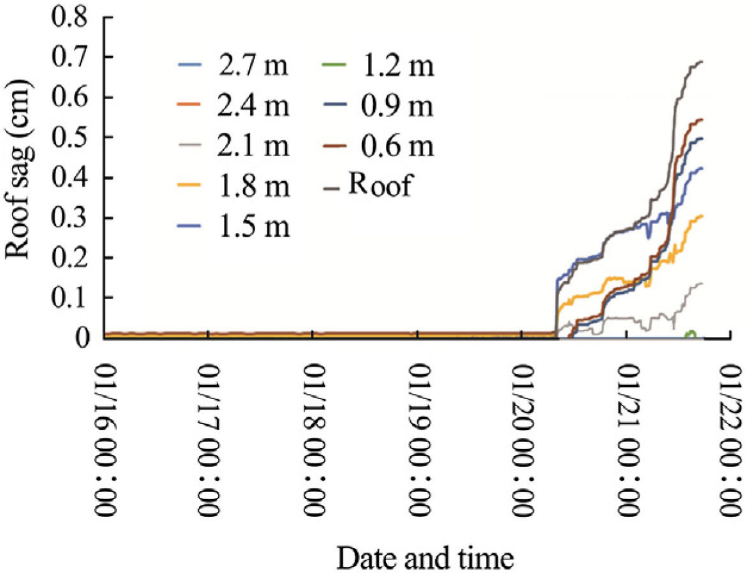

Fig. 10.
2.7 m solid side roof extensometer reading in response to R & P retreat mining.

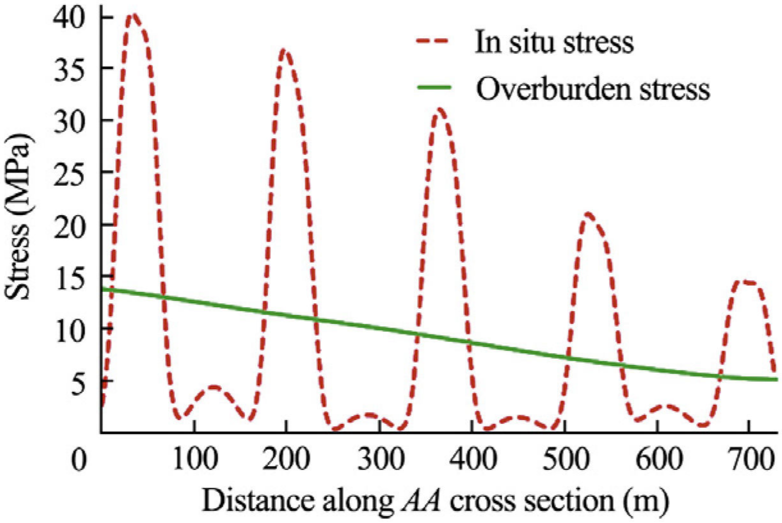

Fig. 11.

Insitu and overburden stress simulated for the Kellioka Seam.

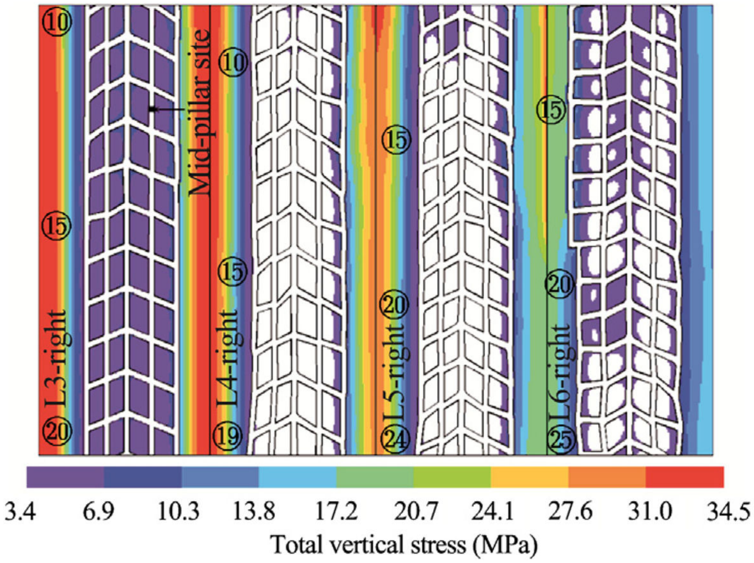

Fig. 12.

Total vertical stress for panels L6-L3 under development loads.

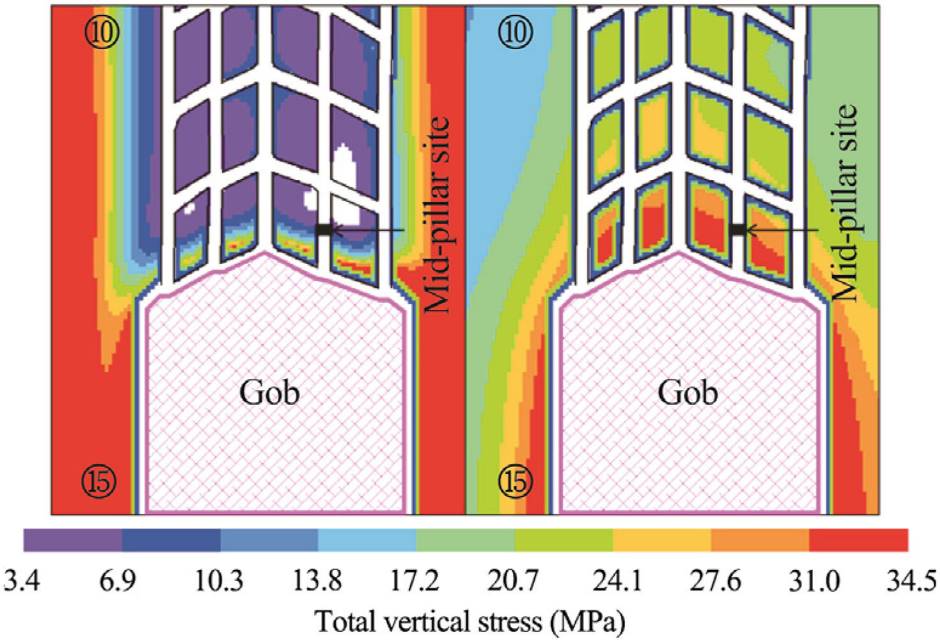

Fig. 13.

Total vertical stress during retreat near the instrument location for the multi-seam (left) and single-seam (right) cases.

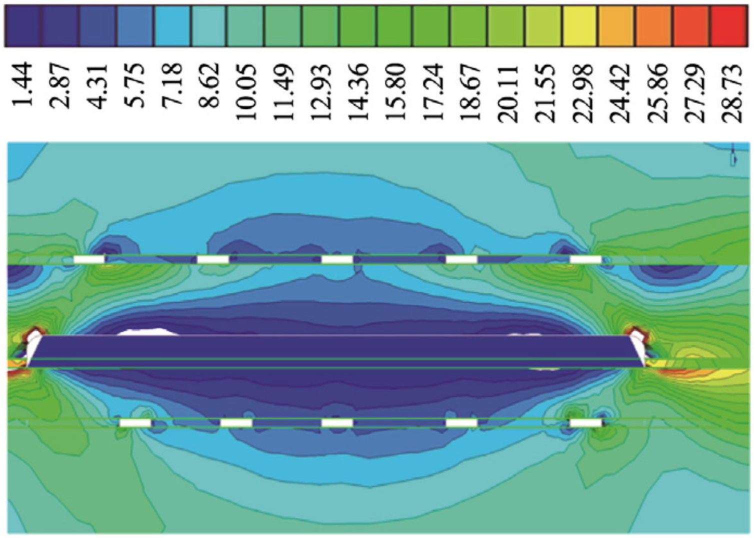

Fig. 14.

Phase 2 model results showing stress redistribution around the overlying gobs and panels developed in the Kellioka seam.

Table 1

Horizontal stress, vertical stress, and strength factor for entries 1, 3, and 5 for panels L6 through L3.

Panel	Entry	Sigma *XX* (MPa)	Sigma *ZZ* (MPa)	Strength factor
6	1	11.05	4.84	2.64
	3	8.86	3.52	3.55
	5	12.29	6.23	2.22
5	1	10.85	5.07	2.34
	3	7.83	3.04	3.77
	5	10.70	4.13	2.39
4	1	10.56	4.41	2.14
	3	6.18	2.80	5.04
	5	9.80	3.33	2.41
3	1	10.10	5.16	1.83
	3	3.80	2.61	12.68
	5	7.72	3.05	2.80