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Design concerns of room and pillar retreat panels

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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.

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

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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.

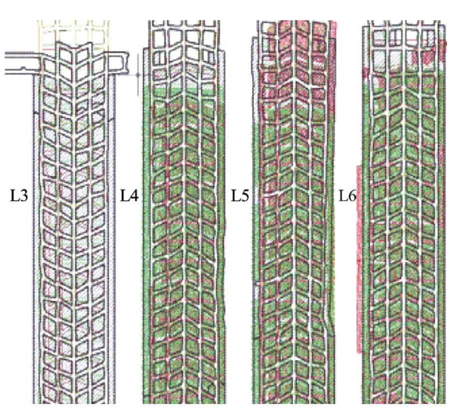

Fig. 1. General layout of the panels in the area of interest (showing previous mining above the current seam).

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.

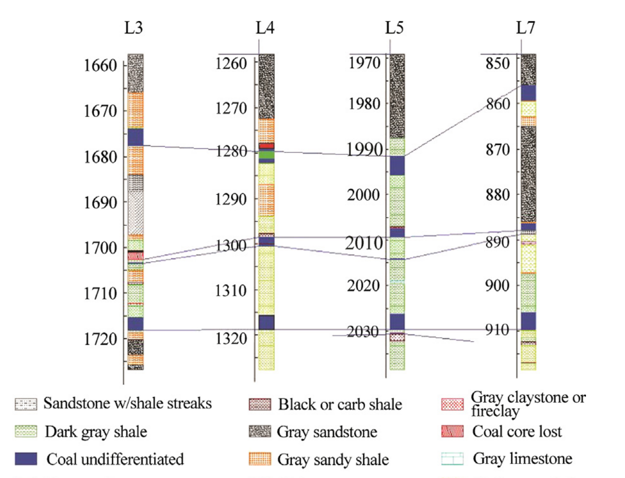

Fig. 2. Geological core logs from the L7 to L3 panel area, showing significant changes in the immediate roof, floor, and interburden strata at the mine.