

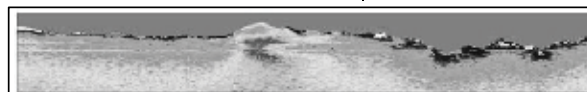
nodes. Figure 10 illustrates safety factor distributions that follow after application of gravity forces, cutting to the present surface topography and then mining all longwall panels and the main entries and crosscuts. The color bar at the top of the figure indicates element safety factor values. Three elements span entries and crosscuts of 7m (21 ft) and seven elements span square pillars 21x21 m (70x70 ft). Black elements are yielding; grey elements are mined. The speckled pattern is a consequence of statistical and associated spatial variability in strata properties. These results suggest there was some difficulty in driving the mains. Width of the barrier pillars 150 m (450 ft) appears just adequate in view of the many yielding elements scattered through the barrier pillars, especially near mid-length of the mined panels.

Some details are shown in an expanded view in Figure 11(A) where three coal seams are visible. Only the left half of the section is shown extending from the mined panel to the center of the five main entries. Variability is again plainly evident as are streaks of yielding elements in the overlying coal seams. The floor shows considerable yielding at the left edge of the mined panel. (The sharp change in contouring is caused by a change in stratigraphic units.) Importantly, about one-third of the barrier pillars show yielding adjacent to mined panels (P12 on the north side and P13 on the south side).

Figure 11(B) is a much earlier two-dimensional view obtained using laboratory values of rock properties with no joint effects (1, 2, 3). This view is optimistic in the sense that lower moduli and strengths as expected in the mine would lead to more yielding as is quite evident in Figure 11(A). However, this view also shows significant barrier pillar yielding, too.



(a) Plan view of the big mesh shows element safety factors at mine level. Edge length is about 16 km (10 miles)



(b) Vertical west to east section through the big mesh center. Red area is through the center of mining and main entries. Width is about 10 miles; height is about 2.4 km (1.5 miles)



(c) Vertical south to north section through the big mesh center. Panels 13-18 are left; mains are in the center red zone, and Panels 7-12 are to the right. Black elements are yielding. Width is about 16 km (10 miles); height is about 2.4 km (1.5 miles).



(d) Close-up near the main entries with mined panels 13-18 and 7-12 left and right. Close-up width is about 8 km (5 miles). The black outline indicates location of the dual "small" mesh cross-section with a width of about 0.7 km (0.4 miles.)

**Figure 9.** Element safety factor distributions in various sections of the CCM whole mine "big" mesh.

As mining progresses with development of entries and pillars in the north barrier pillar and subsequent retreat mining in this barrier pillar, the extent of yielding increases as shown in Figure 12 in a south to north cross-section through the mid-length of panels along side the main entries and outside the barrier pillars. Again, the speckling is associated with variable strata properties and breaks in color patterns occurs at strata interfaces. Eventually all the coal in the section is yielding including the overlying two seams. The yellow zone above and below the mains indicates a safety factor of about 2 that steadily decreases as mining progresses to a red and pink indicating safety factors less than 1.6. As mining progresses there is considerable floor heave indicated near the outer edges of the barrier pillars. Not shown in the plot window of the figure is progression of yielding elements in the remote roof.

The trend in the data is consistent with the fact that mining six longwall panels north and south of the main entries and barriers and subsequent development of entries in the barrier pillars leads to a high overall extraction percentage (roughly 90%). Overburden weight is then concentrated on what little coal remains unmined unless complete closure or caving occurs in adjacent mined panels, which seems likely (6,7).