

Impact of Longwall Width on Overburden Behaviour

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ABSTRACT

The longwall panels at Clarence Colliery have experienced intermittent sudden weightings on the face that have caused some production delays. These weightings have typically been more severe on the wider faces. A program of surface subsidence and extensometer monitoring was undertaken above Longwalls 4 and 5 to investigate the behaviour of the overburden strata during longwall extraction on two faces of different widths.

The monitoring indicated that a dome shaped zone of large downward movement extends up into the overburden strata to a height equal to about the panel width.

A major strata unit between 50 m and 70 m above the coal seam influences the behaviour of the overburden strata and may be a factor in the observed sudden loading of longwall face supports. Downward movement of this major unit appears to concentrate on vertical fractures. Increased loading on the face supports could then be expected. The downward movement of this major unit appears to be more significant in the overburden behaviour above the 200 m wide longwall compared to the 160 m wide longwall face.

INTRODUCTION

The longwall panels at Clarence Colliery have experienced sudden weightings on the face that have contributed to production delays. The relationship between overburden caving behaviour and longwall panel width is thought to be a contributing factor to these face weightings. To investigate this relationship more fully, a program of monitoring overburden displacements was undertaken over two longwall panels of different widths using extensometers installed and monitored from the surface (Mills and Gale 1997). This paper describes the results of that monitoring.

BACKGROUND

Clarence Colliery mines the Katoomba seam, the uppermost seam in the sequence. The immediate overburden strata comprises a sequence of competent interbedded fine grained sandstones and siltstones with some weaker coarse grained sandstones. A major sandstone unit occurs at about 25 m above the seam with another major unit some 50-70 m above the seam. The sandstones in each unit are generally massive and free from bedding.

The Clarence lease area has a number of major faults that are generally oriented NNE-SSW. Major joints in the roof are sub-parallel to these faults. There is a conjugate joint set at right angles to the main set. The longwall face orientation is normally 330°. The major joint set orientation is generally 315° to 320° but joint set orientation can vary to become parallel to the face. Both the major and conjugate joint sets are typically vertical and of a smooth planar nature. Clay infilling is common.

Fig. 1 shows the location of the four surface extensometers and two subsidence lines over Longwalls 4 and 5. The first extensometer was installed in the centre of Longwall 4 and was monitored during retreat of both panels. Three more extensometers were installed over Longwall 5 on the same cross-section, one in the centre of the panel and the other two offset 65 m toward each gateroad. Subsidence measurements were made on two cross-lines over Longwalls 4 and 5.

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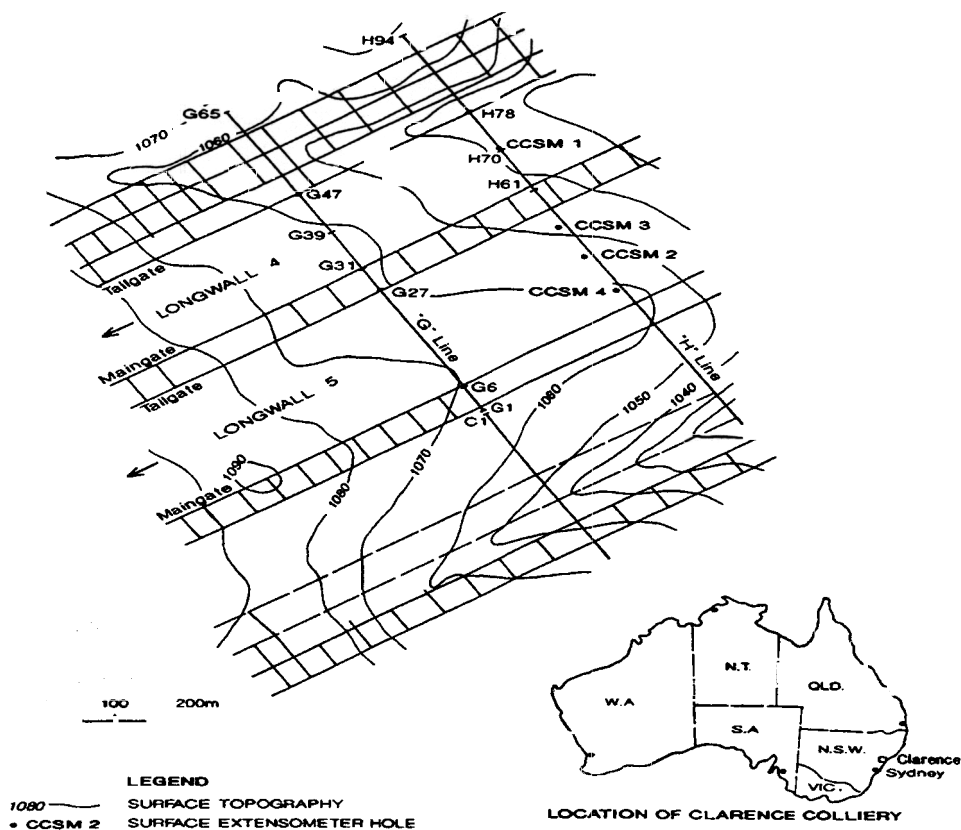


Fig. 1 - Location of monitoring boreholes and subsidence lines at Clarence Colliery

In the vicinity of the extensometers, the Katoomba Seam is 3.6-3.8 m thick and essentially level. The depth of overburden changes as a result of gently rising surface topography from approximately 240 m at the centreline of Longwall 4 to just over 260 m above Longwall 5. Longwall 4 is 160 m wide. Longwall 5 is 200 m wide.

Surface extensometers

Each of the four extensometers had ten anchors located at intervals down the hole, the anchors being more closely spaced near the seam. The uppermost anchor is located at 40 m below the surface. The deepest anchor is located as near to the bottom of the hole as possible. In most cases the deepest anchor was positioned approximately 20 m above the Katoomba Seam.

Fig. 2 shows the surface assembly of the Longwall 4 extensometer with the extensometer head elevated and the cover removed. The three other extensometers were of similar design. Each wire (seen leading into the collar of the hole) is connected to a downhole anchor.

A tension pulley assembly maintains a constant tension on each wire. The tension pulley diameter is calibrated so that one turn equals a set displacement (0.2 m or 0.3 m). Electrical resistance potentiometers register the number of turns on each tension pulley. The extension on each wire is directly related to the resistance registered by the potentiometer. At Clarence, the extensometers were logged using a battery powered electronic datalogger located in a nearby weatherproof container.

Surveying of the holes showed some deviation of the holes from vertical. This deviation was taken into account when analysing the results.



Fig. 2 - Extensometer head assembly, Longwall 4, Clarence Colliery

RESULTS

The total movement of the extensometer anchors is the sum of the downhole extension plus the subsidence at the headframe. The vertical subsidence has been added to the downhole extension to give the total displacement of each anchor.

The extensometer on the centreline of Longwall 4 subsided 73 mm during mining of Longwall 4. A further 112 mm occurred during mining of Longwall 5 giving a total of 185 mm. The extensometers at the centreline and on the tailgate side of Longwall 5 subsided 280 mm and 260 mm respectively. The maingate extensometer subsided 80 mm.

Longwall 4 extensometer

Fig. 3 shows the results from the Longwall 4 extensometer. The vertical displacement of each anchor is plotted against depth for various positions of the longwall face.

Downward displacements were first detected on the bottom anchor (23 m above the coal roof) when the longwall face was approximately 15 m past the bottom of the hole.

For the next 15-20 m of longwall retreat most of the movements continued to occur within the first 40 m of overburden strata. During this period, the horizon 40 m above the coal seam moved down only 50 mm, while the bottom anchor moved down 1.2 m.

When the longwall was 44 m past the hole, the face remained stationary for a period of approximately 24 hours. During this period, the first 40-50 m of overburden strata moved downward more or less "en masse" with most of the separation occurring above the 40 m horizon. The bottom anchor displaced a further 300 mm to 1.5 m and the 40 m horizon moved downward 270 mm.

As mining proceeded, downward movements continued to increase in magnitude and progressed higher into the overburden sequence.

When mining was 220 m past the hole, the top 40 m or so of the overburden strata remained essentially unaffected by sub-surface movements. This top 40 m bridged across the panel without significant cracking or vertical dilation. The only deformation was a small amount of downward sag deflection.

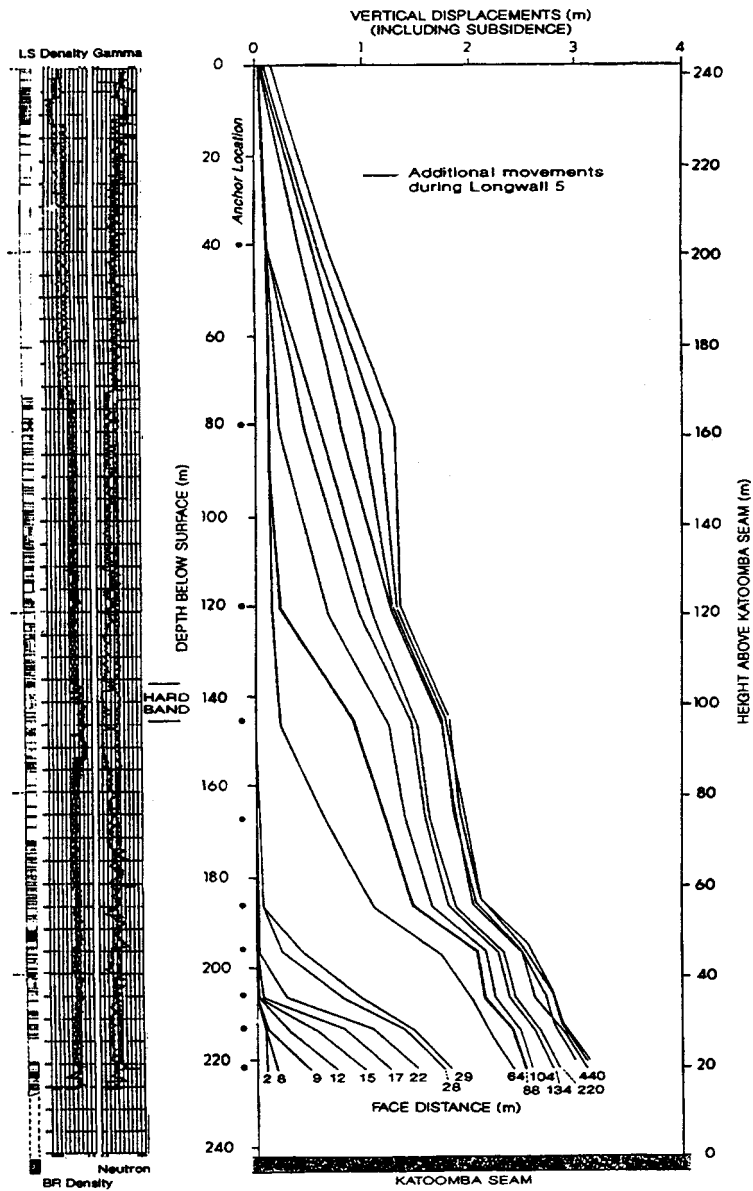


Fig. 3 - Displacements measure on Longwall 4 extensometer at Clarence Colliery

By the completion of the panel, the 40 m anchor had moved down some 0.55 m while the surface had still subsided less than 80 mm. The unit bridging across the panel at this stage was less than 40 m thick in the centre of the panel.

Fig. 4 shows contours of downward displacements plotted against face advance. The axes are at the same scale so angles are preserved.

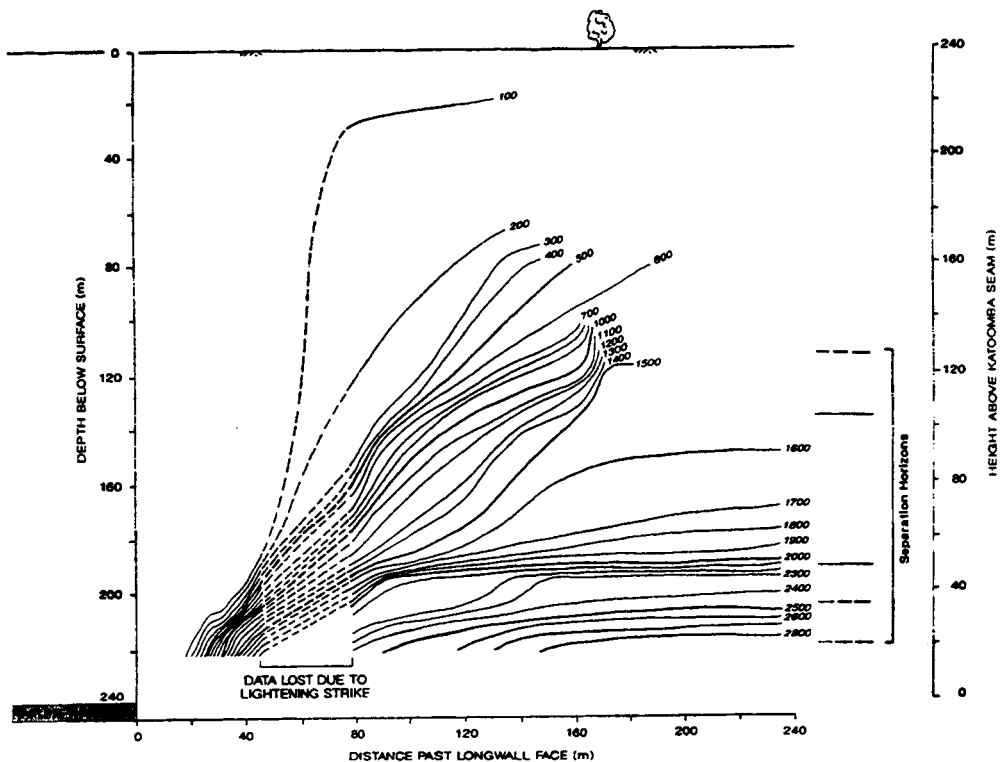


Fig.4 – Longwall 4 extensometer displacement contours versus face advance at Clarence Colliery

There was essentially no movement in the overburden strata ahead of the face. Behind the face (ie: toward the goaf), there was a zone of relatively small movements (20-100 mm) that extended upward initially at an angle of approximately 40° from vertical to 50 m into the goaf and then at a steeper angle to almost reach the surface.

The 200 mm contour represents the line below which downward movements accelerate rapidly. The transition between relatively small displacements (<200 mm) and much larger displacements occurs within a relatively narrow zone. The 1 m displacement contour angles up behind the face at approximately 50° to the horizontal and the 2 m contour at 60° to the horizontal.

By the time that the face was 160-180 m past the extensometer, most of the major movements had occurred in the lower overburden strata as indicated by the flattening out of the displacement contours in Fig. 4. Additional movements occurred mainly in the top 80 m of overburden. These additional movements occurred over an extended period.

The extracted void width of the longwall was 160 m. It would be anticipated, based on geometry alone, that most of the overburden movements would be complete by the time that the face had advanced half the panel width past the site. However, downward displacements continued to occur well after the longwall had passed indicating a dynamic component of movement in addition to the geometry related component.

During mining of Longwall 5, the extensometer at the centre of Longwall 4 showed downward movement of 100 mm. Movement occurred more or less uniformly throughout the full overburden section. This movement is consistent with elastic compression of the chain pillar between Longwalls 4 and 5 causing general lowering of the overburden strata on one side of the panel.

Longwall 5 extensometers

Fig. 5 shows the downward displacements measured on each of the Longwall 5 extensometers.

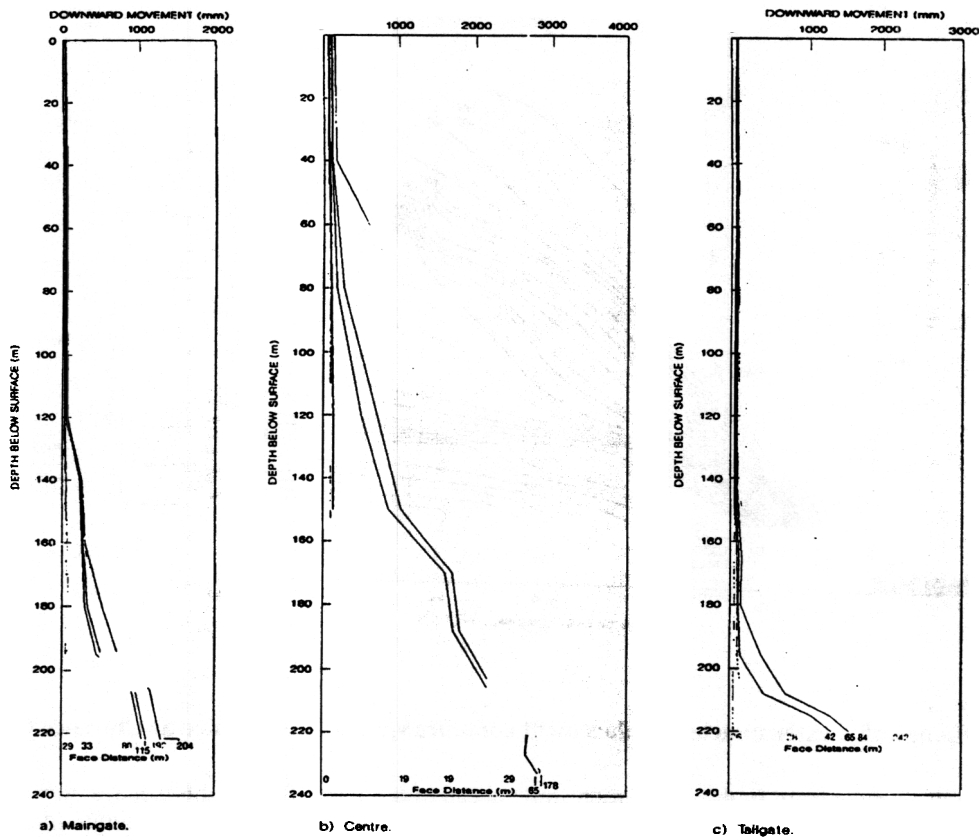


Fig. 5 - Longwall 5 extensometers – displacement versus depth at Clarence Colliery

The first movement detected on the bottom anchor of the centre extensometer (23 m above the seam) occurred when the longwall face was some 10-15 m past the extensometer. Thereafter, there was an upward progression of displacements similar to that observed in Longwall 4. The progression observed was cyclical. Initial movements were concentrated below a series of parting horizons. The magnitude of movement below each horizon continued to increase until a point when there was downward movement “en masse”. At some stage during the latter stages of this process, a new separation horizon developed higher up in the sequence and the cycle was repeated.

As the cycle progressed higher into the overburden, material lower down was recompressed. The permanent dilation after recompression was of the order of 1 m in 50 m or 2%.

The longwall panels were not wide enough for large downward movements to extend through to the surface. The upper 40 m or so of overburden strata bridged across the panel. The downward subsidence in the centre of the panel was 185 mm when the longwall face was 250 m past. Approximately half of this subsidence was associated with elastic compression of the chain pillar between Longwalls 4 and 5 and the immediate roof and floor strata. The remaining 80-90 mm was associated with downward sag deflection of the overburden.

The displacement mechanism indicated by the maingate and tailgate extensometers is similar to the early stages of movement on the centre extensometer. The height to which downward movement occurred at the maingate and tailgate extensometers was lower than in the centre of the panel. In the centre of the panel, large displacements extended upward some 220 m above the seam to within about 40 m of the surface. At the maingate and tailgate extensometer locations, large displacements only extended upward 130 m and 100 m respectively.

The extensometers indicate movements on the maingate side of the panel are larger and extend higher into the roof strata than on the tailgate side of the panel. It appears as though a separation horizon at 130 m above the seam was mobilised on the maingate side of the panel whereas on the tailgate side of the panel, the separation was concentrated at 90 m above the seam.

A zone of recompression occurred in the centre of the panel in the lower 80 m or so of overburden strata. This recompression zone was not apparent at the location of the other two extensometers.

Fig. 6 shows the contours of downward displacement measured on the central Longwall 5 extensometer. This plot indicates that:

- there is effectively no downward movement in the overburden strata ahead of the face;
- the zone of large downward movements occurs below a line that extends at approximately 35° behind the face;
- the overburden strata moves down in blocks that are defined by discrete separation horizons; and
- the major separation horizons appear to be common to both longwall panels.

Longwall 5 centre extensometer displacement contours versus face advance at Clarence Colliery

Immediately below the 200 mm contour, the rate of ground separation increases rapidly as indicated by the close spacing of the 500 mm and 1 m contours.

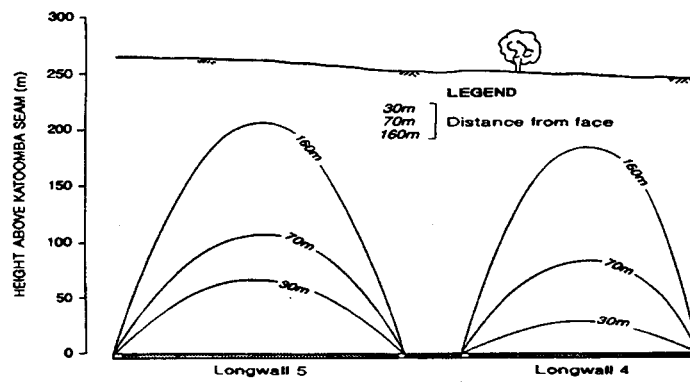
The overburden strata appears to have moved downward in discrete blocks. A block between 50 m and 90 m above the seam moved downward more or less uniformly throughout its full section. The first major downward movement of the block occurred at about 40 m behind the face. At this point, the 500 mm and 1 m contours are near vertical indicating a zone of large shear displacement on a near vertical fracture surface.

The concentrated downward movement on a single vertical fracture surface is consistent with the history of periodic weighting on the face supports particularly on the wider longwall faces. Downward movements of 1 m in a 30-50 m thick unit located 60 m above the seam would be expected to cause additional loading on the face supports if it were to occur within close proximity to the face.

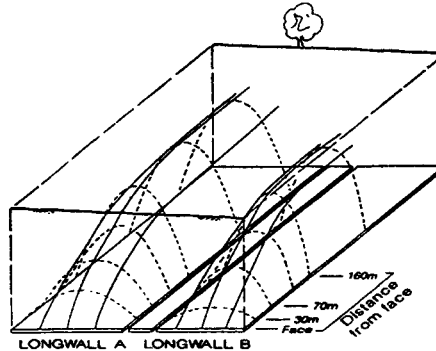
Three major separation horizons developed at 20 m, 50 m and 90 m above the seam. These horizons coincide with lithological boundaries in the otherwise relatively massive overburden strata.

Fig. 7 shows the zones of large downward displacement inferred from the extensometer measurements for various distances past the longwall face. The edges of this zone are somewhat arbitrarily defined because the downward movements decrease exponentially. For the purposes of discussion, the 200 mm contour has been assumed to represent the edge of this zone.

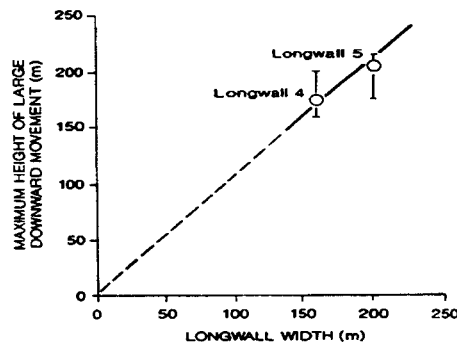
The zone of large displacement was essentially dome shaped above each extracted longwall panel. The sides of the zone were steeper than the front edge. The front edges extended back from the face over the goaf at about 35° from vertical. The sides extended upward from the chain pillars at approximately 20° from vertical.



a) Cross sections.



b) Schematic isometric of completed longwalls.



c) Relationship between longwall panel width and height of the zone of large downward movement.

Fig. 7 – Zones of large downward displacement above two Longwall panels of different widths at Clarence Colliery

The top of the zone of large displacements was some 1.0-1.1 times the panel width above the coal seam. For the 160 m wide longwall, the top of the zone was 170-180 m above the coal seam. For the 200 m wide longwall panel, the top of the zone was 200-210 m above the coal seam.

The zone of large displacements did not appear to fully develop until the longwall panel had retreated in excess of 160 m past the extensometer. The rate of development was similar for both longwall panels.

The top of the zone of downward movement appears to be a linear function of panel width for the lithological sequence at Clarence Colliery. The intersection of the top of this zone with the surface coincides with the point at which bridging of the overburden strata across the longwall panel ceases.

CONCLUSIONS

The surface extensometers over Longwalls 4 and 5 performed successfully and provide a detailed picture of how the overburden strata behaves during mining of two different width longwall panels.

Downward movements occurred in the overburden strata within a dome shaped zone above each extracted longwall panel.

The zone of movement extended through the overburden strata to a height of approximately 1.0-1.1 times the panel width. The height of movement was greatest in the centre of the panel decreasing on each side nearer to the chain pillars.

Movements within the overburden strata occurred as downward movements of discrete blocks. Separation was concentrated at horizons 20 m, 50 m, 100 m and 130 m above the coal seam.

A major unit between 50 m and 100 m above the coal seam appeared to influence the behaviour of the overburden strata. This unit may be a factor in the observed periodic loading of longwall face supports. Downward movement of this major unit was concentrated on a vertical fracture that appears to be a pre-existing joint.

The major unit between 50 m and 100 m above the coal seam appears to be a more significant factor in downward movement of the overburden strata for wider longwall panel.

REFERENCE

Mills K.W. and Gale W.J. 1997. "Overburden and Subsidence Monitoring – Longwalls 4 And 5 Clarence Colliery". SCT Report CLR1055.

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