LONGWALL MINING THROUGH FAULTS AT MORANBAH NORTH

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ABSTRACT: The coal mining industry has had to contend with the hazard of geological structure since earliest history. In recent years, there has been considerable success in mining through faults of less than seam displacement, generally consisting of relatively simple structures with a limited zone of influence. Generally, longwall mining through fault structures of greater than seam displacement has been less successful. At Moranbah North, recent experience has demonstrated that both large displacement and structurally complex faulting should not present a barrier to successful and economic development and longwall extraction.

Moranbah North operates its longwall mines in relatively weak strata with varying geological conditions. A fault zone consisting of a series of structures with a combined total displacement of up to 7.5m was mined through in Longwall Panels LW102, LW103, and LW04. Considerable production delays occurred in LW102 associated primarily with maingate end issues. Lessons from this experience have been incorporated in planning and operation to achieve successful mine throughs without significant production delays in LW103 and LW104. In LW103 and LW104, a detailed geological model was developed from surface to seam and in seam drilling and 3D seismic exploration. This also allowed development of an accurate 3D picture of the faulted areas in mid panel. Flight plans detailing the optimum cut horizons to maintain a practical grade, minimise total stone cut, and maintain roof coal beam thickness were incorporated into underground operational fault management plans. In addition to this, installed support was considerably upgraded to ensure stability.
Overall, the decision to mine through the fault in LW103 and LW104 has allowed substantial savings (compared to a longwall relocation around the fault) and minimised resource loss. The ability and confidence to mine through greater than seam displacement structures or zones of structure will continue to be of significant benefit to Moranbah North in maintaining high production output and cost effective resource recovery across the lease.

INTRODUCTION

Located in the Bowen Basin of central Queensland, Moranbah is 200km west of Mackay (Figure 1). Moranbah North is a modern, high capacity longwall mine, operated by Anglo Coal (Moranbah North Management) Pty Ltd and supplies premium quality high fluidity hard coking coal to the export steel market.

Moranbah North to date has mined out four longwall panels LW101 – LW104 shown Figure 2, varying in total length from 2.3 km (LW101) to 3.7 km (LW104). All longwall panels retreat up dip, mining from south to north. Coal is extracted from the Goonyella Middle Seam (GM seam), which varies in thickness from around 3.5m to 6.0m. Longwall extraction aims to maintain a minimum of 1.0m to 1.5m of coal in the immediate roof to maintain stability. Typical heights of extraction vary from 4.0m – 4.6m thick.

An extensional fault zone comprising normal displacement faults with combined displacements varying between 4m – 7.5m has been encountered and mined through in longwall blocks LW102 – LW104. Following a roof fall around the fault zone at the maingate end of LW102, subsequent maingate and tailgate ends have been comprehensively supported with a combination of secondary support (cable bolts, pre-tensioned long tendons, and steel sets.), shuttering and grout pumped false roof, and PUR injection from the maingate end. In addition, a detailed geological model was developed for LW103 and LW104, using surface, and in seam drilling, and 3D seismic exploration. This facilitated the implementation of:

[1] International Mining Consultants Pty Ltd
[2] Anglo Coal (Moranbah North Management) Pty Ltd
[3] Anglo Coal Australia Pty Ltd
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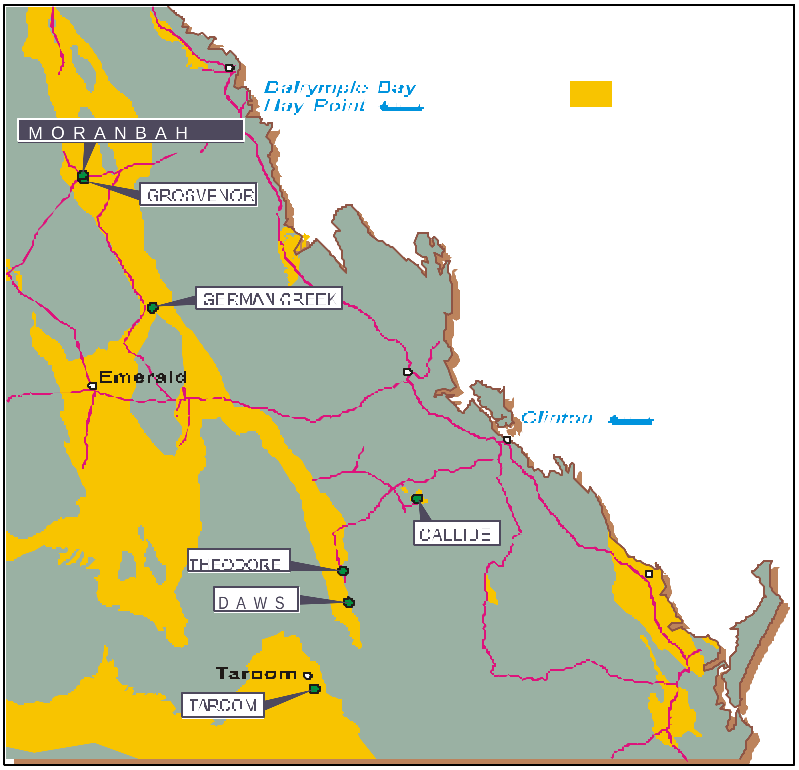

Fig 1 – Moranbah North Location Map

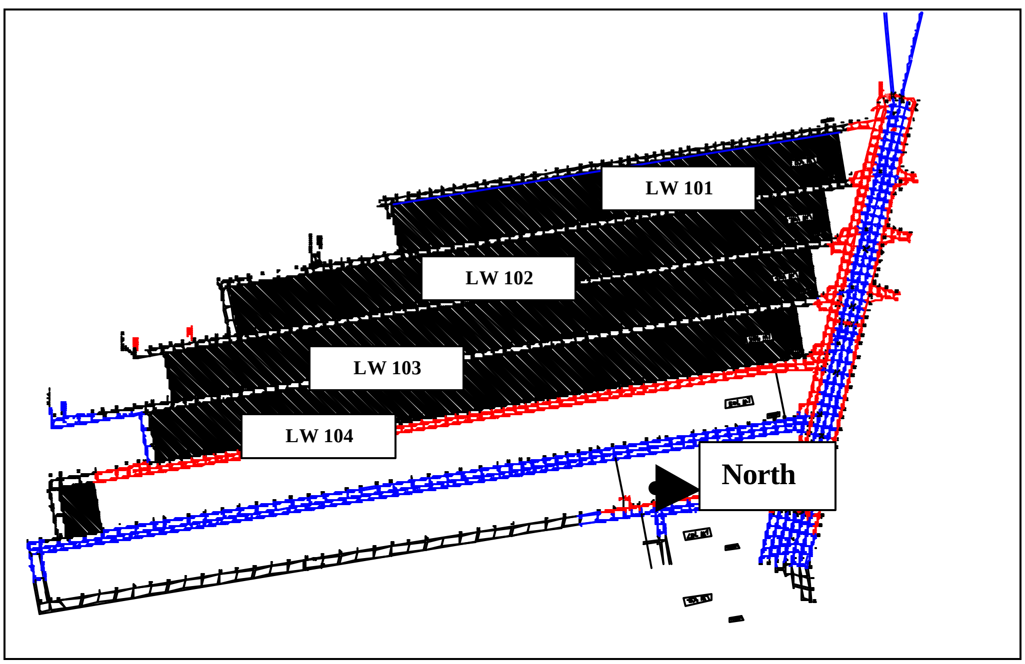

Fig 2 – Moranbah North 100's series longwall panels (101 – 104 shown hatched / longwalls extracted to date).

- Accurate positioning of seam drilling, spiling and pressurised microfine grout injection into the immediate roof of the planned extraction horizon.
- Accurate development of proposed longwall drivage sections (flight plans), detailing the optimum cut horizons to maintain a practical grade, minimise total stone cut, and maintain an adequate roof coal beam thickness; and
- Crew presentations and an operational underground Fault Management Plan, with associated triggers and responses, based on the operational, technical, and maintenance requirements for fault driveage.

This paper details the depth of up front technical and operational planning, and control required to achieve successful longwall retreat through significant (in excess of seam displacement) faulting in the GM seam.

A chronology of fault mine throughs is presented. Review of previous fault mine throughs in each case has allowed lessons to be learned and refinements to be incorporated into future fault mine throughs.

Above all, it is stressed that the successful fault mine throughs at Moranbah North have only been achieved through a collective team effort involving:

- Underground operators, emergency response zone (ERZ) controllers, Shift Managers, production staff and management at Moranbah North through implementing and complying with the Fault Management Plans and installation of required ground support;
- Moranbah North Technical Department for designing flight plans from geological plans, secondary support and spilling design, providing daily underground reconciliations of as mined vs predicted fault positions, and compiling crew presentations and Fault Management Plans;
- Anglo Coal Brisbane Coal Office (BCO) for assistance with exploration and fault modelling based on 3D seismic, in seam and surface drilling, and for providing assistance with ground support design and spilling requirements; and
- External Consultants in various capacities including Geowork Pty Ltd, Strata Engineering (Australia) Pty Ltd, and the CSIRO for micoseismic monitoring through the LW103 fault driveage.

HISTORY

Longwall 102

In mid 1999, development operations in panel 102 unexpectedly encountered a 3.8 metre displacement fault set, downthrown inbye. The zone had not been interpreted at this location from geological modelling despite a 250 metre exploration borehole grid. Some development delays were incurred to regain horizon, install adequate support and concrete critical roadway surfaces.

The longwall mine through is detailed later, however, a failure occurred, which delayed the longwall by 18 days. Back analysis of the delays highlighted the need for improved accuracy of the model, and improved support strategies. Figures 3 and 4 show details of the failure area.

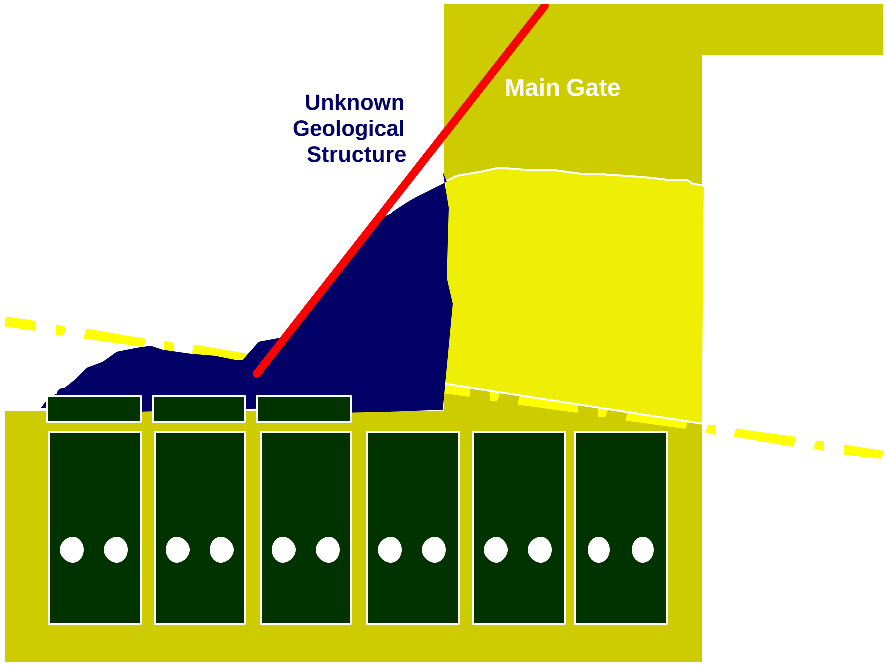

Fig 3 – Plan view of LW102 maingate end roof failure

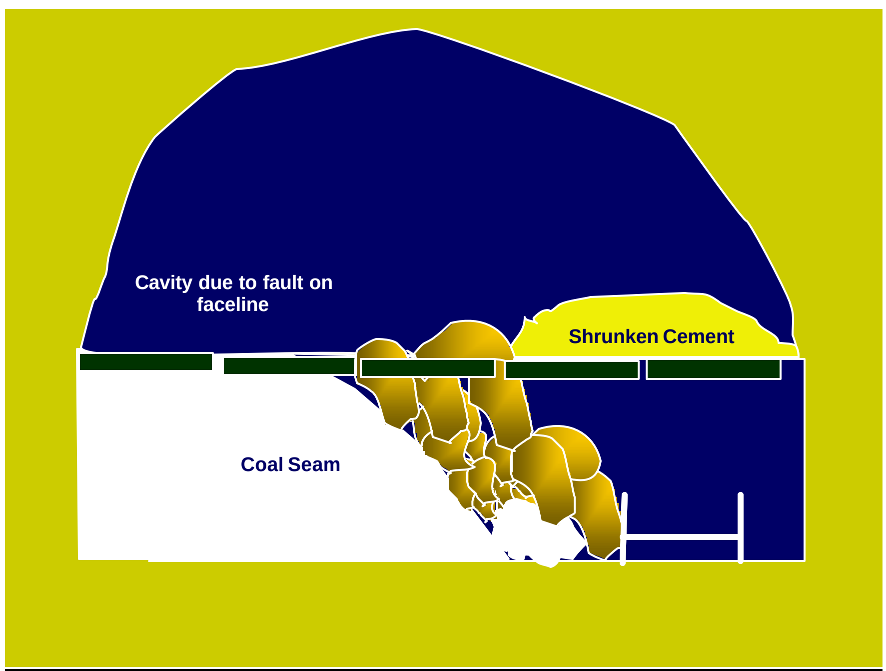

Fig 4 – Section view of LW102 maingate end roof failure

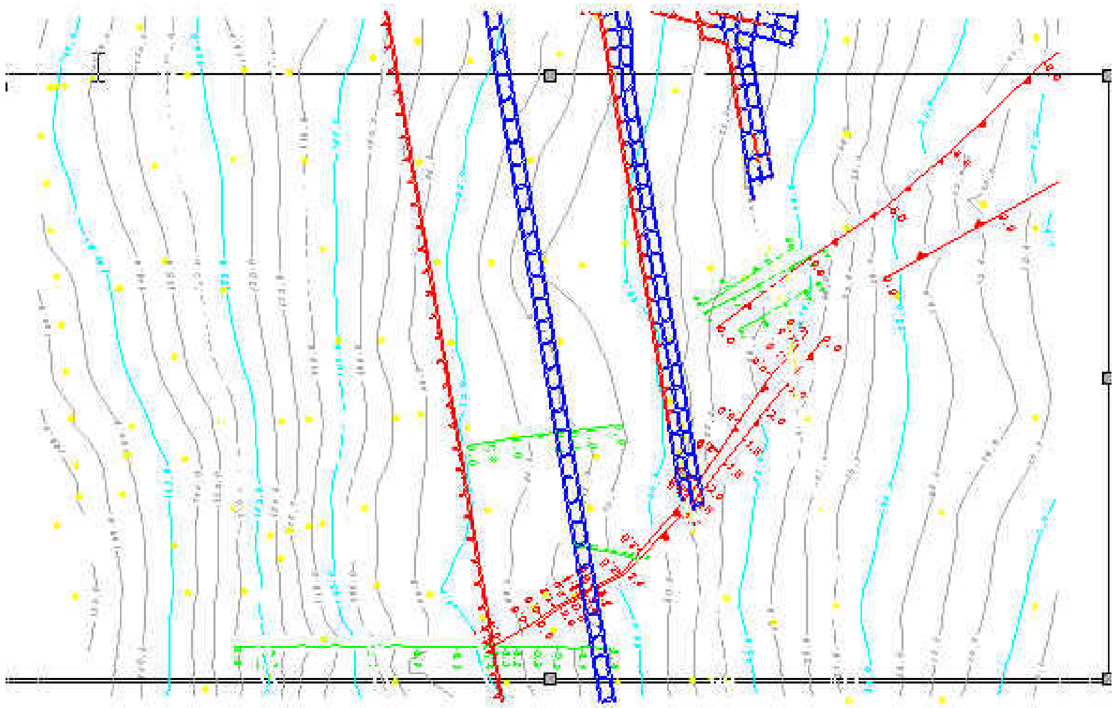

Fig 5 – Maingate 103 fault interpretation following seismic, in seam and surface drilling

Longwall 103

In mid 2000, development in maingate 103 encountered a 5m total displacement fault zone in a location outbye of that predicted (projected from 102). The fault zone consisted of a splayed series of up and down thrown faults with significant displacement (4.9m belt road, 6.7m travel road). The fault intersection away from the predicted location once again highlighted the variable geology and constraints associated with fault prediction in the GM seam from surface drilling and geological modelling only, without utilisation of more sophisticated exploration tools.

In order to avoid results, similar to those experienced in LW 102, in future longwall panels, detailed additional assessment and analysis work was completed, including;

- Inseam drilling to confirm fault location and floor RLs;
- 3D seismic exploration and interpretation;
- Detailed roadway re-mapping of the fault zone (see Figure 4);
- Roof and floor drilling in both maingate and tailgate to confirm development roadway roof and floor coal thicknesses;
- Detailed geological mini-model generation on a 1 metre by 1 metre grid;
- Review of numerical modelling for panel 102 mine through;
- Review of panel 102 microseismic monitoring results and conclusions;
- Re design of the support requirements, cross block, as well as in the gateroads.
- Review and confirmation of operational horizon control system utilised; and
- Review of the operational aspects and associated issues with LW 102 fault mine through.

Figure 5 shows a structural interpretation following the use of more sophisticated exploration techniques including seismics, in seam and surface drilling to produce a more detailed and confident geological structural interpretation. Figure 6 shows the detailed mapping following development while Figure 7 an interprepation of the gradient changes.

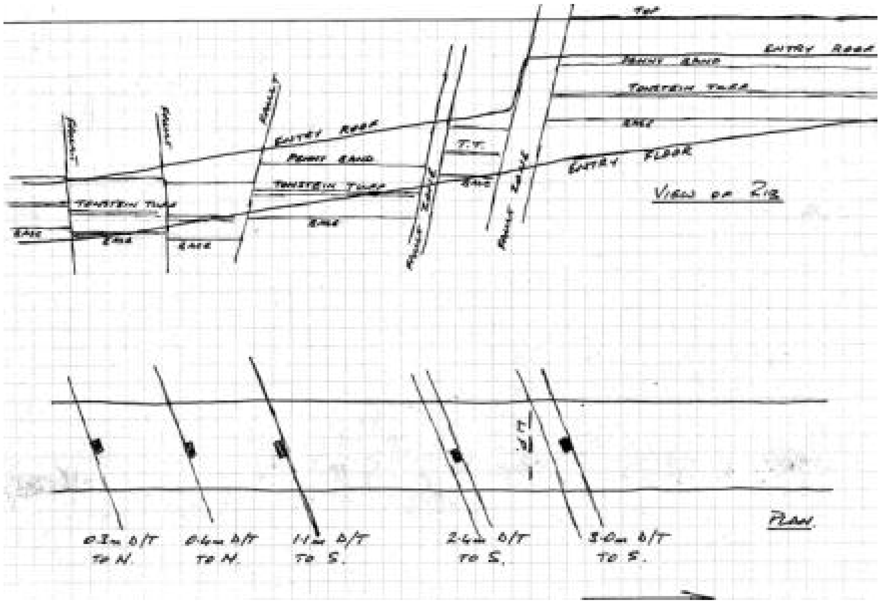

Fig 6 – Maingate 103 mapping of maingate fault system

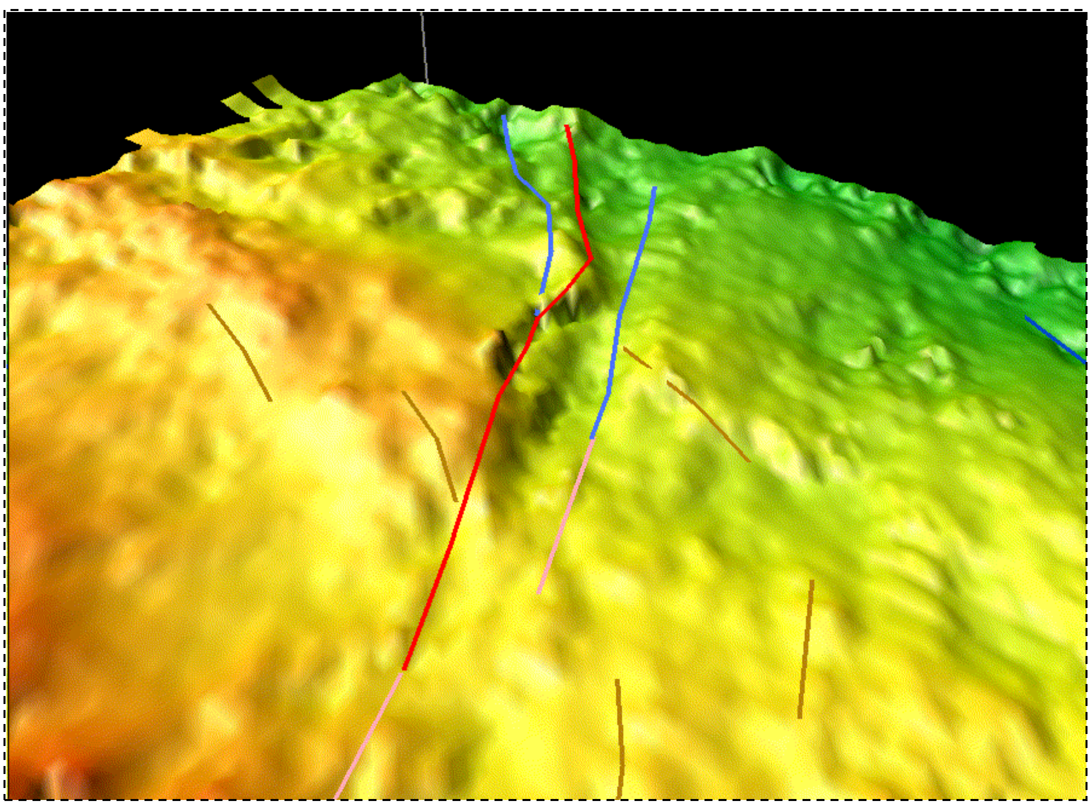

Fig 7 – Seismic (dip gradient change) interpretation of LW103 fault zone

Assessment indicated that the horizon control system used in panel 102 was adequate and appropriate, though more disciplined supervision was required. The ground support strategy implemented for LW103 was aimed to address the failure mechanisms assessed from LW102. Significant additional support beyond that used in panel 102 was installed in both gateroads

Flight plans were developed from the improved geological model, with proposed cut horizons based on:

- Optimising the coal beam roof thickness;
- Minimising the amount of stone cut (reducing dilution and potential damage to equipment);
- Maintaining a practical working grade across the face to conform to the longwall equipment limitations.

In LW103, the plans and sections generated from the geological model proved to be very accurate when reconciling predicted vs actual geological structure mapped on the longwall face. Longitudinal and transverse sections through the zone were used as guidance and provided a visual direction on anticipated ground appearance. This allowed the crews to confidently grade through the fault, with horizon control monitored and recorded, through the use of inclinometers. Figures8 shows a modelled interpretation and Figure 9 a flight plan developed from the geological model

Micoseismic monitoring

Two existing microseismic monitoring geophone strings in the panel were recommisioned. The microseismic monitoring was used to measure any potential reactivation of the fault zone as the longwall face approached the area. A system of daily microseismic monitoring, recording and plotting of events in plan view was coordinated on site through the site Technical Department and the CSIRO. Daily plots were distributed to crews for information.

The microseismic monitoring indicated few events located around the fault zone itself, which is likely considering the inability of faults to transmit shear forces across the fault plane. Most significant microseismic events were located 100m – 300m inbye of the longwall face, biased towards the maingate end. Figure 8 shows a typical microseismic plot with the size of event indicated by the size of the circle.

Some mapped outbye faults were re-activated at distances in excess of 500m outbye of active mining. The CSIRO have observed similar behavior at other mine sites.

Results of the mine through indicated that the support strategy was very effective in that no significant fault plane reactivation, roof or rib failure occurred. No movement was recorded above or within the horizon of the false roof. Some delays were experienced due to maingate end equipment failures and soft or broken floor areas, where shields had to be packed to assist elevation of the front of pontoons to negotiate grade. In addition, the floor of the maingate proved to be soft, which allowed the BSL to bury into the floor.

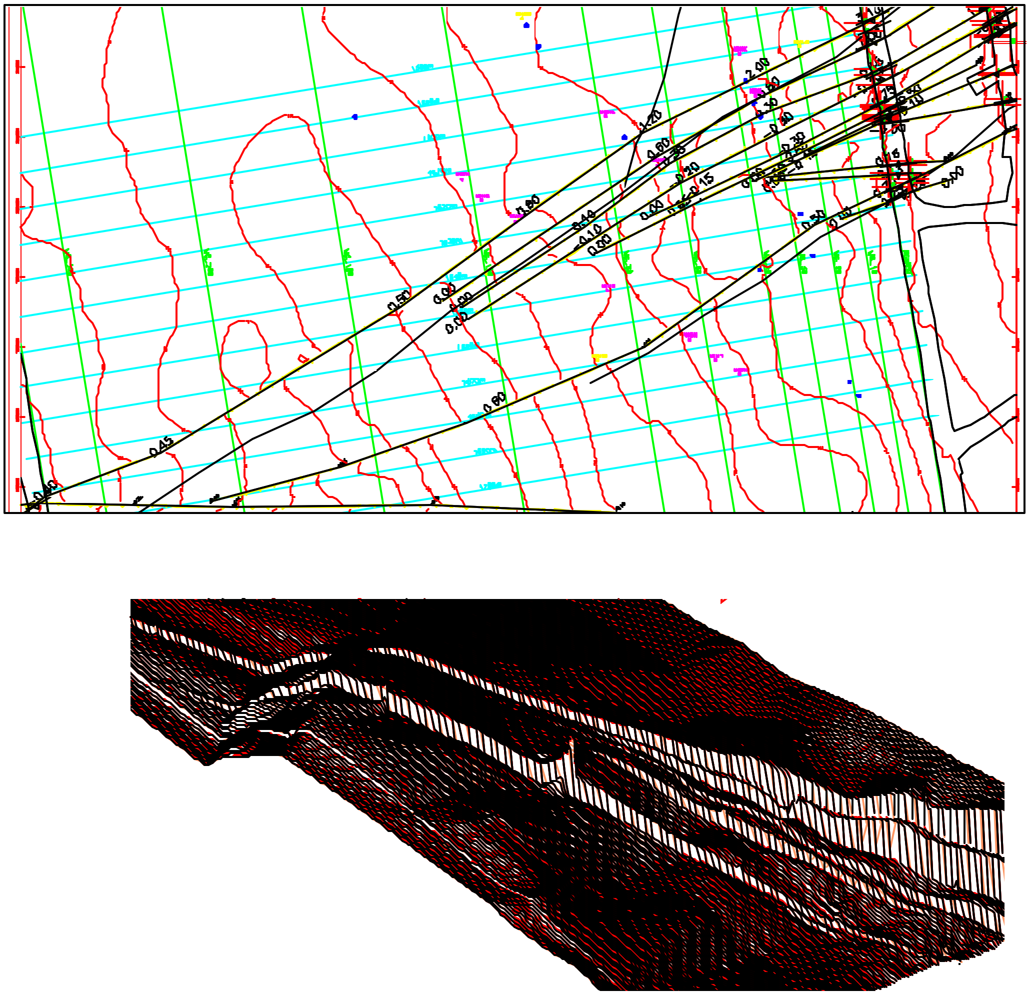

Fig 8 – Modelled fault zone with survey flight plans and ECS modeled grid (bottom) – model gridded and interpreted by S. Argent (Anglo Coal Australia Pty Ltd)

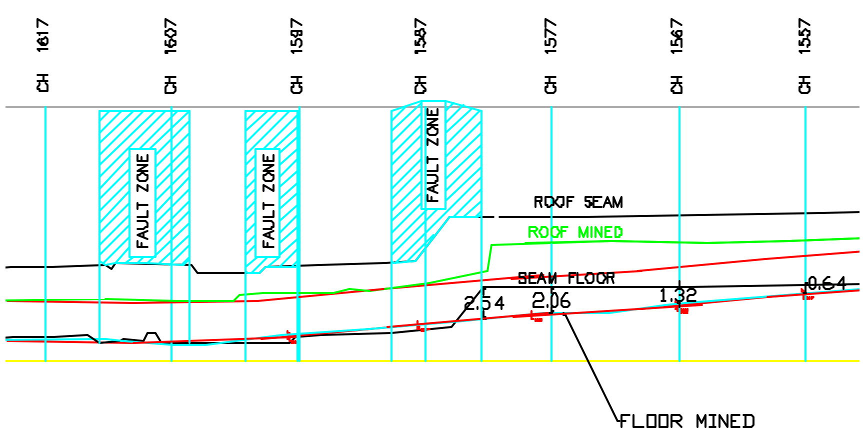

Fig 9 – Flight plan based on geological model (LW103) – A.Varvari

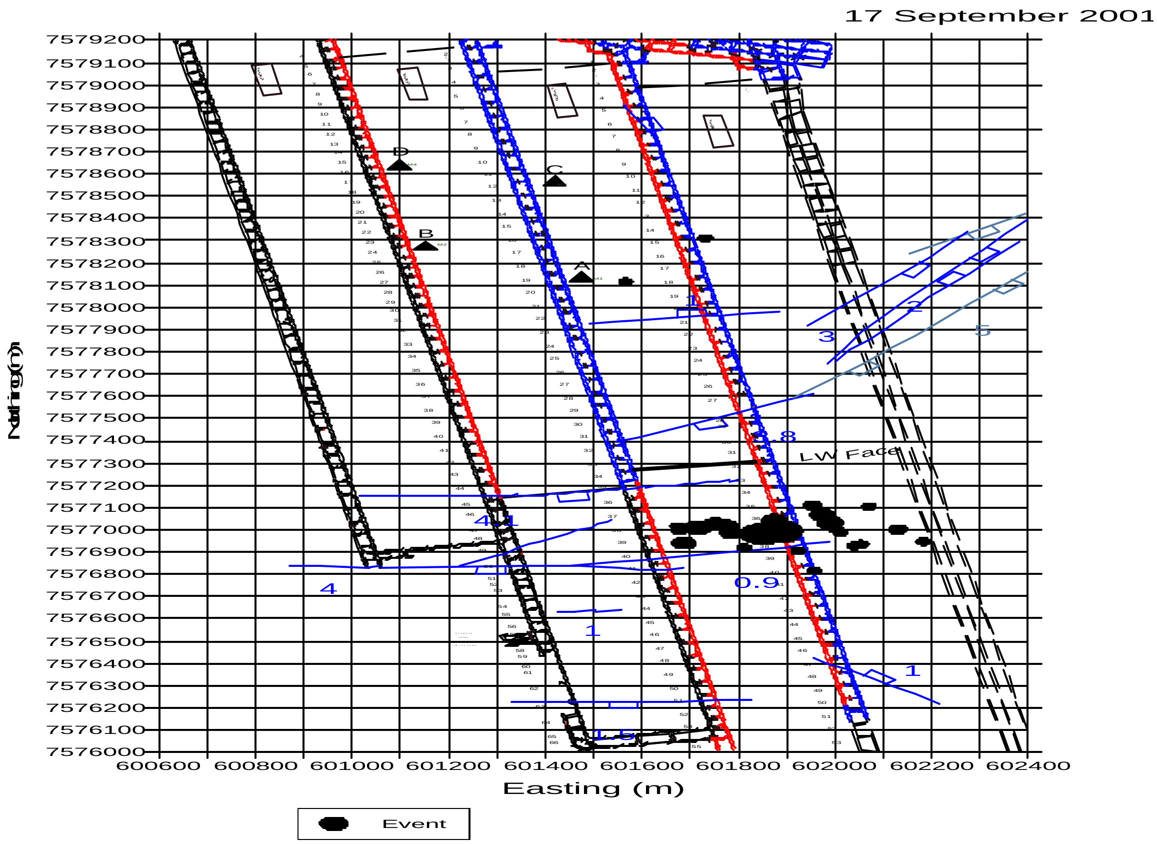

Fig 10 – Typical microseismic monitoring plot as longwall face approached fault zone
Note lack of activity

Summary – LW103 fault mine through:

Positives:

- Fault mine through was safe with no Lost Time Injuries LTI);
- Cutting horizon was maintained to plan and the flight plans and fault management plan proved accurate and appropriate;
- There was no unexpected mid panel geological structure – the geological plans and sections proved accurate;
- No fault reactivation indicated from microseismic monitoring and maingate end monitoring;
- Proved that magnitude of fault displacement alone is not a limiting factor to longwall retreat within the GM seam.

Learning points:

- Significant time was lost at the maingate end due to floor breaking up on the incline (from inbye to outbye) in the belt road. This resulted in push problems, mechanical breakdowns and delays. A self propelled excavation devise (SPED) was required to pull the pantechnicon through the bottom portion of the hill. A decision was made to concrete this zone in future fault intersections and all future belt roads with gradient differentials in the vicinity of the main fault zone;
- With timber leg / RSJ supports and a false rib, the space available at the maingate end in the belt road was at times very tight. If movement of the immediate roof had occurred, it is likely that the steel sets would have fouled the BSL. Consideration of alternative support techniques for future belt roads in the vicinity of the main fault zone, to maximize available space without compromising on the effectiveness of ground support was considered appropriate. The steel sets were made to a tight tolerance, and were difficult to install.

- Ensuring that the maingate roadway provided by development is on grade (for fault driveage), and adequately dimensioned for ease of longwall retreat

outbye around main fault zone and significant microseismic activity inbye

Longwall 104

Based on the success of the LW103 mine through, a similar approach was adopted for the LW104 mine through.

For development (maingate) panel 104, additional exploration drilling and fault interpretation was used to facilitate a pre-planned longwall mining horizon at the maingate end and drive the development roadways on pre-planned grade. This exercise proved very successful in providing a practical grade for longwall retreat mining through the maingate end and eliminating the requirement for installation of a false roof in future maingates.

Geological structure was modeled in the same manner as the previous (LW103) fault mine through and was based on surface and in seam drilling, exploration, mapping, accurate resurvey in the gateroads, and 3D seismic interpretation. The final geological model is illustrated in Figure 11. The LW104 fault zone was found to be greater than the seam displacement over a significantly greater length than LW103 fault zone. A fault zone with 6m – 7.5m total displacement was predicted to run across the entire block over a lateral retreat distance of some 270m.

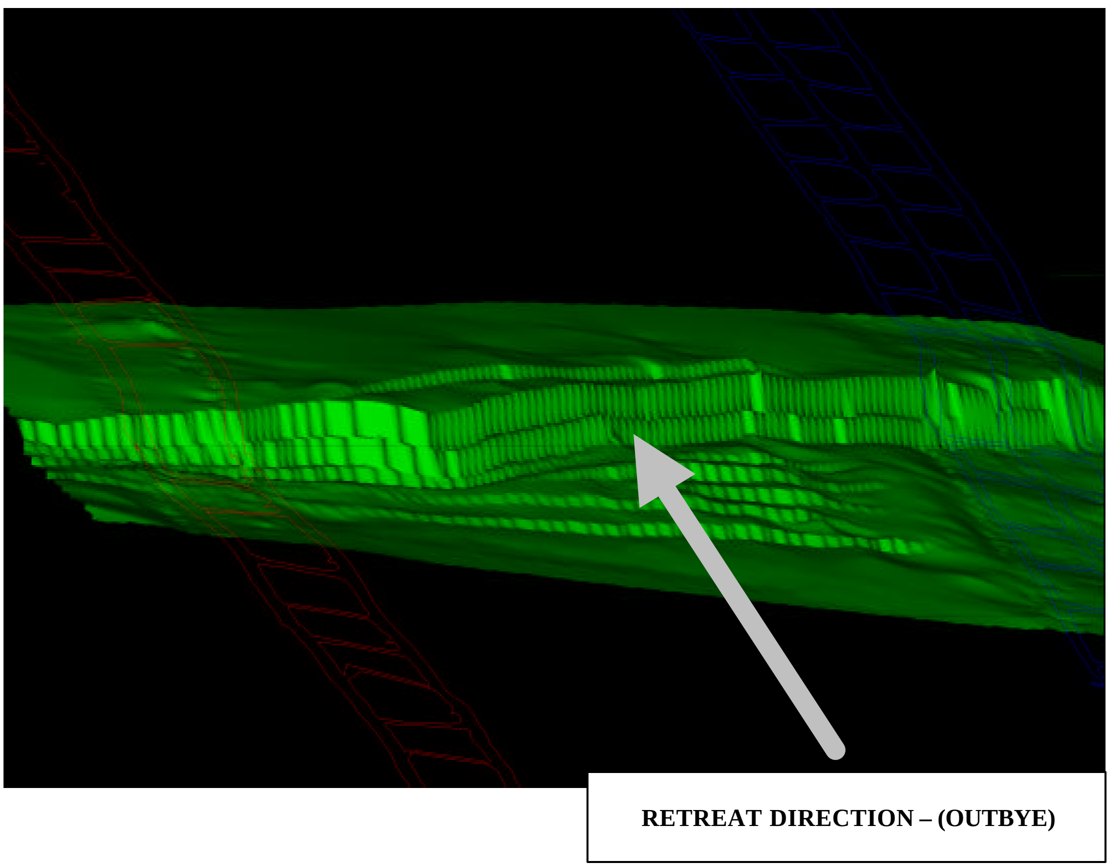

Fig 11 – Modelled fault zone for LW104 – model gridded and interpreted by S. Argent (Anglo Coal)

Flight plans and a detailed Fault Management Plan were complied in the same manner as for LW103. On site Technical Services personnel mapped the face on a daily basis throughout the fault zone to reconcile the position of actual geological structure against predicted, determine the actual longwall flight paths against design, and advise on corrective action and adjustments to maintain correct flight paths where appropriate.

The actual vs predicted fault locations proved to be reasonably accurate as illustrated in Figure 12.

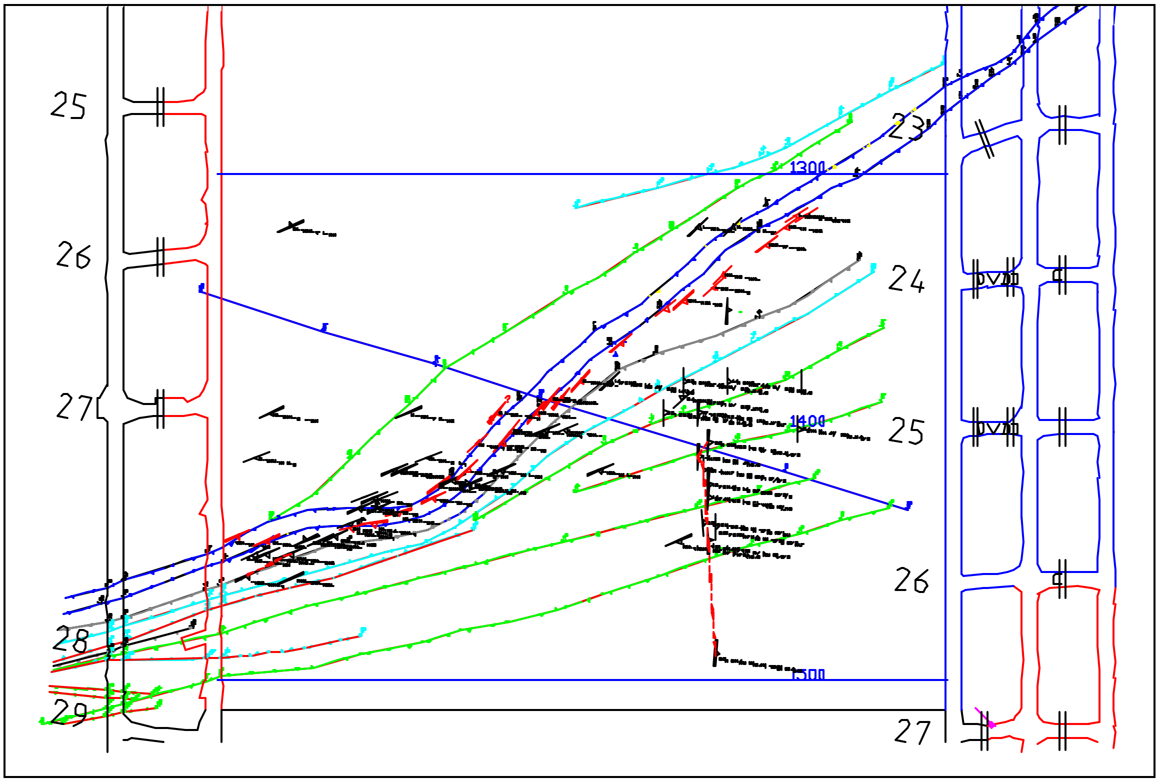

Fig 12 – Actual vs predicted fault structures – LW104 fault zone

Summary – LW104 mine through

As with the LW103 fault mine through, the LW104 fault mine through was successful, particularly in the following regard:

- The planned fault drive throughduring development included having the belt road at a pre-determined grade. Concreting the floor of the belt road through the fault affected area facilitated easy negotiation of all longwall equipment through the maingate end;
- The fault mine through was safe with no LTIs;
- Minimal strata control issues on the face (one minor roof fall in an area towards the maingate end also associated with horizon control, and soft floor.) during fault mine through;
- In genera the cut horizon was maintained to plan and the flight plans and fault management plan was followed. Towards the maingate end a kink developed across the face resulting in stone cutting greater than planned on the maingate side of the fault. However, good work by the crews ensured that this was quickly corrected and evened out by the time the main fault zone had tracked through to the maingate; and
- There was no unexpected mid panel geological structure – the geological plans and sections proved accurate.

SUPPORT AND MONITORING

Summary

The support installed for mining through the fault at Moranbah North, has been modified, and grown, driven by lessons learnt on previous longwalls. In most cases the installation of the support, and the logistics has been more complex, and arduous than initially planned. This has for the most part been due to the support having to fit 'around' the operational constraints of a producing longwall. In future panels where support is required, the installation is planned to be well ahead of the longwall.

An overall monitoring plan has not been used during the respective mine throughs, however, data obtained to date indicate stable maingate, and tailgate conditions, once the correct levels of support were achieved.

LW102

Small throws, and tight faulting in the tailgate of LW102, necessitated only primary bolting, and the use of 6.1m point anchored Flexi Bolts on a 2.2m spacing.

The larger overall displacement, and closer spacing of the faults in the maingate, required additional support. Additional 1.8m roofbolts, with mesh, and point anchored Flexibolts on a 1.8m x 2.2m spacing were used. There was no stabilisation, or consolidation of the fault over the block.

During mining of the last 8m of the fault zone in the maingate, a failure of the rib along the jointing, (running sub parallel to the gate road), allowed a large fall to occur in the maingate, and on the face, see Figure 13. A significant quantity of material had to be removed from this area, and blasting of the stone in the fall was required.

Fig 13 – Open cavity above the gate end supports at the maingate LW102

The grouted false roof, installed to allow the maingate chocks to push forward, came loose, and added to the fall. In addition, the cut height on the face, was 750mm lower than planned, mainly due to soft floor. This exposed more block side rib, possibly assisting in the rib failure. 18 days were lost due to this failure.

The position, and throw of the faults resulted in changes in grade on the face, which in some instances were greater than able to be accommodated by the longwall equipment, and damage to dog bones and other equipment resulted.

Instrumentation

Although Tell tales were installed in the maingate, in the immediate vicinity of the fault, it was not possible to install monitoring devices. The readings on the outbye instruments were normal, and did not provide any warning of the failure that occurred in the maingate.

Learning points:

- Stability of the maingate block side rib is crucial where the faulting intersects the gateroads.
- The provision of an accurate fault 'Flight Plan' is vital to success in mining faults. It is important that all the longwall equipment parameters are fully known and understood. (i.e. in some cases manufacturers figures bear re checking)

LW103

The lessons learnt in LW 102 were to a large extent applied to the fault mine through in LW103. These consisted of:

- Great improvement in the prediction of the position, and nature of the faults / Fault Zone.
- This improvement allowed for confidence in the placement of grouted steel spiles over the block, to stabilize the fault zone. 30mm thick walled boiler pipe was installed in parallel spile holes, drilled in the block, over the fault zone.
  A total of 34 holes, varying in length from 15m to 130m and 56mm diameter were drilled at 90 degrees to the roadway. The holes were spaced approximately 1.5m apart, and once the steel pipe had been inserted, were pressure grouted using microfine cement.
  The drilling of the holes over an operating longwall belt shown in Figure 14 proved to be difficult and slow. One of the contractors drill steels caused considerable damage to the longwall belt.

Fig 14 – Drilling of the spile holes over the longwall belt. LW103

- No permeability tests, or measurements of the grout quantities were taken, however, all holes were pumped to refusal, and when the area was mined through, grout was visible on the face.
- The injection of microfine cement into these holes provided additional stabilization of the broken ground.
- Due to the unexpected early intersection of the fault in the maingate, the height of the maingate again necessitated the installation of a false roof. This installation was a considerable improvement on that installed in LW 103.

- The support in the maingate was increased. 14m fully grouted, and trussed minicage cables installed in the 'high area', as well as inbye the fault zone. These cables were adequate to provide stability to the maingate during retreat. The support system is illustrated in Figure 15.

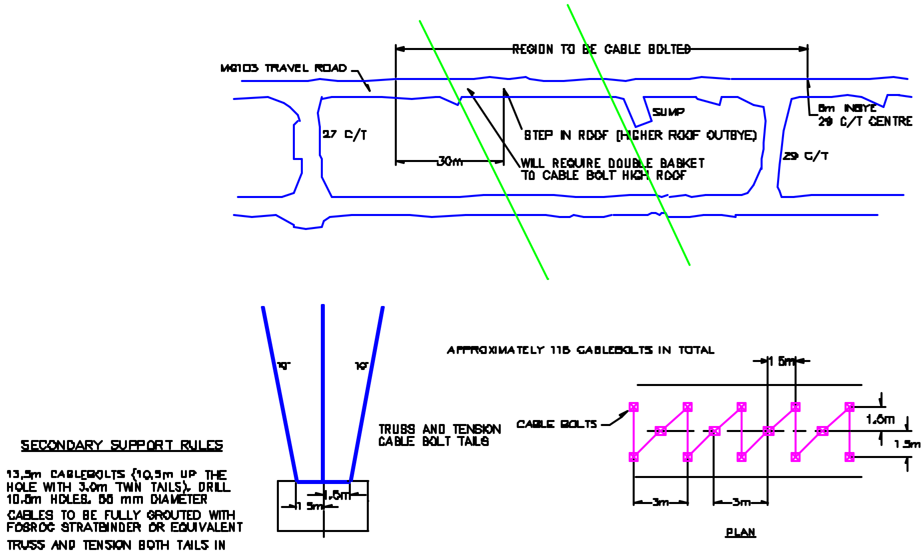

Fig 15 – Maingate cable support in Fault Zone

- In addition to the cable support, it was decided to install steel sets on a 1.2m spacing through the fault zone. These were supported on steel legs on the pillar side, and were bolted into the rib, and supported on timber legs on the block side as illustrated in Figure 16. The steel sets provided the base for the false roof.

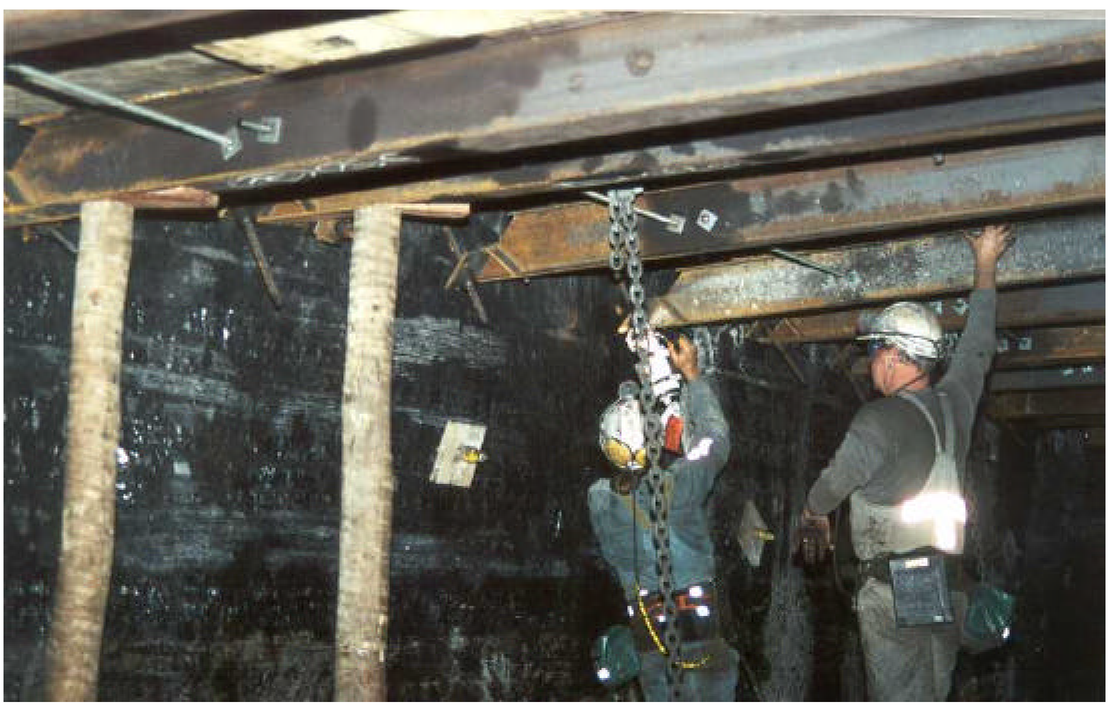

Fig 16 – Installing steel sets in the maingate LW103

- The block side rib was reinforced, using PUR injection, and cutable tendons.

- The tailgate received additional support in the form of fully grouted, and trussed cables across each fault, and closely spaced Link and Lock standing supports. A 1.4 x 1.4m Link and Lock was especially produced for installation in the higher areas.
- Inclinometersas shown in Figure 17 were used on the face (Pan line), allowing the crews to have a simple form of assessment of the attitude of the longwall equipment.

Fig 17 – Magnetic Inclinometer attached to Bretby. Panline LW103

Instrumentation

- A surface extensometer was installed just outbye of the main fault zone with a number of anchors set at various levels in the overburden. The purpose of this surface extensometer was to assess the relative strata movements of the anchors through the overburden. As such the surface extensometer was used as a post analysis tool, rather than a monitoring device capable of triggering a response during mining.
- Tell Tales were installed at various locations in the roof and rib at the maingate end (belt road). The main area of failure in LW102, was the 'False Roof', Tell Tales were therefore installed in this area, and routinely monitored by ERZ Controllers as the longwall retreated through the fault zone. Little or no movement was recorded on the Tell Tales. There were areas where some bagging of the roof occurred, however the roof support ensured stability throughout the f ault zone.
- Cross panel and centerline (down block) surface subsidence surveys were undertaken on a frequent basis to assess the impact of the fault zone on the surface subsidence profile. Figure 18 shows a centre line subsidence plot showing the impact of the fault zone on the subsidence profile through time and increased face retreat distance. Surface subsidence over the fault zone is shown in Figure 19.

The increased relative level of subsidence recorded inbye of the fault position at the tailgate end is clearly visible. It should be noted that this area is in close proximity to the roof fall in LW102 MG, where a substantial quantity of material was removed.

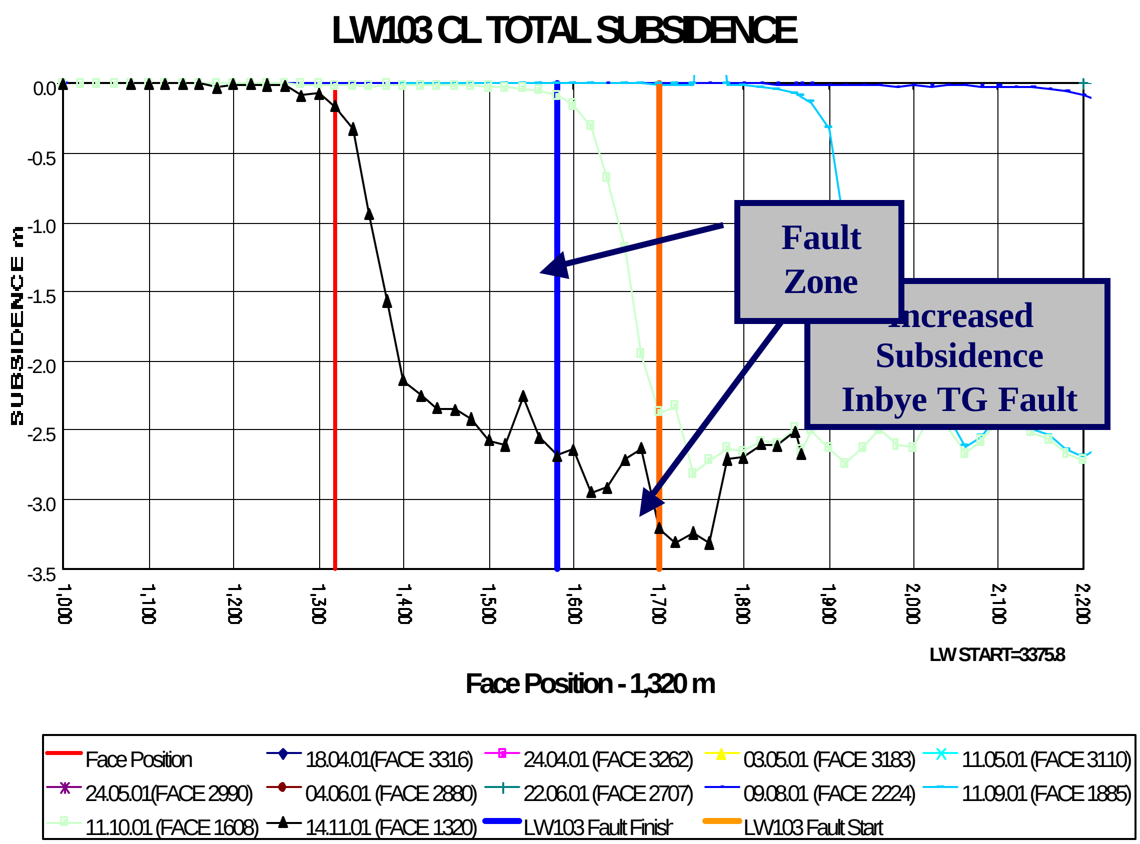

Fig 18 – Centre line surface subsidence plot LW103

Outcomes

- Safely mined through the fault zone, no LTI's, or major damage to Longwall equipment.
- Average longwall production through the faulted zone, 93 500 tonnes per week.
- No support issues in the tailgate, or over the block. No strata control issues on the face during fault mine through, evidence of pressurized grout permeation was visible on the longwall face and this is illustrated in Figure 20.
- Ground support at the maingate and tailgate ends performed well with monitoring indicating adequate ground control.
- The BSL dug into floor in fault 'Ramp up zone', causing delays.

Fig 19 – Surface subsidence over fault zone – LW103

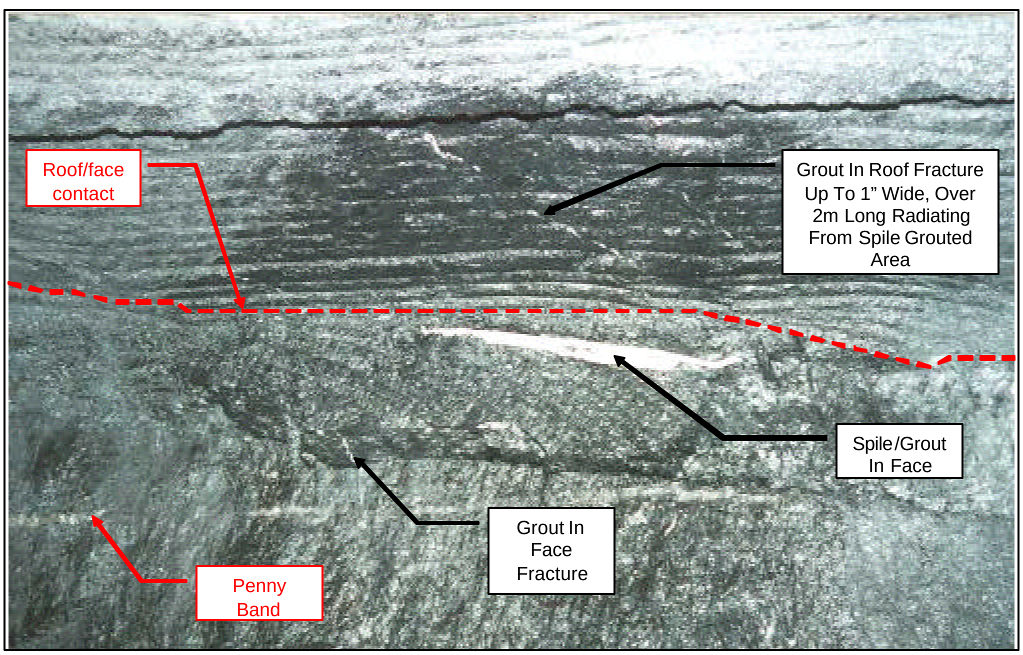

Fig 20 – Grout permeation in face due to pressurized grout injection – LW103

Learning points:

- Soft floor in fault zones, can cause as many problems as soft roof.
- In areas of anticipated dense faulting, and broken ground, it is advisable that some form of 'Over the Face' stabilization be undertaken.
- The accuracy of the geological 'Fault Plan' is important in ensuring that the planned flight path for the longwall equipment is well thought out, and useable
- Maintenance of Longwall Equipment prior to entering thefault zone is important.
- Steel sets may become entangled in the longwall supports in confined areas.

LW 104

With the additional information provided by the successful mining of the fault, in LW103, it was possible to improve further on the support design for LW104. Unfortunately the additional support work had to be done in the tailgate, during normal longwall mining operations. This caused some delays. In addition, the support work done in the maingate, and over the block, were completed over an operating Longwall belt.

With the precise predictions of the fault positions, it was possible to accurately drill fans of spile, and grouting holes over the block, for steel spile, and grouting purposes.

As these holes were generally longer than those in LW103, it was decided to utilize directional drilling to prevent any chance of the longwall intersecting the holes in the roof. There are obvious cost implications, however the improved stability provided by grouted steel spiles in the immediate roof (approx 1m to 2m above the cut horizon) was well worth the expense.

A total 15 holes were drilled from the tailgate, and 38 from the maingate. Again, the holes were 56mm diameter, and 38mm thick walled tube was installed, and grouted. In this instance, the grout useage was monitored, however no permeability testing was possible due to time constraints. In an area identified as being 'soft' when drilled, it was possible to pump more than 500litres (more than hole capacity) of a Thixotropic grout into each of 5 holes. This would indicate voids in the fault zone were filled. The layout of sp iled holes in the tailgate is shown in Figure 21 and in the maingate in Figure 22.

The support installed in the maingate consisted of :

- 13m bulbed cables, fully grouted and trussed, in a similar pattern to that used in LW103.
- 6.1m and 8.1m fully encapsul ated, and pretensioned Hi Ten cables between the grouted cables, angled over the block . Approximately 40 Hi Tens were used.
- Bolting and meshing of the ribs (pillar, and block side) for a distance of 80m around the fault zone which was approximately 30m long in the maingate.
- Installation of 8m cutable dowels with PUR into the block side rib, to prevent the failure that occurred in LW102.
- A rib spray was applied, more from an interest point of view, to check the performance under friable conditions.
- A concrete floor, with steel guide rails was constructed in the maingate in the 'ramp up' zone.
- The tailgate rib (which was 6m high at one point) was bolted, and meshed on both the pillar and block sides.
- 6.1m long grouted cutable bolts were installed in the block side rib.
- The tailgate was fully cogged (Link and Lock), with extra large footprint cogs used in the high zone. The cogs were on an approximate 1m skin to skin spacing.

All the same systems of Flight Plans, inclinometers, and excellent fault crossing plans were used in LW104.

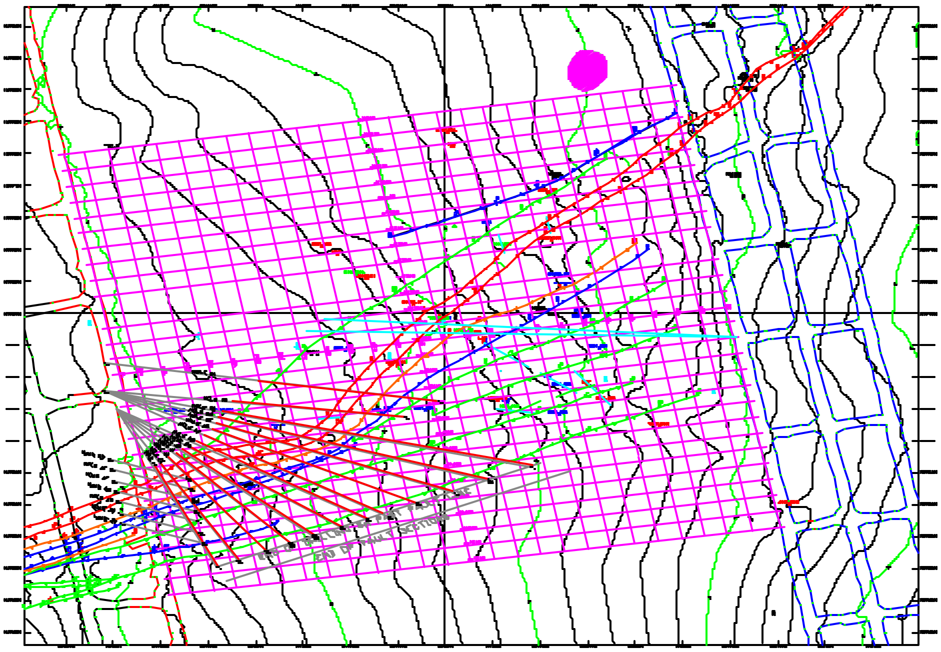

Fig 21 – Tailgate 'Spile' plan. LW103

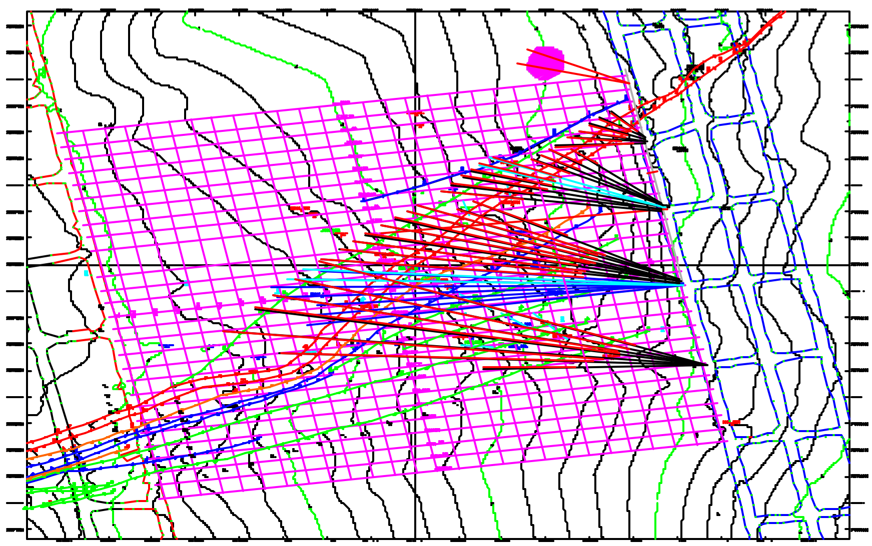

Fig 22 – Maingate 'Spile' drilling layout. LW103

Instrumentation

The only instrumentation installed in the fault zone, were Tell Tales on a regular pattern. The maximum displacements measured were 57mm in the Travel road, alongside the fault zone, and 93mm in the Maingate, just ahead of the wall. Generally stability was good.

Outcomes

- Fault mined through with no LTI's.
- Support all worked excellently. The ramp in the maingate worked well.

- Production through the fault zone over budgeted figures for the area. Actual approximately 84 000 tonnes per week.
- Actual faulting very similar to that modeled. Maximum errors approx 2m in position intersected.

Learning Points

- Soft floor conditions require care when negotiating. At one point the powered supports near the maingate, were low in the floor, but with care, were able to be raised to the correct cut level.
- The use of directional drilling proved to be expensive, however provided a good outcome.
- In order to improve the installation of support, and reduce costs, this work should be done well ahead of the face, and if possible, not in a producing tailgate, or over an operating maingate belt.

Summary

Significant faulting has successfully been mined through at Moranbah North primarily due to an excellent collaborative team effort by many people in various areas ranging from:

- Exploration, geological and technical assessment;
- Designing and installing required ground support and mid panel fault consolidation;
- Developing accurate flight plans and an appropriate mining strategy based on technical information;
- Effective communication and training of all responsible individuals in fault driveage strategy prior to implementation;
- Disciplined control and supervision underground by production, maintenance, and operational personnel; and
- Adopting an approach incorporating back analysis and continuous improvement systems.

CONCLUSION

The success of fault driveage to date at Moranbah North has proved that the magnitude of fault displacement alone is not a limiting factor to longwall retreat within the GM seam. Overall, the cost effectiveness of the decision to mine through the fault in LW103 and LW104 has allowed substantial saving (compared to a longwall relocation around the fault) and minimised resource loss. The ability and confidence to mine through greater than seam displacement structures or zones of structure will continue to be of significant benefit to Moranbah North in maintaining high production output and cost effective resource recovery across the lease.