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GIBSONS COLLIERY – THIN SEAM AND ULTRA CLOSE MINING

Ken Singer[1]

INTRODUCTION

Thin Seam Mining Pty Ltd (TSM) is contracted by Allied Coal Pty Ltd (Allied) to mine the Balgownie Seam at Gibson's Colliery, Russell Vale. TSM will utilise *place change* systems of work as practiced in West Virginia, USA. For that purpose TSM has imported purpose-built, low-profile mining equipment from the USA. The equipment has been retrofitted in Wollongong with electrical systems that comply with Australian Standards. Presently the TSM workforce consists of approximately 14 operators from West Virginia, and 14 from Australia.

There is more coal mined in the state of West Virginia than in Australia. Most of that coal is mined in coal seams less than 1.5m in thickness. At Russell Vale the Balgownie Seam comprises a high quality coking coal and is approximately 1.2m thick. It was previously mined in the 1960's and 1970's via a longwall operation, however that operation proved unviable. The inability of previous operators to extract only the coal seam was one of the reasons previous operations were not sustainable.

Gibson's Colliery has accessed the Balgownie Seam directly from subcrop on the Illawarra Escarpment. This required the use of concrete portal structures, steel sets, roof bolts, timber, and void fill material. It will be necessary to cut across a number of existing Balgownie Seam roadways in the near future. Those workings are not accessible at present.

In the area of interest, the Balgownie Seam lies approximately 10m below the Bulli Seam where previous operators extracted up to 50% of Bulli Seam coal.

Some of the distinctive features of Gibson's Colliery include;

1. Up to 70% recovery by first workings alone.
2. A high quality coking coal that is will be blended with other coals, or sold alone.
3. Both the Balgownie seam and the overlying Bulli Seam are believed to be devoid of appreciable levels of water and gas in the area of interest.
4. Roof support that comprises 1.2m mild steel bolts in the mains, and 0.9m bolts in production panels. Secondary support where required comprises 6m long cable bolts.
5. Bolts installed with a Fletcher roof bolter utilising vacuum drilling. Cable tendons are currently installed with a conventional air leg roof bolter.
6. Place changing systems with plunges currently set at a maximum of 14 metres.
7. 100 metres of advance per production shift with a single continuous miner production unit
8. A positive (forcing) ventilation system that offers notable advantages over an exhausting system
9. Utilisation of existing surface infrastructure that has lowered capital investment
10. Two production shifts per day, and one maintenance shift, 5 days per week.
11. A workforce that believes it is possible to mine thin seams safely and at high production rates

GEOLOGY AND STRUCTURE

The roof of the Balgownie Seam consists of an overall fining-upwards sequence from coarse grained sandstone/pebble conglomerate through laminated to fine grained sandstones and mudstones. Within this overall trend, there are local variations in the nature of the immediate roof to the Balgownie Seam, ranging from carbonaceous mudstones through planar and cross-bedded sandstones to pebbly conglomerates. However, the

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vast majority of the roof is a sandstone - flaggy in parts, but mostly massive cross-bedded sandstone. The strength of the sandstone in the roof of the Balgownie seam ranges from 50 to 100 MPa.

Joints in the sandstone roof of the Balgownie Seam trend at approximately 355°, 100°, and 050° with respect to Grid North. At the shallow depths in which mining has been conducted, some of the joints present as decomposed zones. It has been found that there are a number of small throw normal faults that are aligned parallel to the 355° joint set.

The floor of the Balgownie Seam consists of carbonaceous mudstone, coal shale and laminates.

MINING HISTORY

Bulli Seam

Knowledge of the remnant pillars in the Bulli Seam is based on the original cloth plans held by the colliery. These show areas of hatching marked "pillars extracted" or similar. The nature of the remnant pillars inside such areas is unknown – it is possible that there are large pillars or stooks left in these areas. Elsewhere the plans show Welsh bords and main headings.

Fig. 1 shows a non-validated digitised version of the plan over the immediate area of interest: the Bulli Seam pillars are shown. Taking this interpretation at face value, Gibson's Colliery will be located under large pillars and goaf.

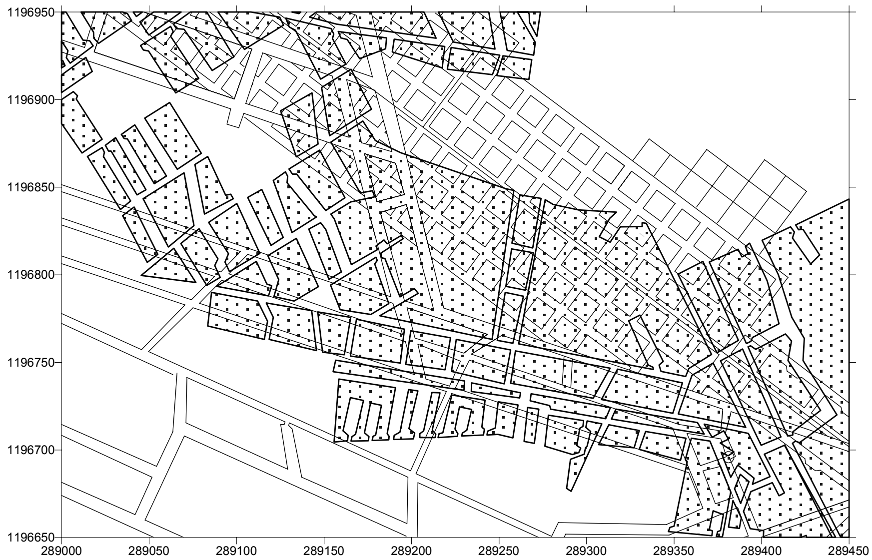

Fig. 1 Plan of Mining Area

Balgownie Seam

The Balgownie Seam was worked by longwall methods in the mid 1970s immediately to the south. This area was also under Bulli pillar goaf. Discussions with the previous Balgownie Seam miners provided the following information:

1. Roof support was mostly by props and bars
2. Difficult roof control when at shallow depths – headings driven southwest from the escarpment were very poor (note that the Gibson's layout has different orientations).
3. Conditions improved markedly as they went deeper, and this coincided with a change in direction of the driveages towards the west.
4. There were occasions when the mining conditions were typified by heavy rib crush, a step in the roof, open cracking (dipping between 40° and 60°), and a flush of water. These were interpreted at the time to be associated with remnant pillars in the Bulli Seam goaf.

5. There was a general belief that the poor roof conditions and the larger roof falls developed underneath the Bulli Seam goafs, possibly under remnant pillars in the goaf.
6. Minor roof falls developed in the presence of bedding partings close to the roof
7. Faults and associated joint zones were often associated with roof falls,

RISKS

Two specific risk types were identified as having the possibility of affecting the project.

Generic Mining Risks

In July 2001, a core risk assessment identified the following geotechnical risks:

1. Catastrophic collapse of pillars
2. Roof or rib fall

Both the core risk assessment and the subsequent risk assessment on gas and ventilation, suggested that one option was to form wider roadways – 6.2m. These were seen as offering larger cross-sectional areas for ventilation and wider spaces between mining equipment. Approval for wider roadways has not yet been sought. Risks associated with the movement of mobile equipment in confined spaces was addressed in a separate risk assessment on crush injuries.

The strata control risk assessment identified the following hazards:

1. Fall of previously supported roof
2. Fall of scat between supports
3. Struck by rock while scaling
4. Struck by rib

It is significant that thin seam and ultra close mining were considered not to introduce additional geotechnical risks compared to 'normal' seams.

Business Risks – Ultra-Close Mining

In the late 1960's or early 1970's a number of physical models were developed by ACIRL. The models showed the onset of floor heave when Balgownie roadways were located under and immediately adjacent to Bulli Seam pillars. For the case of the roadways under the Bulli pillars, a tensile failure developed in the roof. For roadways adjacent to the pillar, shear and tension failures developed in the roof. The nature of the shear failures in these physical models is consistent with the observations made by the earlier miners in the Balgownie Seam. Finite element modelling has been conducted to confirm the physical models. These models predict roof failures and floor heave of similar nature to those seen in the physical models.

Based on the modelling, a review of US work, and the experiences of TSM, a number of failure mechanism are possible, depending on the interaction of the stresses with the rock types. Beyond approximately 70 metres of cover, remnant pillars in the Bulli seam and goaf edges may impact on the strata conditions in the Balgownie seam. Roadways offset from any overlying pillar remnants may experience floor heave and roof falls. As remnant pillars are approached, there will be shear failure in the roof, rib spall and floor heave. Directly under any pillars, mining conditions may be better, with rib crush and possibly the opening of joints in the roof. Roadways aligned parallel to any joint sets and under remnant pillars may suffer from roof tensile failures.

The mining strategy that has been adopted is that once an area associated with a remnant pillar is recognised, the number of roadways in the adverse area will be minimised. No roadways will be formed in these areas if roof joints are present and sub-parallel to the roadways. Because the pillar stresses needed to create the poor ground conditions have to be high, the area that will be affected will be relatively small. It should be noted that to get high stresses, small isolated Bulli Seam pillars must be present.

MANAGEMENT

Some of the management issues are discussed below.

Layout

The mine layout was developed to maximise inherent roof performance and to prevent catastophic pillar failure. The layout is based on aligning roadway so that they are not parallel to the regional joint sets in the interburden. In addition, the layout is flexible so that it can change when remnant pillars are encountered.

Pillar sizes have been set on the following guidelines:

1. Production panels with a factor of safety of 1.6,
2. Interpanel pillars with a factor of safety of 2.0 assuming full extraction of the panels
3. Main pillars with a factor of safety of 2.0

Pillar stresses are based on overburden load assuming the Bulli Seam has not been extracted. This means that the loads will be underestimated when under remnant pillars in the Bulli Seam. The risk that this introduces in terms of pillar performance is judged to be acceptable because:

1. There is no intention to form pillars in such ground
2. The location of the remnant pillars in the goaf is not known so no practical alternative strategy is available.

Width to height ratios of the pillars are all greater than 10, so it is likely, that should any pillar failure develop, that the result will not be the shedding of load to other pillars, but they will fail in a plastic manner. This means that any failed pillars will remain load bearing after failure.

Hazards And TARPS

The geotechnical hazards for Gibson's are the same as for all underground coal mining – unpredicted roof geology, poor support installation, faults - plus the business risk of ultra-close mining.

Trigger Action Response Plans (TARPS) have been developed for the range of strata control variables anticipated at Gibson's Colliery. The TARPS require operators to respond to conditions that are not normal, and to report variations. That has required Gibson's Colliery to train its operators in the range of variables anticipated.

Training has included operators walking roadways with a geotechnical engineer, and witnessing first hand some of the conditions experienced by operators of the past. This has been possible because Gibson's Colliery has utilised several hundred metres of roadways that were developed between 30 and 80 years ago.

Managers Support Rules are considered support standards. Philosophically, the need for operators to "install additional support if considered necessary" is seen as a departure from the support standards and must be reported. This action is encouraged and warrants further investigation as the support standard may be deficient, and require amendment.

Each shift, operators are required to drill a test hole to confirm the nature of the roof strata, and to confirm that the required pre-tension is achieved by the support system. Regular testing of the distance to the Bulli Seam is to be included in the mining sequence.

Roof Support Standards

Flat Roof - Typical Condition
The key to roof support design in cut and flit pillar panels is to recognise the following three points:

1. The roof will fall to a unit that is in excess of say 20cm – 25cm thick
2. The stress changes related to the cutting of the place will fully develop within 5m of the face
3. There will be no subsequent stress changes.

With a demonstrably stable roof, either as-cut or after any fall, and no further stress changes, the question of roof bolt design is what is the role of roof bolts ?

The observational evidence from the 1970's is that roof falls developed if the distance to the first major parting in the roof was less than 0.6m. We have used this as the basis of a roof support strategy based on the suspension of a rock layer of this thickness. This leads to a light pattern of short bolts.

Roof Support Associated With Remnant Pillars
Based on the reported mining conditions elsewhere in the Balgownie Seam, roof falls can be expected below remnant pillars. It is noted that some of these falls may be delayed that is, not occur at the face itself. In areas of open cracks, indicative of tensile conditions, there is a risk of the roof unravelling to a significant height and possibly interconnecting to the Bulli Seam. In this situation, forcing ventilation minimises the risk of gas inflow to Gibson's Colliery.

It is assessed that a long tendon support will be required in these areas – based on cables or coupled bolts. The design should be based on dead weight suspension. The critical design parameter for this support is the likely height of the fall – this controls the length of the tendon as well as the load capacity of the system. The likely fall height is not known but it has been assumed at this stage that it is 3m. if triangular shape and 2m if a flat fall block. This gives a dead weight 22.5 tonnes - 30 tonnes per metre of roadway respectively. Note that the key unknown is the height of the fall. Until some experience is gained, it is recommended that any suspect ground be secured, the mining face relocated, and a geotechnical assessment made.

Rib Support
Given the thin seam of 1.2m and especially when wide roadways are adopted, pattern rib bolting should not be required. Some spot bolting around join and fault zones may be required.

PROGRESS TO JANUARY 2002

The portal was developed immediately behind the main office building at Russel Vale. The strata consisted of approximately 5m of colluvium, overlying an additional 10m-15m of weathered rock. The intensity of weathering decreased with depth: immediately beneath the colluvium the weathered coal measure strata was of lower strength. The initial roadway intercepted the brick portal structures of the old Gibson's Tunnel. These brick arches were filled with cementatious products supplied by Foscroc via Ventmine, with the grout preventing the arch from collapsing as steel sets were positioned. The installation of this grout exceeded our expectations and not only filled the voids but also penetrated into the fill above the brick arch.

The shallow workings are characterised by low horizontal stresses. Low horizontal stresses introduce the risk of joint-controlled failure with roof falls developing by slipping on vertical joints. The mining layout response was to seek a minimisation of the number of roadways parallel to the joint sets in the roof. When joint zones were intersected in areas of low confinement, the response was angled cables installed through the joints and over the coal solids. A persistent decomposed zone was identified and in that zone plunge lengths were reduced and straps and cable bolts were installed, as planned.

Up to 3 cutthrough, the roadways were formed at 2.0m high. In the first week of thin seam operations, the 2nd week of January 2002, Gibson's Colliery achieved a 70 metre and an 80 metre shift. In the second week, several shifts in excess of 100m were achieved. Those shifts were 9 hours in length, and several hours were lost due to delays experienced while commissioning the equipment.

ACKNOWLEDGEMENTS

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Graham (Spot) White of the CFMEU, for his participation during enterprise negotiations, and for genuinely welcoming our American colleagues into the Wollongong community.

	NORMAL	LEVEL 1A TRIGGER Cut and bolt installation	LEVEL 1B TRIGGER Remnant pillars	LEVEL 1C TRIGGER Strucutre	LEVEL 2 TRIGGER Strata aleret
DEFINITION	Extended plunge (more than 6m) is judged to be possible. Flat roof or falls less than 0.5m high No or very little rib spall	Plunge more than 0.5m overwidth Less than full length not due to ground conditions Bolt installation is not to design requirements Bolts not taking torque	Open vertical cracks in the roof Open angled cracks in roof Flush of water in the plunge Excessive rib spall Visual signs of weighting including: Noise	Faults, dykes, joint zones encountered. • Visual roof deformation such cracking developing along rock defects • More than 0.3m throw fault • Roof falls more than 0.5m high	Cannot set ATRS to roof of fall Inability to adequately support with available support standards Miner or Fletcher buried or cannot be withdrawn under its own tractive effort
REFERENCE	PINCH OUTS SLABBY ROOF RIB CONDITION 0 - 1		HIGH STRESS RIB CONDITION 3-5	JOINTED ROOF FAULT CLAY VIENS PINCH OUTS	
POSSIBLE INTERPRETATION	Immediate sandstone roof beam No remnant pillars No faults or joint zones	Incorrect or not maintained equipment Incorrect materials Broken ground Support standards not followed Operators not competent	Under influence of remnant pillars	Fault zone Joint zone and low stresses	Geology more complicated than anticipated by geotechnical engineers Complex roof and remnant pillar interaction
ALL PEOPLE	Continue production and conduct work to sequence and support standards Awareness of Strata Domain Plan	Review installation requirements and check supplies Install additional support to standards or stop.	Inform coordinator and Mine Statutory Official During excavation minimise size and time of roof exposure	Inform coordinator and Mine Statutory Official Continue production During excavation minimise size and time of roof exposure	Stop production. Withdraw equipment. Inform coordinator and Mine Statutory Official Install supplemental support as directed.
MINER DRIVER	Cut to width and length as set in support standards Record plunge conditions on sheet	Return to design width and length of plunge Record width and length on sheet Continue production	Stop plunge Record width and length Relocate miner Await instructions from officials	Reduce plunge to allow satisfactory roof for bolting Record width and length Await instructions from officials	Withdraw miner No—road area Advise coordinator and Mine Statutory Official immediately

	NORMAL	LEVEL 1A TRIGGER Cut and bolt installation	LEVEL 1B TRIGGER Remnant pillars	LEVEL 1C TRIGGER Strucutre	LEVEL 2 TRIGGER Strata aleret
BOLTER	Install to support standard Measure and record width and length of plunge Record on sheet Any additional support to be recorded Drill test hole at beginning of shift Conduct torque test Place and advance no-road signs	Inform coordinator if equipment fault Repair equipment immediately Record on strata sheet Records any time a plunge is left unbolted for more than 4 hours	Support using latest recommendation from strata review team Record on sheet	Support using latest recommendation from strata review team Record on sheet	Withdraw bolter No-road area Notify coordinator and Mine Statutory Official immediately Install additional support as directed
MINE STATUTORY OFFICIAL	Continue Statutory and other inspections Monitor instrumentation as required by strata review team	Determine if mining should stop pending repairs/new supplies. Record on statutory report	• Continue statutory and other inspections • Install temporary supplemental support if required to ensure immediate stability • Note location, geological and geotechnical details and remedial action taken on shift or statutory report • Communicate with oncoming Mine Statutory Official as per mine communication system. • Record on statutory sheet	• Inspect place with coordinator and determine if mining should continue • Invoke strata alert if mining does not continue • Install supplemental support. • Note location, geological and geotechnical details and remedial action taken on shift report • Communicate with oncoming Mine Statutory Official as per mine communication system. • Record on statutory sheet	• Inform SCP • Monitor extent and development of fall. • Safety contact with All People • "No Road" entries to fall area. • Await advice from mine manager. • Supervise recovery of fall.

	NORMAL	LEVEL 1A TRIGGER Cut and bolt installation	LEVEL 1B TRIGGER Remnant pillars	LEVEL 1C TRIGGER Strucutre	LEVEL 2 TRIGGER Strata aleret
COORDINATOR	Produce to daily production plan	Advise Mine Statutory Official Schedules repairs/new supplies	• Relocate production pending advice • Inform SCP • Communicate with oncoming Mine Statutory Official as per mine communication system.	• Advise miner driver if mining is to continue • Communicate with oncoming Mine Statutory Official as per mine communication system.	• Arrange for initial support materials and equipment.
MINE MANAGER (If off-site, may be delegated to person he deems competent)	Weekly mine-wide audit Authorises cut sequences Reviews statutory reports on a weekly basis	Completes non-conformance and verification form	Inspect strata conditions as soon as practical Organise and manage installation of supplemental support to ensure immediate stability Review situation and action required with Geotechnical Engineer Discuss production plan with GMM – consider abandoning roadway if not beltway.	Weekly mine-wide audit Authorises cut sequences Reviews statutory reports on a weekly basis	Inspect fall. Coordinate and organise recovery of fall. Implement fall recovery operation. Monitor and adjust plan in cooperation with GMM and Geotechnical Engineer. Review geotechnical report of fall. Approve and implement recommendations Notify Inspectorate if applicable
SURFACE COMPETENT PERSON	Transfer health and safety issues to shift notes	Transfer health and safety issues to shift notes	Contact mine manager Transfer health and safety issues to shift notes	Transfer health and safety issues to shift notes	• Inform mine manager and General Mine Manager
GEOTECHNICAL ENGINEER (If off-site, may be delegated to person he and mine manager deems competent)	Update panel geotechnical profile and provide advice to Mine Manager.		Update panel geotechnical profile and provide advice to Mine Manager.	Update panel geotechnical profile and provide advice to Mine Manager.	• Inspect strata conditions as soon as practical Advise in fall recovery support system. Conduct an investigation and issue a report on the fall.
GENERAL MINE MANAGER	Provide resources		Review production plan belt road		Review geotechnical fall report.. Review production plan belt road