Experience with the First Modern Longwall Installation in Western Canada at Smoky River Coal Limited, Grande Cache, Alberta.

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ABSTRACT

In January, 1997, the first modern, heavy duty longwall face installed in western Canada began production in the #10 seam at the 9G mine of Smoky River Coal Limited. The first panel was completed in November, 1997, after which the coal face was secured, the equipment removed, serviced and re-installed on a second panel, which commenced production shortly thereafter.

While it is true that the results obtained were not as good as had been anticipated, the experience has shown that longwall mining does have a future in western Canadian mining conditions.

This paper describes the development, installation production and stripping/reinstallation of the longwall at 9G Mine. It describes the equipment and methods used, as well as some of the problems encountered and their resolution. It also presents recommendations developed for the benefit of future longwall installations in western Canada.

INTRODUCTION

Smoky River Coal Limited (SRCL) produces approximately three million tons of metallurgical and thermal coals each year from surface and underground mines located at a site 20 km north of the town of Grande Cache in western Alberta. Underground mining has historically been concentrated in one seam, the #4 seam, for the following reasons:

• The coal washes well to produce an excellent coking product for export sale,
• The seam is typically 4.8 m to 6.4 m in thickness, allowing excellent production from room and pillar retreat sections,
• The roof of the coal seam is typically strong, requiring only minimal roof support - four to six 2.4 m long mechanically anchored bolts in a 6.7 m wide entry.

Considerable reserves of a similar rank of coal occur in #10 seam, although the ROM has a slightly higher ash content due to ash bands in the upper 0.9 m of the typically 3.9 m thick seam. Unfortunately, #10 seam has a weak roof, comprising a 6.0 m thick sequence of coal horizons, carbonaceous shale, thinly interbedded mudstones, siltstones and sandstones, which has proved difficult to support in the limited conventional room and pillar mining operations conducted in the seam in the past.

In an effort to maximise resource recovery, SRCL made the decision in the mid-1990's to try to extract the #10 Seam by longwall methods. Longwall mining had been tried on two separate occasions in #4 Seam on the property prior to this decision, with no success, but management felt that improvements in longwall technology and the geological environment of #10 Seam promised greater success.

This paper describes some of the background to the longwall experiment, development, mining and the problems encountered. It closes by offering some recommendations for potential future longwall operations in western Canada.
BACKGROUND

Mining History

SRCL began mining in the 9G Mine area in 1981 when they established the surface infrastructure and drove rock tunnels from the surface to intersect #4 Seam. These tunnels intersected #10 Seam. #4 Seam was mined from 1981 until the summer of 1982 when it was put on a care and maintenance basis. Mining resumed in 1987 and the last areas were depillared in 1996.

In 1981, a brief test project was conducted in #10 Seam, with the thought of developing a room and pillar mine in the seam. However, the roof conditions proved to be unsuitable for room and pillar mining. In 1994 and 1995, SRCL reviewed the geological data for the seam, as well as the roads developed in 1981. It was determined that the roof conditions might be suitable for longwall mining and that new roof support technology could allow the development of the necessary roadways. An application for a test program was submitted to the Alberta Energy Utilities Board (AEUB) in early 1995.

The test program, comprising development of in-seam roadways, satisfied SRCL management that the roof conditions in #10 Seam were suitable for retreat longwall mining, and two mining panels were planned in the #10 Seam at 9G Mine using the surface infrastructure already in place from previous #4 seam workings.

Geology

The 9G-10 Seam underground development is located within the Smoky River Coalfield within the Rocky Mountain Inner Foothills. It lies west of Sheep Creek and overlies the completed and abandoned #4 Seam workings. Structurally it lies within an anticlinal system that is bounded on the north by the Muskeg Fault and in the south by the Mason Fault. These two boundary faults are major thrusts that dip to the south and roughly parallel the axial trend of the anticlinorium.

The dominant structure in the area is the 9G anticline. The axis of the anticline plunges to the east at roughly 4°, dying out to the east. The profile of the anticline is not symmetric. It has a steeply dipping southern limb (up to 45°), and a northern limb that dips 15 to 25° next to the anticline and up to 40° further north.

The longwall panels are located on the north limb of the 9G anticline. Southwards development is limited by the anticline axis while development to the north is limited by seam dips in excess of 30°. To the east, development is limited by the subcrop of the seam. To the west it is limited by the maximum mineable panel length.

The surrounding strata are of the Gates Formation (of the Lower Cretaceous Luscar Group) and outcrop near the mine. The Gates Formation is subdivided into three members: the Torrens, the Grande Cache, and Mountain Park. The Torrens is a distinct marine sandstone and siltstone sequence about 30 m thick. It is overlaid by the Grande Cache Member. This member consists of approximately 158 m of non-marine siltstones, sandstones, mudstones and all of the significant coal seams in the area, and is overlain by the Mountain Park Member, the youngest rocks subcropping in the area. This member consists of 155 to 192 m of non-marine sandstones, mudstones, siltstones and minor coal seams.

The significant coal seams present are numbered from the lower (older) to the upper (younger), and comprise #4, #8, #10 and #11 seams. These seams are consistent in their character and thickness. #4 Seam has been mined extensively using conventional room and pillar mining techniques. #8 and #11 Seams are not considered economic because of thickness and low quality.

#10 Seam is located an average 74 m above #4 Seam. It averages 3.4 m in thickness in the area and is uniform in character. Within the defined longwall mining area all of the coal lies at dips of 25° or less.

The immediate 6 m of roof above the seam consists of a thinly interbedded sequence of shales, sandstones, siltstones, carbonaceous shales and coal horizons. Experience with stand-up times during development, when 2.4 m
of advance in a 5.5 m wide roadway stood between cutting and bolting, indicated a rock mass rating of 30 to 40, confirmed by coring. In many places, however, immediate collapse of the roof occurred, indicating a lower rating. The nature of the immediate roof – carbonaceous mudstones and coal seams, with the first competent unit, a siltstone, occurring 3 to 4 m above the seam, complicated support, as did the propensity of the exposed roof to deteriorate dramatically in wet or humid conditions.

The floor of the seam consists of about 1 m of shale, then 2.4 m to 3.0 m of siltstone that coarsens to sandstone in some places.

**Surface Infrastructure**

The 9G Portal area was fully developed for mining #4 Seam. This included office and dry facilities, a work-shop, material storage areas and the coal conveyor from underground as well as a coal stockpile area.

Coal is trucked from the portal stockpile to the Sheep Creek breaker station. From there, the coal is transported to the plant via the existing Tunnelway, washed and shipped to port via rail.

**Mine Layout**

Access to #10 Seam is achieved from two rock tunnels developed from surface to reach #4 Seam. The rock tunnels cross #10 Seam, at which point cross measures drivages were made to establish an air loop in #10 Seam itself. The 1 North development is driven north from this, providing access to the 2 West and 3 West development districts. Access to the 1 West development district is via the 1 South district (Figure 1).

Each development district comprises a pair of roadways, a belt road and a supply road, connected by cross-cuts at intervals of about 150 m. The west districts were developed to serve as gateroads for the longwall panels. 1 West served as the tailgate (supplies, return air) for 1 Panel, while 2 West served as the maingate (supplies, intake air, coal clearance) for 1 Panel and the tailgate for 2 Panel. The 3 West district served as the maingate for 2 Panel.

The gateroad districts were driven to the furthest extent of the longwall panels, and a face installation roadway driven between them. The longwall equipment (see below) was installed, and the panels retreated towards the portals. On completion of 1 Panel, the longwall equipment was stripped, serviced, and reinstalled in the 2 Panel face installation roadway.

The plan area covered by the longwall panels covers the #4 Seam depillared area.

**MINING SYSTEM**

**Criteria for the Application of Longwall Mining**

The basic technological requirements for the successful application of longwall systems are:

- Good roof caving characteristics.
- Absence of geotectonical disturbances (faults, washouts etc.)
- A relatively strong, competent floor to withstand the pressure generated by the mechanical support.
- A uniform coal deposition.
- A large enough deposit to design an optimal panel size/number of panels.

All the above conditions are met in the #10 Seam, 9G Mine. The major reason why #10 Seam has not been mined
Figure 1: Layout of 9G-10 Mine
on Smoky River Coal Limited property was that the roof was too weak for room and pillar technology. Therefore improvements in longwall mining technology offered an opportunity to utilise a vast coal deposit in the 9G Mine area as well as in other mine areas.

Another reason for selection of the longwall technique is the potential production capacity. In spite of the substantial cost of the longwall face equipment, this is a modern, high production system that is widely applied in Europe, United States, South Africa and Australia. The system is a highly productive and efficient method for the tough competitive economic environment of today.

Longwall mining is most efficient in flat, thick seams. As gradients across the faceline increase, difficulties associated with powered support stability and coalface alignment also increase. Although #10 seam is not excessively steep, gradient changes along the length of the panels result in changes in face length and difficulties in aligning the top and bottom ends.

As well as production capacity and efficiency, longwall mining has other advantages over the room and pillar method:

- Simplicity of layout affords an opportunity for more predictable strata control aspects.
- In ideal conditions, less coal is left in extracted gobs, improving recovery and reducing the risk of spontaneous combustion.
- Crews work under a fully supported roof at all times. Better safety is a major advantage.
- A clear, well-defined ventilation system design substantially decreases the risk of unexpected methane accumulations, and airborne dust is easier to control.
- Longwall layouts allow better separation of intake air and extracted areas, difficult to achieve in room and pillar operations.
- Recent technological developments allow for a high level of automation of the entire production process, reducing the physical strain on workmen in comparison to traditional methods of mining.

Development

Roadway development for the longwall panels was accomplished with four Dosco HD1300 Roadheaders, one to each active heading, loading onto shuttlecars dumping to a Stamler feeder breaker which loaded the coal onto the single conveyor belt provided for each development district. Crosscuts at 150 m intervals connecting the twin gateroads allowed the shuttlecar serving the supply road Dosco to access the belt.

The Dosco Roadheaders were initially selected because of cross-gradients in the roadways, which, it was thought, would be difficult to cope with using continuous miners. The HD1300's proved able to cut out the required profile and load the coal at rates comparable to continuous miners, but because of their large size and the distance between cross-cuts, it was impractical to tram them out of the way to allow the use of conventional mobile roof bolting equipment (Fletcher type). The weakness of the roof strata also played a role here; experience showed that cuts exposing more than 2.5 to 3 m of roof quickly deteriorated, which would have been inefficient to mine using "place-changing" methods.

Instead, the Dosco Roadheaders were fitted with self deploying hydraulic drill rigs located on each side of the cutter head for the installation of roof bolts. Supplied by Hydramatic, an Australian company, these units were to have allowed rapid roof bolting between cutting cycles, ensuring advance rates fast enough to develop the two panels in a timely manner.

Unfortunately, the relatively lightweight drill rigs proved to be unsuited for the roadway profile and the ground
conditions. Loose material spalling from the roof tended to damage hydraulic hoses, resulting in considerable downtime, and the cross pitch prevented the timber-jacks on the drill units from engaging the roof, resulting in rig instability and a large percentage of bad bolt installations. Rig instability led to strain on cylinders and other parts, compounding maintenance problems.

The hydraulic controls were also relatively insensitive, which made alignment and control difficult. Bolting cycle times were in excess of 90 minutes for the installation of roof support.

The installed support comprised five 3.6 m long (1.2 m + 2.4 m coupled) by 25.4 mm diameter resin grouted roof bolts with 200 mm x 200 mm x 9.5 mm domed plates through 6.7 m x 1.42 x 8 gauge steel mesh panels to prevent loose material from falling between bolts. The ribs were retained with four 1.5 m mechanical bolts with wooden headers and washers, which retained a plastic, snow fence type fire retardent mesh to retain loose rib material.

The inability to install roof support in an efficient manner was perhaps the most significant factor in slowing development progress.

Figure 2 illustrates 1 Panel Maingate after development.

**Production**

The total longwall system consisted of the following subsystems; coal winning and clearance, roof support and ancillary systems. The major components of these sub-systems are described briefly below.

**Coal Winning and Clearance**

The coal winning machine is a Long Airdox/Anderson Electra 1000 double ended ranging drum shearer, with a total installed power of 957 kW. With a length of 13.4 m and a weight of 63 tonnes in total (Figure 3), it is capable of cutting up to 4.0 m of coal at speeds of 20 m/minute in flat seams on a rack bar type haulage system. The double ended ranging drum configuration cuts a 0.8 m web and is capable of cutting roof to floor in both directions. The shearer was fitted with a radio remote control for improved operator safety.

The shearer loads coal onto a Long Airdox/Becorit heavy duty chain conveyor with twin 38 mm inboard chains. Two 521 kW power units, one at each end, provide a haulage capacity of 2,700 tonnes per hour. The face conveyor loads onto a 26 m long stage loader, capable of handling 3,500 tonnes per hour, on which is mounted a Long Airdox/Becorit SB900 crusher to prevent oversize material from reaching the gate belt. The stage loader feeds the gateroad belt over a crawler mounted belt tail piece (Figure 4).

Outby, two belt take-up and storage units provide 183 m of belt capacity to allow continuous retreat without belt downtime.

SRCL provided the structure, belt and belt drives for the gateroad belts. In 1 Panel, the belt width (1.2 m), belt structure installation, and the location of the belt drive at the bottom of an incline caused serious delays. These were rectified somewhat in 2 Panel, but poor alignment of belt structure, which was a lightweight type ideally suited to room and pillar operations, still caused delays.

**Roof Support**

Roof support on the face and face-ends was supplied by Glinik two leg, 700 tonne shield-type supports. Each support was 1.75 m wide, and weighed 23 tonnes. Face-line supports were equipped with fore-poles to retain the coal face, and all supports were provided with equipment to prevent flushing of the gob into the faceline and to allow safe and efficient operation on seam dips of up to 25°. Figure 5 shows the installed powered roof supports.

Shield destined for the maingate and tailgate face ends were supplied with modifications to allow better roof control
Figure 2: Typical Maingate (Belt Road) Development

Figure 3: Long Airdox/Anderson Electra 1000 DERD Shearer
Figure 4: Longwall Face Systems, showing AFC, Stage Loader and Crusher.

Figure 5: Installed Powered Roof Supports
in these areas, and to accommodate the conveyor drive equipment. The two maingate shields (each weighing 24.5 tonnes) were also equipped with a custom designed canopy linkage that was supposed to allow better operation in cross-gradients. This proved to be ineffective, and was removed for 2 Panel, with significantly better performance as a result.

Although capable of manual operation, the powered supports were also fitted with an electro-hydraulic control system that allowed automatic lowering, advance and resetting of the supports, as well as a surface monitoring station that allowed the status of each unit to be checked.

The hydraulic pumps and fluid tanks for powering the face supports were located on the surface, with high pressure main and return ranges established in the maingate. Because of the severe winters, these lines had to be insulated. Although there were some freezing incidents, the system worked well.

**Ancillary Systems**

The Versatrac VT630 longwall system movers originally supplied were battery operated with a lift capacity of 36 tonnes. Weighing 29.5 tonnes, they were designed to achieve tramming speeds of 4.8 km/hr, to install and remove the heavy-duty face equipment. They never performed to specifications, for a number of reasons, some of which were related to roadway conditions. However, they were significantly under-powered for the mine environment, and as a result maintenance was required on a constant basis. Some of the under-capacity was corrected prior to the second panel installation, and significant improvements in performance were obtained.

The retrieval of longwall supports from a faceline is a difficult and sometimes dangerous task. The “Mutt” crawler mounted shield retrieval unit, however, proved equal to it. Weighing 31.6 tonnes, the unit has a maximum boom lift capacity of 21 tonnes, and a 20 tonne winch, which allowed the face supports and other equipment to be manoeuvred for transport by the Versatracs.

**PERFORMANCE**

**Development**

Budgeted development advance rates were 10.6 m per shift by each roadheader, based on three eight hour shifts working a 5 and 2 rotation. This was close to what had been achieved in continuous miner sections in #4 Seam, albeit under better roof conditions and using a “place-changing” system.

The average advance rate achieved during all development work was 4.4 m/shift. Budgeted development performance was never achieved; in fact 5.3 m/day was only exceeded 30% of the time.

**Production**

Budgeted coal-face production was 45,000 tonnes per week based on three eight hour shifts working a 5 and 2 rotation, or 3,000 tonnes per shift. Some allowance was made for the “learning curve” at the start of 1 Panel.

The longwall commenced production on January 13, 1997. By March 13, 1997, it had produced 212,000 tonnes at an average of 3,500 tonnes per day. Budgeted production rates were only rarely achieved, and for more than 60% of the time production was half that budgeted for. In a similar period immediately after starting production, 2 Panel averaged 3,800 tonnes per day, a marginal improvement.

**DISCUSSION**

There is no doubt that experience with the first modern longwall installation in western Canada was well below expectations, although there were also some positive results.
The Dosco Roadheaders showed that they could cut out rapidly and to profile, although ultimately development rates were severely curtailed by the method of installing roof bolts that had been selected. Although successful elsewhere, in this application the Hydramatic drill rigs had major problems. Drill stability was poor and correct alignment was difficult with the insensitive hydraulic controls. This resulted in crooked holes and misalignment of bolts, resulting in installation failures and excessive bolting cycle times. In addition, the hydraulic system was prone to hose damage and cylinder failures. Use of an “orphan” system did not make matters any easier.

Installation of face equipment was severely affected by under-designed equipment movers that were incapable of performing their function in the 9G-10 underground environment. This necessitated major, costly, design changes and refits prior to stripping the first face, although the modifications appear to have provided some subsequent benefit.

The face equipment itself performed to levels in excess of the contract requirements. Total system availability was 100% for extended periods. However, the longwall system itself was never severely tested because of problems with the outby belt system. The shearer, capable of cutting speeds of more than 20 m/min. in flat seams, was seldom operated at more than 3 m/min because the coal could not be conveyed away fast enough by the gate belts and outby systems.

However, this is not to imply that the system was perfect. In particular the maingate shield design, incorporating an articulated top canopy which the designers, Glinik, assured would provide better roof control in dipping seams, proved to be a nightmare. Irregular roof caused the canopies to tilt and snag, and for much of the time the two maingate shields lay virtually on their sides (Figure 6). The articulated top canopy was removed for the second panel, with much better success.

A major factor in the failure to achieve the planned output was the inefficiency of the coal clearance conveyor and the complexity of the conveyor route. This was somewhat alleviated by the use of a 54” belt for the second panel, but was never fully satisfactory. Any down-time as a result of face or outby problems resulted in a loss of production that could never be made up because the coal clearance system was poorly suited for the anticipated duty.

Perhaps the greatest overall contributor to the poor performance of the longwall system in 9G-10 mine was the effect of siting the longwall panels over an abandoned room and pillar mine. Irregular pillar edges up to 7 m high and only 73 m beneath the longwall resulted in severe deformation of the strata in and around #10 seam, with consequent loss of structural integrity. These interaction effects on the already weak roof strata, created weak zones of roof strata of an irregular and variable extent, resulting in:

- overloading of the roof support system in the roadways requiring expensive, time consuming remedial work to counter. Although the remedial work proved successful in supporting the roadways, when subjected to longwall abutment stresses further failures occurred, especially in the tailgate of 2 Panel, which had already been subjected to the stress redistribution associated with the passage of 1 Panel.

- weak roof on the coal face which caved in front of the supports in very large blocks that had to be broken before they would pass beneath the shearer, or to run through the breaker station mounted on the stage loader. This occurred particularly when outby delays - gateroad maintenance or equipment failures - left the face idle over pillar edges in #4 Seam.

However, despite these seemingly insurmountable obstacles to the success of the project, lessons were learned and the second panel, although much shorter than planned, proved more successful. Improvements to the coal clearance system and to the support of the access roadways learned during development played a major role in the increased productivity.
Figure 6: Problems with the Maingate Supports
RECOMMENDATIONS

There a number of recommendations that can be made to those considering the use of longwall equipment for the first time, based on the lessons learned by SRCL.

The most basic lesson is to use careful judgement in selecting the location of longwall workings. The presence, 67 m below the #10 Seam longwall panel, of an irregular 6.7 m high room and pillar extraction resulted in poor roadway and face conditions and subsequent roof falls. Even in the absence of abandoned mines, correct site selection is essential to simplify the initial panels where most of the learning curve is covered.

On a similar theme, restrict the number of new technologies applied wherever possible, and where new technologies must be selected make sure that they are adequate for the task. In this application a major reason for the sterilisation of large volumes of coal was the non-performance of the roof bolt installation system.

Other recommendations are to:

1. Ensure that coal clearance systems can adequately handle the full production capacity of the mining equipment, not just the budgeted daily production.

2. Understand that longwall mining is very much less flexible than room and pillar methods. Room and pillar sections have multiple, redundant entries. Longwall installations do not. A fall in a longwall gateroad can severely affect production, so greater care must be taken to ensure that falls do not happen.

3. Provide adequate training before introducing new technologies, and ensure that those charged with working with them know the implications of poor implementation and are properly supervised.

4. Take great care in the specification of ancillary equipment to ensure that it will work properly all the time in the most arduous conditions expected.

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Although the results of the longwall experiment were not as successful as had been hoped, SRCL employees, contractors, consultants and equipment suppliers too numerous to mention individually applied themselves with diligence in difficult conditions and often under great pressure. We thank them for their individual and collective efforts on Smoky River Coal’s behalf.