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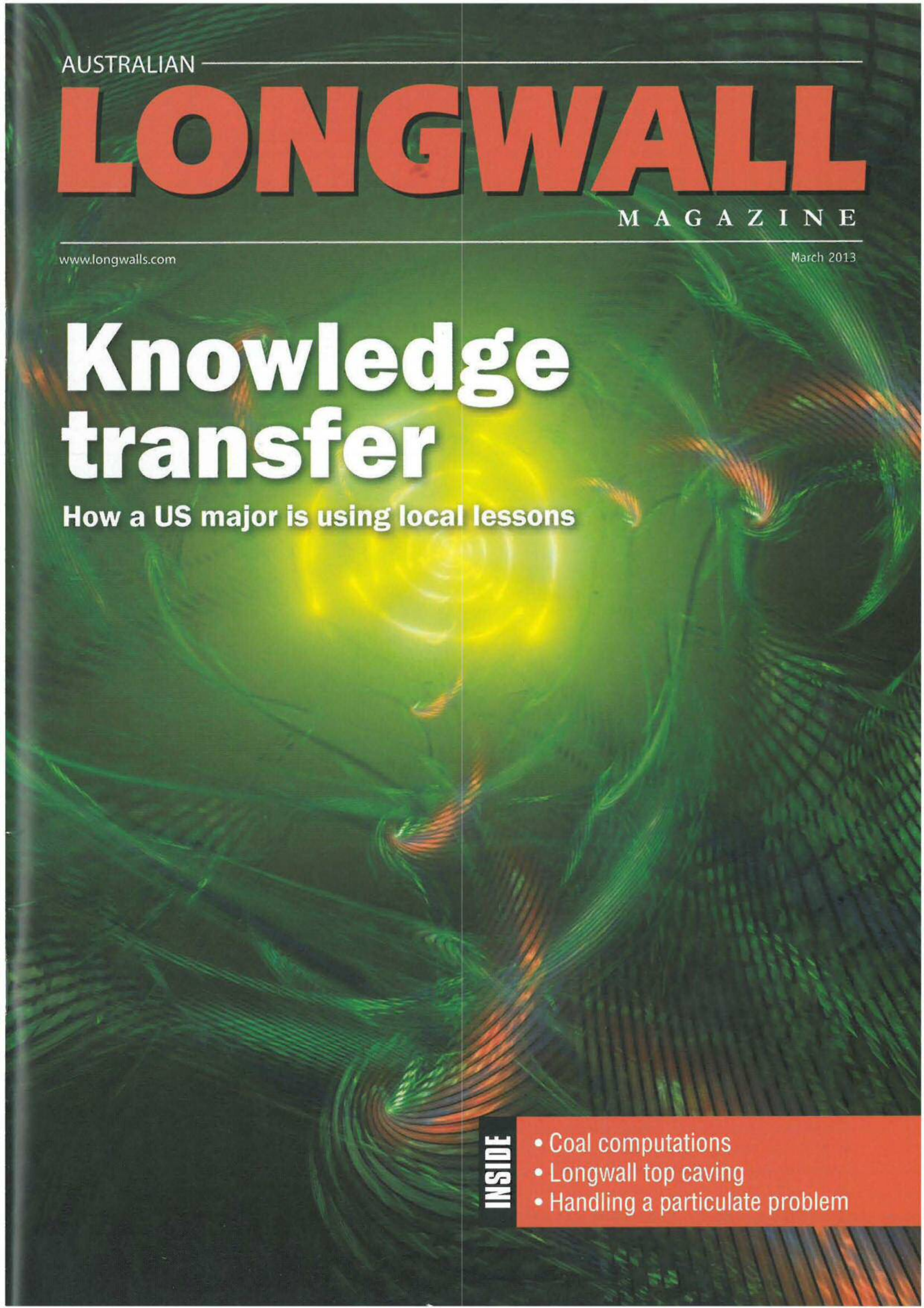

Knowledge transfer

How a US major is using local lessons

INSIDE

- Coal computations
- Longwall top caving
- Handling a particulate problem

LTCC comes of age

Most coal single pass mining methods are cut up to 5m in height. Many coal seams around the world are higher than 5m. By only cutting the single pass, coal mines are sterilising the remaining uncut roof coal, up to two-thirds of the coal seam can be left behind. Longwall top caving may be a way around this. By **Allison Golsby**

Different forms of longwall top coal caving (LTCC) have been in practice for more than 130 years in countries such as Spain, the former Yugoslavia and France.

The technique, sometimes referred to as sub-level caving, was developed to enable mining in areas which were traditionally considered too geologically difficult to mine.

LTCC is a method of extraction for underground mining of thick seams. It uses a traditional longwall set-up with modified shields and an extra armoured face conveyor (AFC) at the rear of the chocks.

The longwall coal cutting process and natural forces are used to aid in the recovery of the coal above the cut horizon.

With this method of extraction only a single longwall is developed at the base of the seam. The control of the strata at the longwall face is by powered supports or chocks. At the face, the coal is mined with a shearer at a set height, and transported out of the mine using the front AFC. As the longwall advances, the upper coal section of the seam is then induced to cave at the goaf side and is removed by the rear AFC, which is situated behind the face supports.

The space behind the rear legs of the modified chocks allows lateral and vertical movements of the goaf shield for control of caving.

At the end of every longwall cutting pass, when the face conveyor and chocks are advanced, the rear conveyor is still protected by the goaf shields.


Allison Golsby

The goaf shields are then retracted to direct the caving coal onto the rear AFC. Controlled drawing optimises coal recovery. The canopies should be provided with openings in case caving has to be initiated by fraccing or stimulation.

The drawing of caved coal onto the rear AFC is controlled in various ways. In one control system, the caved coal is restrained by wire mesh spread over the top and ▶

Rear AFC at the back of roof supports.

down the goaf end of the chocks. Openings cut into the wire mesh allow the coal to pass through onto the conveyor.

Another system uses steel bars hinged at the top rear of the longwall supports and angled into the goaf at about 60 degrees.

Of course, the viability of the longwall top coal caving method depends greatly on the flow characteristics of the caving coal. If it tends to large blocky fractures, it is unlikely the method will be successful.

The major advantages of these methods are the possibility of a very low cost per tonne of run-of-mine coal, high productivity and a high percentage of recovery.

How does top coal caving work?

Top coal caves because it has been fractured due to abutment stresses and loosened by the mining process – the lowering and setting of supports. To the extent that when the longwall chock is advanced, removing the lower restraint from the top coal in the caving zone directly above it, overburden pressure and gravity induces the broken coal to flow down onto the rear AFC.

The cave of coal may require some external stimulation from "feathering" with the rear caving door but, once initiated, the top coal will cave back to a given angle above the supports – the caving angle – dependent on its strength.

Hard coals may have a caving angle of only 40-70 degrees whereas soft coals may have a caving angle up to 100-110 degrees.

Based on the data published in the September 2012 edition of the *Australian Longwall Magazine*, I calculate that 20% of the longwall pits open in Australia could implement LTCC effectively, based on seam height, mining method and seam dip.

In order to use the LTCC method successfully, the coal should part readily from the roof. In cases of sticky coal, LTCC in two lifts should be applied.

First, a longwall face is developed at the horizon of the seam. After that, a second longwall face is developed at the floor horizon of the seam, and the coal remaining between the two faces is recovered by caving.

Thick seams can be almost completely extracted using the Velenje Vertical Concentration method.

Geotechnical information and behaviour will influence the equipment selection.

It is not just the biggest or strongest, but the equipment selection decision-making process should include chock slide aperture size and type; anticipated longwall advance speed; type of chocks; belt size; angle of the chocks; depth of mining (vertical stress); horizontal stress and coal strength and natural coal fractures.

Other considerations for equipment selection include thickness of top coal and inter-seam stone bands; overburden properties; chock capacity and rear AFC and motor size and location.

Could a longwall be developed that can cut 9m?

Superchocks are produced that can function at a 9m cutting height. If a support can then hold a 9m face will it then be cheaper to LTCC than high face mine?

Transporting larger supports and the required larger development dimensions will need to be considered from a cost and time requirement point.

Will support transport become the next challenge?

Supports have been developed to cut 6m, but the face stability management is challenging. Some shield supports have faces that apply support to the front of the face and retract out of the way as the shearer approaches. The higher the face the less stable it will be.

What are the limits of super chocks?

All items on a longwall face have to be considered as parts of an integrated unit and be fully compatible, although poorly designed and inadequate roof supports are likely to have a greater effect on results than other items. Inadequate support design may lead to loss of roof control with significant safety risks and damage to equipment, as well as loss of production.

Ground movement may occur if the support is inadequate and can lead to roof failure and loss of control.

With the large number of longwalls which have been worked, it is likely that similar conditions will have been encountered elsewhere. Useful information may already be available to design the longwall components.

Overdesign will avoid the risk of loss of control but at a cost and possibly will introduce other problems associated with size and weight.

Support design/selection considerations should include the ability to control the rate of closure of the mined opening. This will include setting and yield loads, support stiffness, hydraulic system pressures and support geometry.

Load distribution on roof and floor strata, hydraulic systems with regard to ease of operation, minimisation of potential leakage points, speed of operation and pressure requirements need to be considered in chock design. So too does the support operating height range to handle seam thickness variations and to enable transport around the mine when fully closed.

The overall size and weight for transport purposes and the ergonomic aspects both for operation and for maintenance/parts replacement also are important factors to consider.

Cost has intentionally been excluded from the list of considerations.

It may be a factor in deciding between two otherwise satisfactory offers or may be the deciding factor in continuing or abandoning a project.

Costs should not be a consideration in determining the adequacy of support systems. That should be a purely engineering exercise.

If the bearing pressure on the strata is too great, this can cause roof failure in itself, especially at the goaf edge where horizontal constraint is lost.

A higher load is more easily obtained by increasing the leg cylinder diameter, but this, of course, comes with increased cost and more difficult material handling if a leg replacement is required.

As conditions become more onerous, both high pressure set and large leg diameters are required.

Unlike conventional longwall mining where the trend in recent years to ensure face stability has been towards stronger and stiffer chocks, the LTCC process benefits from a lower capacity support (around 600 tonnes). The cyclic lowering and raising the canopy during face advance and from chock closure during the cutting cycle are also important for LTCC.

These actions open fractures on bedding planes and induce the second fracture set drawn in oblique to fractures induced from abutment stresses.

LTCC chocks are also not subject to as intense periodic weighting effects due to the thickness of the coal roof they interact with and hence may be of lower capacity than those used under a hard roof.

Is LTCC the answer?

The advantages of the LTCC mining method compared to high reach single pass longwalls include the development costs and the investment in face equipment provision of services, which are well below those required for mining methods with similar extraction ratios and seam heights.

Also, some coal is extracted without the use of and costs of cutting this coal. That means a small number of faces can produce large quantities of coal. Supervision is simpler and, therefore, there is greater efficiency of engineers and supervisors and other personnel.

Productivity is high with LTCC, there is enhanced resource recovery compared to traditional longwall. Subsidence is mainly instant, allowing for enhanced planning and more exacting compliance in mining with mine planning.

There is increased face stability, reduced risk of goaf spontaneous combustion.

The environmental impacts (particularly subsidence) can be more readily tailored to the sensitivity of the area by controlling the extent of coal recovery from the caving process. ▶

It is also suitable for highly fluid coal.

The disadvantages of LTCC may include surface subsidence, which may very much change the landscape above the mine and may damage natural or man-made structures or features. There also can be increased dust generation and poor ventilation for the rear AFC, resulting in an accumulation of dust and gases, and more heat measured in kilowatts from additional AFC drives on the face.

There may be explosive hazards from rear AFC drives when exposed to gas made from the caving coal with limited ventilation.

Caving characteristics could be difficult to model, particularly in greenfield sites. There could be increased dilution, with the caving recovery manually operated and dependent on operator skill and judgement.

LTCC requires the coal to have good caving and fragmentation characteristics. Gate road supports take up the entire width of roadway.

With LTCC it can be difficult to manage goaf flushing and spills at the tailgate drive area.

The LTCC system is considered ideal for thick seams (from 5-12m), whereas standard longwall equipment is only capable of mining in seams of up to 4.5m.

The LTCC mining method requires a powered roof support for the main gate roadway, specifically designed shields to control the caving of the top coal. It requires the site selection process to include geotechnical suitability.

It also requires increased installation and recovery roadway span widths, particularly at 8.5-9.5m at gates.

Conclusion

To date, LTCC has not been widely used in Australia. The technique should not be implemented with the assumption that one methodology fits all coal seams or ground conditions.

There are many factors that need to be taken into account. Experiences at the coal face may dictate how LTCC is implemented in individual mines. Re-engineering the methodology may be necessary to take account of the ground conditions and the physical characteristics of the coal seam at the individual mine.

Compared to high reach single pass longwalls, the LTCC method offers a lower face height, resulting in smaller and less expensive equipment, better face conditions, and combustion improves spontaneous control in thick seams.

The cavability of top coal influences include coal strength, cover depth, top coal thickness, joint/cleats in seams and overlying strata. Many geotechnical factors influencing the performance of the LTCC method in thick seams have not been investigated thoroughly in Australia or elsewhere.

Caterpillar has extensive experience in the design of shield supports for specific mining conditions.

To gain confidence in LTCC predictive modelling, empirical data needs to be collected, collated and assessed against the modelling to refine the modelling outputs.

Some of this can be achieved through stress measurements and using particle flow markers ahead of the face.

As with any mining technology change, consultation, contingencies, change management and continuous improvement processes are critical to its success. AL

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