LONG-HOLE DRILLING FOR IN-SEAM EXPLORATION

By

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ABSTRACT

Long-hole drilling technology has rapidly developed since the 1970's and has seen a mixture of success and failure in securing funding and support from research agencies. The means now exists, to provide definition of geological structures approaching the accuracy required by mine planning. It is up to the industry and research agencies to continue to support these developments which are clearly needed across the industry.

INTRODUCTION

The prediction of geological structures ahead of the working face has always been of high importance in the Australian and international coal mining industry. With the growth in less flexible, high production mining methods, the need to define geological structures in advance of mining has increased.

The importance of geological structure prediction was recently reflected in an industry wide research survey by the Australian Coal Association. The prediction of faults, discontinuities and interruptions to the seam was placed in the top priority research category for both surface mining (Tennent et al., 1987) and underground mining (Goff and Hibblewhite, 1987).

Prediction of the location and nature of geological structures is made difficult by:

1. the geological complexity and variability, and
2. the limitations of the various prediction methods.

This paper broadly assesses the applicability of long-hole drilling as a predictive tool with respect to:

1. different geological environments,
2. the basic methodologies and equipment available, and
3. areas for future development.

Reference is made to the cost factors affecting long-hole drilling options.

The sections on "Methods Employed" and "History" summarise and update the...
description by Williams et al. (1986).

METHODS EMPLOYED

Long-hole drilling is carried out by either rotary drilling, in which the entire drill string is rotated by the drill chuck, or down-hole motor drilling in which the drill string remains stationary and the bit rotates.

In rotary drilling, borehole vertical trajectory is controlled by varying the revolution and thrust applied to the bit, the actual values depending upon ground conditions, consumables used and depth of drilling. The revolutions and thrust are independently controllable. The drill rig must have the power to push, pull and rotate rods to the required depth. A high capacity water pump is required to provide the necessary flow and pressure to clear the hole of cuttings.

The down-hole motor is powered by the flushing water turning a helical rotor within a stator. It consists of the following major components (Figure 1).

1. A rotor and stator motor assembly.
2. A bent housing and connecting rod assembly which gives the tool its steering ability.
3. The bearing pack and drive shaft assembly, and drill bit.

Surveying is critical to long-hole drilling and is normally carried out during drilling. The two basic options are

1. pump down single shot camera surveying, and
2. electronic cableless surveying.

In the former method, a camera is pumped down the drill string to behind the bit or down-hole motor. To obtain accurate azimuth readings, non magnetic components must be used around the survey area. The camera is timed to take a photograph of the floating gimbal compass with allowance made for the pump-down time. The tool is retrieved by wireline.

With cableless electronic surveying, the survey tool remains in the drill string immediately behind the down-hole motor, or (more rarely), about 3m behind the drill bit in rotary drilling applications. The tool is activated remotely, by either sending an electromagnetic signal down the rods or sensing the change in water pressure or drilling noise (vibration) with each rod addition.

The basic outputs from both methods are the borehole azimuth, dip and, in down-hole motor applications, "tool face" orientation (i.e. the direction the bent housing is facing). With cableless electronic surveying, the output is to a read out box where additional computations are performed.

Single shot camera surveys are time consuming and depend directly upon the depth of the borehole. At 300m depth, the survey time is around 25 minutes. Unless low survey frequencies are suitable, it is normally not worth employing single shot camera surveying in boreholes greater than 300m depth. Surveys are usually conducted at 15m to 30m intervals with the tendency being to survey less frequently as the borehole length increases.

With cableless electronic surveying, there is no survey time dependence on borehole depth. Depth limitations depend on the ability to transmit clear data. A range of 1000m for the Geoscience survey tool has been proven at Appin Colliery. With surveys taken at every rod change, much greater control can be achieved over the drilling.

While cableless electronic surveying is clearly the preferred surveying option, it has only recently (1986) been introduced into Australia. Costs are relatively high and with the only proven tool to date (the Geoscience tool), local back-up is not yet available. Dupont Australia Pty. Ltd. are manufacturing and supporting the CONCO cableless survey tool. Hopefully, it will only be a matter of
time before this tool is operationally proven in Australia.

**HISTORY**

In assessing the applicability of long-hole drilling for in-seam exploration, it is important to review the achievements and problems encountered to this point in time. Long-hole drilling was initiated in Australia in 1981 by the Australian Coal Industry Research Laboratories Ltd. (ACIRL). The main objective was to improve the efficiency of gas drainage. Drilling trials were conducted using an Acker "Big John" at Talmoor, West Cliff and West Cliff Extended collieries up until the completion of the original National Energy Research Development and Demonstration Program (NERDDP) project in 1985. Maximum borehole lengths of 732m and 825m were achieved by the rotary and down-hole motor methods respectively. Although some problems were experienced in negotiating shear zones, the main limitations were equipment related. The down-hole motor employed had inadequate torque and was unreliable. Surveying time using a pump-down camera was unacceptably long. A cableless electronic survey tool was not available.

In 1987, long-hole drilling for gas drainage commenced at No.2 Mina, Collinsville and at Appin Colliery, Collinsville. Difficult drilling conditions were experienced throughout the project up to its termination in 1989, when a decision was taken to retreat the colliery and conclude the long-hole drilling and gas research work. Rotary drilling was employed with the longest borehole reaching 335m. Severe problems were created from borehole collapse and entrapment of drilling equipment. Irregular seam geometry caused premature borehole termination. Drilling conditions at Appin Colliery were favourable for long-hole drilling. Initially, drilling of sub 300m long boreholes by the rotary method was routinely achieved. Boreholes were maintained in-seam without the need to survey. Appin Colliery has continued to develop and apply long-hole drilling for gas drainage and in collaboration with ACIRL, is currently engaged in a major NERDDP/BHP funded long-hole drilling project. Using a down-hole motor/cableless electronc survey tool combination, the project has succeeded in drilling the first Australian in-seam borehole in excess of 1000m in length. Excellent directional control allowed the drilling of a cross measure borehole from the Bulli seam to tangentially intersect the underlying Knoxwells seam and continue in this seam for a total distance of 923m.

Problems encountered in the Appin Colliery project were primarily in defining and achieving a predictable trajectory response. These were overcome by use of appropriate combinations of down-hole motor bent-housing and bit type and importantly, correct operator technique. No significant in-the-hole problems have been experienced.

In January 1986, a long-hole drilling trial was set up and supervised by ACIRL for BHP Macarthur Collieries at John Darling Colliery. Rotary drilling was employed. The requirement was to locate and identify geological structures for mine planning. Good drilling conditions were experienced during the trial. In spite of an undulating seam attitude, the drill bit preferentially followed the seam. As a result, there was no need for close surveying for drilling control. BHP Macarthur Collieries subsequently purchased drilling equipment and have been routinely engaged in long-hole drilling from that time. The work has succeeded in defining and locating a variety of geological structures. A new record borehole depth of 1008m has been achieved (Rosa et al., 1987).

In 1986, Nethana Drainage Pty. Ltd. commenced long-hole drilling for gas drainage at Tower Colliery. A down-hole motor/cableless electronic survey tool was used. Drilling was initially carried out in the Bulli seam and subsequently in the Wongawilli seam. Difficult drilling conditions, especially in the Wongawilli seam in conjunction with lower than expected gas flows resulted in the project being terminated in December 1987.

In March 1987, a long-hole drilling trial was set up under ACIRL supervision at German Creek. The colliery has since persevered with the technique to define geological structures around the new Southern Colliery. Boreholes have been rotary drilled to a maximum depth of 664m. Lack of vertical control due to an unsuitably high rotational speed range of the drill for the bit design and coal conditions, made the boreholes difficult to maintain in-seam. An attempt to improve arimct control by using down-hole motor drilling was unsuccessful due to unreliability of the particular unit used. Drilling is continuing.

The work carried out across the industry to date, has involved widely differing equipment specifications, variations in technique and considerable differences in the drilling conditions and not surprisingly, a mixture of success and failure. The sections that follow, examine some of the main differences in terms of geology, equipment and technique.

**GEOLOGICAL CONSIDERATIONS**

All methods of geological structure prediction involve interpretation and interpolation. A successful interpretation...
very much depends upon how well the geology of the area in question is understood. With long-hole drilling, the geology is additionally important in determining the in-hole drilling conditions.

The type and degree of structural deformation varies between the coal basins and the coal districts within a basin. Different areas are characterised by particular sets of geological structures (Table 1).

The greater the number and diversity of geological structures, the greater the difficulty in interpretation. In long-hole drilling, this can also mean the greater the difficulty in drilling.

Probably the most difficult structures for both drilling and interpretation, are thrust faults, which are commonly encountered throughout the Bowen Basin. Normal faults are generally widespread and together with differential compaction faults present the least problems for drilling and interpretation.

The approach to exploration drilling is significantly modified by the presence of sufficiently high seam gas quantities. High seam gasiness is particularly prevalent in the Bowen Basin and the Southern District of the Sydney Basin (Table 1).

Where seam gas is not a problem, exploration drilling can be conducted without standpiping or concern over the precision of borehole directional control. In gassy conditions, boreholes are usually standpiped and generally require directional control. As well, the potentially greater risk to personnel must be offset by additional safety precautions.

Coal strength and modulus are likely to prove increasingly important as a preliminary indicator of drilling conditions. Bowen basin coals on average, have a significantly lower strength and modulus than Sydney Basin coals (Rawlings, 1985). The result is broader zones of weak coal associated with geological structures. In drilling terms, it can result in loss of borehole directional control and/or in boreholes that are more prone to collapse.

Long-hole drilling costs are particularly sensitive to in-hole conditions.

### APPLICATION

Long-hole drilling is mainly target applied, either in defining in greater detail (or disproving), geological structures inferred by other means, or proving important

<table>
<thead>
<tr>
<th>Region</th>
<th>High Fault or Dyke Intensity (1)</th>
<th>Normal/Strike Slip Faulting</th>
<th>Thrust Faulting</th>
<th>Differential Compaction Faulting (2)</th>
<th>High Seam Gassiness (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Bowen Basin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern - Collinsville</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Central - German Creek</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Blackwater District</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Moura District</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>B. Sydney Basin</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Newcastle District</td>
<td>X</td>
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<tr>
<td>Singleton District</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Cessnock/Muswellbrook</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td></td>
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<tr>
<td>(Great Coal Measures)</td>
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<tr>
<td>Western District</td>
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<tr>
<td>Southern District</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>C. Tasmania</td>
<td>Fingal District</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

(1) Difficulty in locating longwall pillars in fault free areas in some collieries.
(2) Fault trace is typically irregular.
(3) Generally applies to depths greater than 200m in the Bowen Basin.
mining areas such as longwall blocks, to be free of structures.

The techniques indicated in Table 2 are applicable at different stages of a colliery's development. At the bottom of the table are the techniques employed from in-seam where greatly increased accuracy is expected. Long-hole drilling has the potential to define structures to an accuracy well beyond other techniques.

No predictive technique is ever completely used in isolation. A high increase in confidence level results from two essentially independent techniques producing a similar conclusion. As well, different techniques can be complementary and produce an acceptable result where either one alone may be insufficient.

The combination of in-seam seismic surveying and long-hole drilling is particularly complementary. The in-seam seismic method provides targets for long-hole drilling, the results of which can potentially enhance the in-seam seismic results by re-interpretation.

Although two basic methods have been described (rotary and down-hole motor), within each is scope for a variety of equipment and techniques. These are significant in terms of cost and quality of information obtained.

The variations on these two basic options are outlined below.

**ROTARY DRILLING OPTIONS**

**Survey After Drilling**

This option requires very good drilling conditions where surveying is not needed for drilling control. There is essentially no control on borehole azimuth making it inappropriate for gassy conditions where borehole direction is important. Applicable borehole lengths are 0 to 1000m.

It is successfully used in South Africa and appears to be applicable in the Newcastle Coal District.

It is the lowest cost option. Increasing borehole lengths are reflected in increasing capital costs, but operating costs are relatively independent of borehole length.

**Pump-down Surveys During Drilling**

This is potentially the next lowest cost option, provided boreholes are limited to 300m depth. The depth limitation results from the increase in survey time with borehole depth.

High costs (making this option generally not applicable) occur in the more difficult drilling conditions where boreholes are prone to premature termination in the seam roof or floor. It can result in multiple boreholes being drilled, to eventually reach the target depth. Where gas control is a factor, the problem is exacerbated as standpipes are usually required for each new borehole.

**Cableless Surveys During Drilling**

This option potentially overcomes the depth restriction imposed from the pump down survey tool. No cableless survey tool is currently proven for this role although DuPont Australia Pty. Ltd. claim to be close to marketing a functional unit.

Although the problem of premature borehole termination by seam roof or floor still exists, for greater drilling control is provided through the high survey frequency (every rod change). If the survey tool additionally has a natural gamma sensor, there should be greater scope for avoiding intersections with the seam roof or floor.

**DOWN-HOLE MOTOR DRILLING**

**Pump-down Surveys During Drilling**

This option would be applicable in situations where azimuth control is required. The depth limitations of the pump-down survey tool still apply, realistically limiting boreholes to 300m depth.

Down-hole motors never drill straight (unless the bent housing is replaced by a straight section resulting in loss of directional control). They consequently require a high frequency of survey data for drilling control. The low survey frequency provided from pump down surveys is for the most part, inadequate. It is therefore, a "poor mans" option, applicable where capital is difficult to justify and operating costs are not a visible concern.

The ability to branch and restart a borehole is an advantage which could warrant use of this option.

The intermittent use of down-hole motor drilling to branch or re-direct a rotary drilled borehole can also be advantageous.

**Cableless Surveys During Drilling**

Although this option is the most expensive to set up, it has the greatest flexibility of application for a range of geological conditions. In terms of information obtained, especially from very long boreholes (500 to 1000m), it is likely to be the most cost effective.

The cableless survey tool provides a high frequency of survey data allowing rod-by-rod corrections to trajectory in response to changing in-hole conditions. Borehole azimuths can be very accurately controlled (to within ± 3m of the planned path).

This degree of control means far less wasted footage for drilling to a target depth and pattern.
Table 2
Summary of the Main Geophysical/Drilling Methods For Defining Geological Structure

<table>
<thead>
<tr>
<th>Method</th>
<th>Main Structures Identified</th>
<th>Resolution (Ideal Conditions)</th>
<th>Application /Range</th>
<th>Limitations Caused By:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Based High Resolution Seismic Reflection</td>
<td>faults, seam attitude</td>
<td>3-5m throw faults, location to + 30m</td>
<td>lease-wide evaluation - mine planning</td>
<td>weathering zone, surface access, inadequate reflections in multi-seam sequences.</td>
</tr>
<tr>
<td>Surface Based Magnetometer</td>
<td>dykes</td>
<td>&gt; 0.3m thick location to + 40m</td>
<td>lease-wide evaluation - mine planning</td>
<td>thick surface alluvium, low magnetic susceptibility, cultural noise, geometry.</td>
</tr>
<tr>
<td>In-Subsea Seismic Reflection</td>
<td>faults and dykes</td>
<td>fault throws half seam thickness and greater, location to + 30m</td>
<td>up to 700m ahead of mine workings - mine planning</td>
<td>masking area beyond dominant structures, distance, geometry.</td>
</tr>
<tr>
<td>In-Subsea Seismic Transmission</td>
<td>undifferentiated structure</td>
<td>seam continuity, present or not, no discontinuities</td>
<td>1000-1200m - mine planning</td>
<td>guides can allow transmission through faulted zones.</td>
</tr>
<tr>
<td>Long-Hole In-seam Drilling</td>
<td>faults, dykes, mylonite zones, seam thickness, dykes to 0.5m. Location to + 3m along borehole.</td>
<td>throws of about seam thickness,</td>
<td>up to 1000m ahead of mine planning</td>
<td>interpretation of faulted zones, drilling conditions.</td>
</tr>
<tr>
<td>Long-Hole # Drilling With &quot;Along-Hole&quot; Geophysical (mainly seismic) Logging</td>
<td>faults, ++ dykes, rolls washouts, mylonite, seam thickness changes</td>
<td>faults ** to 0.1m throw, seam thickness to 0.1m, rolls to 0.5m amplitude, dykes to 0.5m thick. Location to + 3m along borehole.</td>
<td>up to 1000m ahead of mine planning</td>
<td>borehole stability/availability. Faults greater than seam thickness unless drilled through.</td>
</tr>
</tbody>
</table>

* indicative values only
** potentially achievable
# currently being researched - conducted by BP Aust. Pty. Ltd. with contracted research to the University of Queensland and ACTEL. Project to conclude in 1990.

The AusIMM Illawarra Branch, 21st Century Higher Production Coal Mining Systems—Their Implications, Wollongong, NSW, April 1988

90.
Especially in the first long-hole, the seam attitude will not be accurately known. The technique used by ACIRL is to periodically intersect and terminate in the seam roof, pull back a few rods, branch off and continue the borehole. Branching away from the seam roof, where gravity is an important assisting factor, only takes a half to one hour to execute.

A potentially major concern with long-hole drilling and especially down-hole motor drilling with a cableless electronic survey tool, is loss of equipment through borehole squeeze or collapse. The down-hole items can cost over $200,000 to replace, depending on the brand of equipment used. Failure to recover equipment, in a longwall pillar for example, can cause additional difficulties during mining.

Given the variety of potential long-hole drilling problems, it remains to discuss the essential ingredients for successful drilling.

SUCCESSFUL DRILLING

Four factors combine to determine the success of the long-hole drilling.

1. Expertise of the drilling team.
2. Standard of equipment.
4. General level of support from the colliery.

EXPERTISE

The wide range of equipment, techniques and geological conditions places high importance on the skills of the drilling crew and technical supervision. Long-hole drilling and especially down-hole motor/cableless survey drilling require specialist personnel. Correct operation of equipment requires specific training. The ability to react positively to hitherto inexperienced events requires both good training and experience.

Planning is important. The best available geological information is required to plan trajectories and identify potential trouble zones. Trajectory information needs to be updated daily and even during the shift. The act of drilling requires a high level of on-the-job decision-making.

The drillers need to develop a “feel” for the conditions and to know where they are within the seam. In down-hole motor/cableless survey drilling, the survey tool sensors are located about six metres back from the bit, not directly behind the bit. The survey results therefore always apply to the previous drill rod, so that the drillers need to “think” one rod ahead in making correct tool face angle adjustments for survey control. The ability to anticipate and cope with difficult ground is inherent in every type of drilling. It assumes greater significance in down-hole motor/cableless survey drilling where the drilling horizon is in potentially all difficult ground, and the cost of down-hole components is relatively high.

Miners Federation personnel are eminently suitable as drillers whether employed as contractors or within the colliery, the expertise required needs to be recognised in the level of training and the frequency of job rotation.

Depending upon the complexity of the conditions, a degree of technical backup is required for planning, trouble shooting and providing supporting technical information such as up-dated trajectory plans. The same technical backup would be involved in interpretation of results which will require synthesis of information not available on the drill site.

EQUIPMENT

Becoming “stuck” in a borehole will inevitably occur. Good equipment can greatly reduce this misfortune and provide the means for speedy retrieval of down-hole components. The drill rig employed should have a capacity well in excess of the planned drilling depth so that adequate pulling force is available to extricate rods “stuck” at the planned drilling depth. Over-reaming with a larger set of rods can be successfully applied provided the drill rig has sufficient capacity.

It also follows that all items of down-hole equipment need to be of the highest quality to minimise down-hole failures.

The water pump needs to provide ample water to flush the borehole and in down-hole motor drilling, to provide optimum torque and power to the drill.

GEOL OGY

Geological factors will have a significant bearing on the design, duration and cost. Failure to make adequate allowance will, at the least, cause time delays and cost blow outs. At worst, it will render the effort a total failure.

Even with top quality expertise and equipment, there will be prohibitive geological conditions where the application of long-hole drilling would be inappropriate.

COLLIERY SUPPORT

Scheduling in underground mines is a generally difficult task. In long-hole...
drilling, accurate scheduling is no less important but potentially more difficult to effect.

Drilling, whether for gas drainage or in-seam exploration, is based on addressing mining events that can be well into the future. Scheduling of drilling is often based on a site yet to be mined out. Delays in mining can throw out the drilling schedule thus adding another cost element to the exercise, in equipment and labour utilisation. Priorities, especially under today's economic constraints, favour production to the extent that drilling activities, from setting up through to operations, can be adversely affected. Timely assistance of electricians, fitters and labour is required in site set ups and site moves.

It follows that successful drilling requires good access to colliery resources. Being a relatively new activity, it is all the more important for those involved in the drilling to make their needs very clear to colliery management from the outset.

PAYBACK

The object of long-hole drilling is not to make holes in the ground per se, but to produce a beneficial result for either geological information or gas drainage. It follows that the worth of long-hole drilling is not to be gauged in its cost per metre, but in the information obtained, or the amount of gas drained. This will vary according to the situation and can only be assessed for each drilling job.

For geological exploration, the drilling is essentially open-hole. In-seam core drilling for more than a few metres is not an option. The metrage rate is very slow, directional control is impossible and the core barrel and bit are more prone to entrapment with the low flushing quantities and reduced borehole clearance used in coring.

The information has to be interpreted from cuttings, penetration rates, system pressures and water pressure (for down-hole motor drilling). Where the picture is not becoming clear, coring has to be undertaken. This involves additional rod running and a marked reduction in drilling progress. As the aim of the drilling is to obtain information, the additional effort (and cost) is likely to be worth it.

Hard dykes will require coring and progress will be comparatively slow.

Soft clay dykes present a serious problem to long-hole drilling. To drill into such a structure with a down-hole motor/cableless survey tool risks complete loss of down-hole equipment. The colour of flushing water is of no assistance during drilling as the water takes up to 12 minutes to flow from the bit to the collar in a very long (1000m) borehole. The driller will need to be alert to possibly subtle changes in drilling pressures and penetration rates and proceed cautiously.

One of the prime aims of the drilling is to identify faulting. The driller will need to differentiate between an inadvertent intersection of the roof or floor and the loss of seam through intersection of a fault. A faulted zone will be preceded by softer coal. Reference to routine records of penetration rates and system pressures will assist the interpretation.

Pulling back and branching several times will also assist in resolving the structure. Finally, cores may be required for confirmation.

Long-hole drilling would rarely be carried out without some target structure to confirm. The previous state of knowledge would be incorporated to assist the process of arriving at a confident interpretation.

RESEARCH

Long-hole drilling is a recent development that is only now beginning to be used by the industry. This paper has sought to highlight what is involved in this type of drilling. It is not a proven technique and involves an element of risk, largely from its unproven state.

Research needs to be conducted in the areas of:

1. drilling, and
2. interpretation.

The cableless electronic survey tool is scarcely out of the development stage. The expensive down-hole component needs to be redesigned to enable retrieval through the drill rods in the event of the equipment becoming stuck in the boreholes.

The natural gamma sensor incorporated in the COMCO survey tool seeks to address the important requirement of a seam following device but the extent of application needs to be tested. Developments in multiple gamma sensors in the United Kingdom have the potential to differentiate between seam roof and floor. There is clearly scope for further research to aid "seam following".

The cableless survey equipment urgently requires bringing to a fully proven stage.

Techniques of overcoming borehole instability problems require development. The use of various drilling fluids needs evaluation. The replacement of casing in unstable zones at any depth of borehole requires development and testing.

Research needs to be ongoing into different bit types and their effect on
directional control and penetration rate.

The ability to interpret long-hole drilling results should be significantly improved if a current project to develop an along-hole geophysical sounding is successful. The project is NERDAP funded, conducted by BP Australia Pty. Ltd. with subcontracted research to the University of Queensland and ACIRL. It takes advantage of the close range given by long-hole drilling, potentially enabling very high resolution geophysical techniques (principally seismic) to be used from within the borehole.

The tool will generically enable definition of a wider variety of structures to a degree far beyond any current technique (Table 2).

ACIRL are currently planning to combine long-hole drilling and in-seam seismic to give geometrical and distance advantages to the in-seam seismic method, involving installation of geophones and sources down long boreholes.

CONCLUSIONS

Long-hole drilling technology has rapidly advanced this decade culminating in down-hole motor drilling with cableless electronic surveying in the past two years.

In that time, the application across the industry has been one of success and failure. Much has been learnt from these experiences and no doubt the learning process will continue. Techniques have been streamlined and equipment significantly improved.

In each application, careful consideration needs to be given to the type of long-hole drilling employed and the prevailing geological conditions.

The greatest range and flexibility is in down-hole motor/cableless survey drilling. This type of drilling is likely to predominate in the years ahead.

Top quality expertise and equipment are required for successful application. It is more involved and potentially more difficult than other forms of coal measure drilling.

Galleries contemplating its in-house introduction must satisfy themselves that they have sufficient continuity of work to justify the building up of the considerable expertise and equipment levels.

Drilling is traditionally costed on a per metre basis. The authors believe this to be a generally inappropriate way to cost long-hole drilling. The object is gain relevant geological information and the cost will require coring, borehole branching and slower open boiling through stone. The most realistic approach is to evaluate the likelihood of reaching the required target depths after assessment of the prevailing conditions, and apply a time constraint to the project thus enabling reasonable accurate pre-job cost estimates.

The cost benefit of long-hole drilling must be assessed in terms of the detail of information gained and its importance to mining. Given the financial penalties resulting from inadvertent intersection of structures around longwall blocks and the importance of defining areas in longer term planning, long-hole drilling in most situations, should prove highly cost beneficial.

Long-hole drilling is the only method that directly tests the area prior to mining, hence providing a potentially high level of confidence and forewarning.

The proving up of structure-free blocks is likely to be accorded similar importance to direct structure location.

With the recent developments in long-hole drilling, the authors would not be surprised to see gassy mines becoming more cost competitive than equivalent non-gassy mines.

Long-hole drilling has the dual application of gas drainage and in-seam exploration. The higher frequency of drilling required for gas drainage will provide far more detailed exploration information than in a non-gassy mine. The gas, especially if methane, is a saleable resource in itself. Appin Colliery is clearly poised to make first use of this advantage.

Significant research remains to be carried out, in developing techniques to drill in adverse geological environments and improving the general efficiency.

The advantages long-hole drilling poses for geophysical-based predictions are becoming more evident as drilling capabilities increase. Current research on the development of an along-hole geophysical sounder for use in conjunction with long-hole drilling will hopefully prove a major advance in geological structure prediction.

The means now exists, to provide definition of geological structures approaching the accuracy required by mine planning. It is up to the industry and research funding agencies to continue to take the challenge and support these developments.

REFERENCES


R.J. Williams and F. Hungerford


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