

DRILLING TO DELINEATE VINTAGE WORKINGS

Longwall directional drilling is one of the best tools a mine can use to identify the location of previous mine workings.

By Michael Bohan and Dan Brunner

Almost three years have passed since the Quecreek Mine breached the inundated abandoned workings of the adjacent Saxton Mine. Fortunately, the nine trapped miners were brought safely to surface thanks to the diligence of rescue workers and the US Mine Safety and Health Administration (MSHA).

Since 1983, there have been over 200 reported breaches into abandoned mines resulting in water and/or gas inundations.

At present, because of current domestic and international market pressures, coal operators are opening new mines, adding additional production units to existing mines, and maximizing coal recovery from existing reserves. In areas where significant mining has occurred, geologists and engineers are squeezing in new developments alongside or in-between abandoned workings, some of which are not well charted.

"Final" or "Closure Maps" are not always the updated mine maps they are intended to be and may not accurately reflect the actual location of all of the workings. In some cases where new developments are contemplated near vintage mines, operators research through historical texts to look for information.

One of the "Best Practices" recommended by MSHA for the safe recovery of coal (and to

optimize coal recovery) near abandoned mine workings, is the strategic application of longhole directional drilling.

Longhole directional drilling

By law, when active mining encroaches to within 200ft of any mine workings, face drilling, or boreholes maintained at least 10ft in advance of any working face (drilled at an angle of 45 degrees relative to the direction of advance, and no more than 8ft apart), are required. This applies when workings cannot be pre-shift examined or are not shown by surveys on a mine map certified by a registered engineer or surveyor.

For mine operators exploiting reserves significantly bounded by old workings, face drilling is a costly, time consuming, labor-intensive effort that requires coordination with face advance.

It is in fact a reactive approach to a potential problem, as detecting old workings immediately in advance of mining typically requires significant and costly changes to mine plans. Fortunately, the law allows for a more proactive approach using longhole directional drilling under 30 CFR 75.388 (g). Longhole directional drilling has been approved by MSHA as an acceptable "Alternative Borehole Pattern".

Directionally drilled boreholes are maintained in the mining seam through the

evaluation of drilling parameters, the use of downhole directional drilling technology, and state of the art measurement with drilling borehole survey equipment. These boreholes are placed to verify coal continuity along their length.

Where voids are anticipated, multiple lateral boreholes can be developed to probe the profile of the coal seam in more detail. As shown on Figure 1, these boreholes can provide a continuous boundary several thousand feet long and delineate reserves significantly in advance of mining for mine planning and maximization of recovery. Directionally drilled boreholes can also intentionally target and intercept old workings to verify their location and allow orientation of old works maps.

Directionally drilled boreholes may be developed from outby locations and do not need to encumber face activities. In fact, in some cases MSHA has allowed mining advance (less than 200ft from old workings) to proceed once the directionally drilled borehole extends 200ft beyond the active face. Additionally, some operators have received approval to mine within 50ft of approved directionally drilled boreholes to maximize coal recovery near old workings.

REI Drilling's units can accurately steer and place boreholes in excess of 5000ft in length.

Drilling measures

Prior to directional drilling, the condition of the old workings are anticipated. For example, if inundated, water pressures are estimated, and data from prior breeches, the potential for gas, or air, the differential pressure between the active mine and abandoned workings (direction of gas flow when breeched), and the mining technique (selective mining of coal benches) are evaluated.

REI uses these parameters to engineer its boreholes to provide containment during and after drilling, and to assess coal continuity in the anticipated mining horizon through focused lateral boreholes.

REI's standpipe installations are pressure-tested to a safety factor of 1.5 times the anticipated static pressure of the inundated mine voids. Its wellhead configuration provides the ability to rapidly close in on a borehole that has encountered water under high pressure, for example, and withdraw downhole equipment for ensuing packer installation or continued drilling in a controlled fashion.

When boreholes intercept old workings, depending on pressures, REI can strategically place a mechanical or inflatable packer to

enable continuation of drilling to delineate the extent of the old workings that have been intercepted without starting a new borehole. Multiple exploration laterals may be developed with multiple packers.

Borehole surveying and charting on mine maps

All boreholes are surveyed during drilling using state of the art measurement while drilling tools. These are precision guidance tools that enable placement of boreholes to within less than +/- 1 degree, which equates to better than 17ft left or right in plan view at a distance of 1000ft from the collar.

Borehole placement is typically more accurate and is established by interception of boreholes during subsequent mining. In one instance, a mine intercepted a 2800ft in-seam old works and coal burn exploration borehole drilled by REI.

The distance between the location of the mine intercept relative to the location of the borehole, as determined by borehole survey and charting on mine maps, was 8.6ft at 2500ft from the collar, resulting in a placement accuracy of less than 0.2 degrees in plan.

During drilling, driller logs of cuttings and borehole surveys are compiled in AutoCAD

format to ensure proof of coal continuity. Areas where roof or floor are drilled, rather than coal, are denoted, and these areas are re-drilled with laterals in the coal prior to certification that the hole was drilled continuously in coal along its entire length.

An accurately surveyed borehole must also be charted properly on the mine's maps. REI requires all mine operators to survey borehole collars (start of hole) so that the charted borehole can be accurately placed on the mine map and physically represent the location of the hole relative to the workings (a very important step).

Determining the lateral extent of abandoned workings

The application of longhole directional drilling to delineate the lateral extent of old workings after these were intercepted by mining is shown in figure 2, representing an actual project.

In evaluation, it is helpful to disregard the actual workings that were not developed until after the drilling program delineated the old workings. The initial planned mining projections (in magenta), and the extent of mining (from three portals) when mining intercepted uncharted underground workings are shown.

Directional drilling was initiated underground at the coal face and proceeded from east to west. Initial boreholes intercepted the old workings and the mine moved the drill west accordingly. REI used borehole packers to recover circulation after interception of the old workings and develop multiple tangential boreholes to the west of primary boreholes to determine the lateral extent of the old workings.

Finally, a tangential borehole drilled from the western-most borehole verified continuous coal around the western extent of the old workings. The figure illustrates the placement of the as-mined developments as a result of the exploratory drilling program. These developments did not intercept any old workings. This reserve would not have been developed in by the old workings without the guidance provided by longhole directional drilling.

Conclusions

In-seam longhole directional drilling has been identified by MSHA as one of the "Best Practices" to prevent unwanted interception of old uncharted or poorly charted abandoned workings and mitigate the potential of an inundation.

Contrary to face drilling under current law, longhole directional drilling is a proactive means of exploration as boreholes can verify coal continuity over significant distances in advance of mining. Strategically placed long boreholes in advance of mining can verify large reserves near old workings and provide invaluable and timely information to allow coal operators to develop optimum plans for maximum coal recovery. *Professional geologist Michael Bohan and President Dan Brunner are from REI drilling.

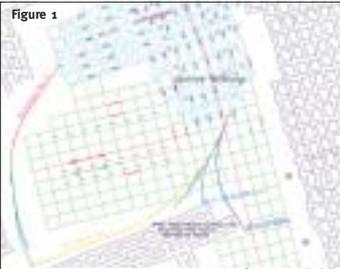


Figure 1
Active mining with projections encroaching within 200ft of uncharted abandoned workings. Actual placement of directionally drilled boreholes to verify and "close" reserves to maximize recovery near old workings is shown. Although not a requirement, borehole 1 and 2 actually physically intersect.

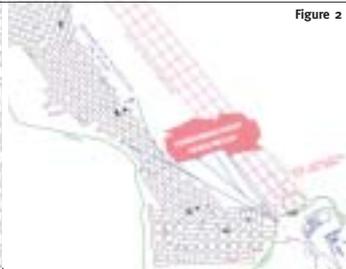


Figure 2
Mining originating from four portals intercepted uncharted old workings. Directionally drilled in-seam boreholes were developed to derive the lateral extent of the workings.