GROUND BREAKING

Philip Shaw, SureWave Technology, UK, explains new developments in mine safety, as well as detecting and locating trapped miners.

In general terms, the mining industry has an excellent record for safety. However, when incidents occur, they are by nature of the mine environment very serious and attract a lot of publicity. The industry is active in finding solutions to reduce accident rates and significant work has been undertaken to ensure that, should a miner be trapped underground, the rescue teams have the best technology available to extract the trapped miners in the shortest time possible.

Recent incidents trapping miners underground include the Sago coal mine explosion in the US in 2006 and the collapse of the Copiapo copper/gold mine in Chile in 2010. In each of these, time was of the essence. The ability to confirm that the miners are still alive is of the upmost importance in giving rescue teams the knowledge they are working to a rescue and not a recovery. The tragic incident at Pike River coal mine, in New Zealand in November 2010, highlights the issue of not knowing if emergency crews are dealing with a recovery or rescue. While it is unknown if the outcome of this disaster would have been different, the advantages of detecting trapped miners signals within an hour or so of an incident is obvious.

The location of the miners is sometimes known, but when it is not the ability to locate the trapped miners' signals is a tremendous advantage, as every second counts if lives are to be saved.

The accident at the Sago mine occurred on 2 January 2006, as detailed in the report published by the US Department of Labor Mine Safety and Health Administration (MSHA). Of the 13 miners underground at the time, 12 ultimately perished.

In the MSHA report, the one trapped miner who narrowly survived relayed the events of the last hours of his colleagues. The survivor indicated that the miners "thought they would be rescued," that "rescuers would bring the machine that locates people to the mine" and that the miners "thought that they would hear shots on the surface, rescuers would drill a hole in the right spot, and they would be taken out and discussed how long it would take." They each took it in turns to bang on a roof bolt with a sledgehammer, but "as time passed it did not look good. They were waiting for the borehole but felt that the rescuers must not have had the right equipment."

Figure 1. Aerial view of Federal mine #2, West Virginia, and the two seismic test sites.

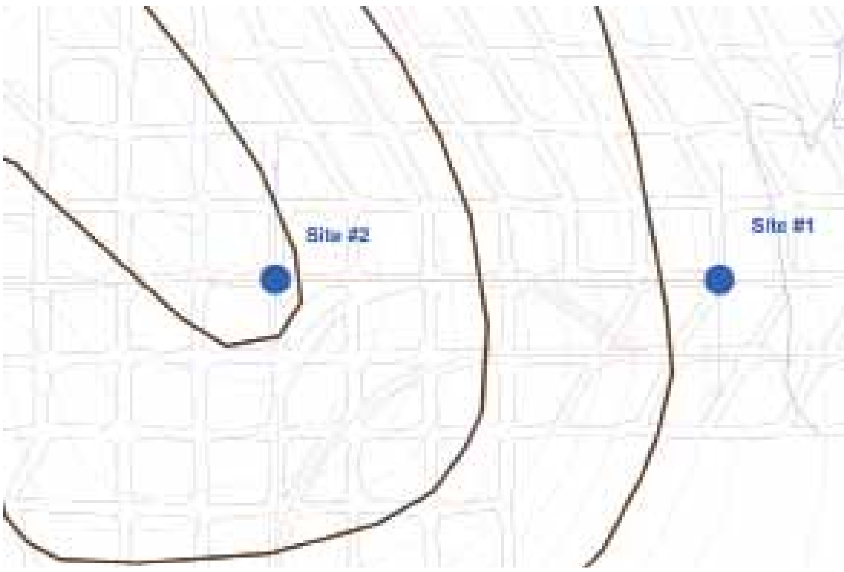

Figure 2. Mine map under the surface test sites.

The mine rescue equipment at the time is reported to have comprised a truck mounted system, tests of which indicated that it "can be an effective means of detecting and locating trapped miners. Signals from miners pounding on the roof of a mine can be of sufficient strength to enable detection over an area of the mine."

"However, the signals are affected by ground conditions, the depth of the mine and seismic noise sources. Estimations of the location of the trapped miner can be of sufficient accuracy to aid the rescue team or aid in the positioning of the rescue drill, but a significant amount of time is required to set up the system and conduct an accurate survey."

The detection and location equipment that is generally available to assist in a mine rescue has severe limitations, which is disadvantageous when time is critical to saving lives. Existing technology to locate trapped miners suffer from practical application restrictions, including the need for a controlled environment and a maximum depth of about 300 ft (90 m).

While the Sago mine was 100 m deep, the Chilean mine was 600 m below the surface, illustrating that detection and location at these differing depths regardless, remained a problem. However, new technology is helping to overcome these shortcomings.

SureWave Technology has recently developed a new and ground breaking portable seismic instrument, TMSP2, which has the proven capability not only to detect trapped miners that have survived an accident, but also to locate them within minutes after deployment of the sensors at depths of up to 2000 ft (600 m) and potentially beyond.

In December 2010, the first field trial of the TMSP2 system was undertaken at the Blue John Cavern in Derbyshire, UK. At a depth of 80 m, the stamping of feet was successfully detected in real time, accurately locating an image superimposed upon a map of the area.

This was followed by a demonstration in February 2011 at the Federal mine #2 in West Virginia where, despite the loss in transit of one of the two sensors, SureWave was able to detect the signals generated by two simulated "trapped miners" banging a crib block on the roof of a tunnel from separate locations at around 300 m below the surface.

The minimal degradation of the signals between the test depths led to the conclusion that the TMSP2 seismic instrument could almost certainly detect to levels up to 2000 ft (600 m) and deeper. The technological achievement of this detection was remarkable in itself, as normal mining activities continued with levels of sound and vibration many times greater than the pounding itself as indicated in Figures 3 and 4.

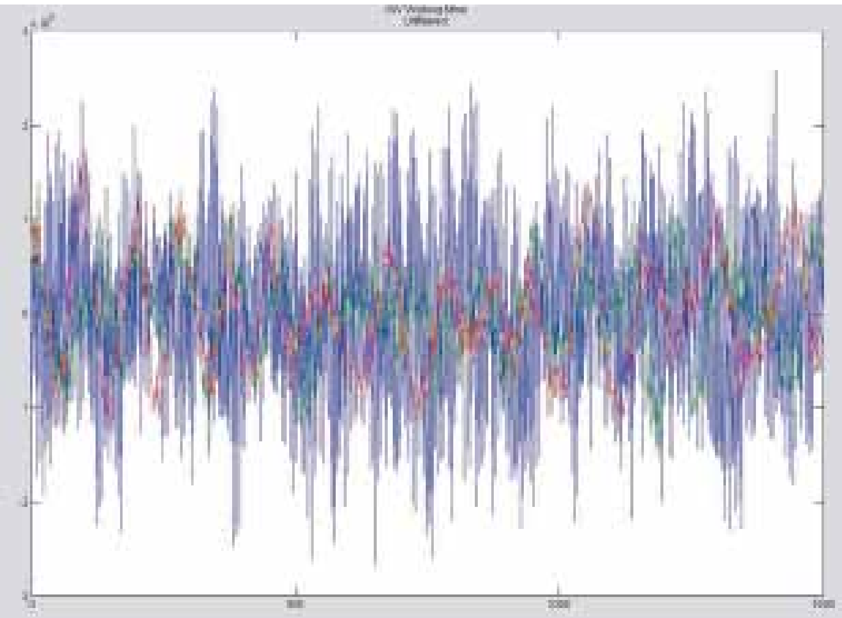

Figure 3. This screenshot illustrates the levels of sound and vibration in the mine that overpower the sledgehammer pounding of the "trapped miners".

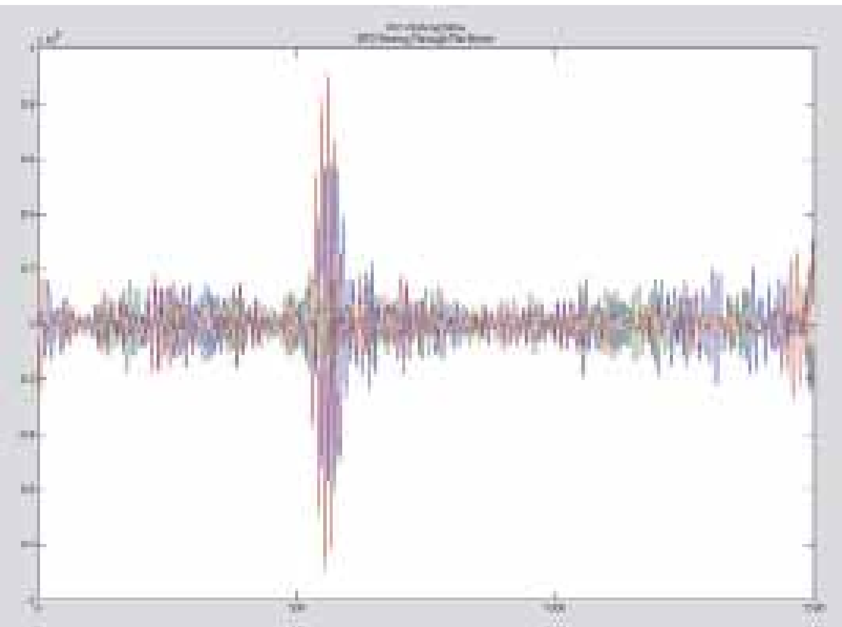

Figure 4. The same signal after application of SureWave IP.

In particular, it was noted that the background noise environment at the site was highly complex and unusually strong. Bulldozers could be heard working on the coal stockpile nearby. Also, the coal cars used for mine's bunker system were only a few feet from the "trapped miners". All of these sources and other unknown sources interfere with the detection of the pounding signals. SureWave has developed proprietary IP to "see through" the vast majority of this extraneous noise to clearly detect the wanted signal. Remarkably, no site adjustment to the techniques is required: the technology works autonomously.

Mine monitoring

While this is in itself a breakthrough, the TMSP2's additional capabilities (developed for model MMSP2) both to detect and accurately locate potential rock outbursts and the presence of moving liquids well in advance have major implications, not only for mine safety, but also for productivity and profitability in both underground and opencast mines.

While safety is the prime concern, the potential to identify savings made through reduced pillar sizes in deep mines and to increase the angle of sidewall slopes by even 1° through real-time monitoring of the geological stability, deep within the strata, can save millions of dollars and significantly impact upon the profitability of the mine.

The SP2 detects micro-seismic signals generated in underground strata that would normally be masked by major mining activities. Weaknesses forming around underground shafts and opencast faces can be identified, potentially preventing collapses or wall slippages. The sensor's unique ability to "see through" noise means it is able to filter out extraneous signals produced by everyday mining activities, and therefore be used during normal mining operations.

Figure 3. Photograph of surface sensor installation.

Figure 4. Photograph of the main processing unit, cabling and batteries.

At a mine in Nottinghamshire in the UK, an earlier version of the MMSP2 (SP1) successfully predicted a rock outburst over four months before the event itself. Independently verified by the University of Liverpool, the device was set up and data monitored over several months. At 22 weeks before the event it accurately identified a cluster of increased micro-seismic activity and at 18 weeks had pinpointed where and when the collapse was likely to take place.

Preferring to believe their existing monitoring devices, which did not detect these signals, the mine owners chose to ignore these warnings. The subsequent collapse, exactly as predicted, caused the closure of the mine and financial losses of over £1 million. Fortunately, nobody was trapped or injured in the accident.

The MMSP2 system was recently deployed to measure the seismic activity within the sidewall slopes of a working opencast coal mine. By monitoring the side wall stability using this advanced technology it may be possible to safely increase the angle and therefore reduce the overburden removal. It is estimated that a 1° increase could give a £500,000/month saving.

Another major strength of the SP2 is its ability to locate deposits of flowing liquids deep in the underground strata that are generating seismic energy. Movements can be monitored in real time, thereby not only aiding excavation activities, but also indicating where breaches might occur. Recent tests performed in underground mines have highlighted the speed at which the system identifies and locates all seismic activity.

The system (MMSP2) was recently set up in an underground mine and within 10 minutes the display clearly showed many features producing micro seismic activity, including a waterfall.

This kind of real-time knowledge informs mine owners and managers of what is really happening within their mines, enabling them to take pre-emptive action to re-plan mining activities and reduce the likelihood of an accident.

No other technology in the world is known to produce such advanced data of this kind, making it a unique safety device in accident prevention, as well as a powerful rescue tool. Not only can it potentially save many lives, but mining companies are set to save millions in lost time. By being able to identify these weaknesses, planned activities can be adjusted to reduce or prevent downtime and lost production, as well as aid the planning of future activities. In short, the SP2 technology offers significant protection to the investment in the mining operation, people and equipment.

Note

Shortly after this article was written, the UK Health & Safety Executive and South Wales Mine rescue made an emergency request to SureWave Technology to deploy the TMSP2 system to assist the rescue and recovery efforts at Gleision coal mine, South Wales, where four miners ultimately lost their lives in an underground coal mine. The system was deployed and fully working within 20 minutes of arrival at a site above the mine. Two separate rescue teams were detected, located and monitored in real time approaching the area where the remaining miners were found shortly afterwards.