After Quecreek

A review of projects to prevent coal mine inundations in West Virginia

By Gary L. Winn, Robert Rice and James Dean

WHEN WORKERS IN AN UNDERGROUND MINE inadvertently break through into an abandoned mine, water may rush into the new mine and trap miners, or built-up methane may enter the new working. Either way, miners are exposed to unplanned hazards, sometimes with catastrophic consequences.

On July 24, 2002, at Quecreek No. 1 Mine in Somerset County, PA, a mining crew working for the Black Wolf Mining Co. broke through into an older abandoned mine—one that dated back to the early 1900s—which quickly flooded their own mine. According to available maps and information, the area in which these coal miners were working was not near any older workings where water or explosive gasses could accumulate over the years.

For three days, television coverage showed the dramatic efforts to rescue the nine trapped miners, efforts that ended successfully when a vertical basket was lowered through a small bore hole to retrieve them.

The Quecreek Investigation

Following the rescue, MSHA launched a comprehensive investigation of the near-disaster [MSHA(b)]. It was found that the primary cause of the water inundation was the use of an undated and noncertified map of the Harrison No. 2 mine that did not show the complete and final mine workings. No certified final map for the mine was available in the state's mine map repository. [Maps certified independently by registered professional engineers or registered surveyors are presumed to be accurate (30 CFR 75.1204) because they must be validated by an external examiner licensed by the state.]

It was also noted that inundation or breakthrough concerns did not stand out at Quecreek. In particular, water entering the section before the incident, normally a warning sign of potential inundation, was similar to previously encountered conditions. Miners had described the Quecreek mine as a wet mine. In fact, it was so wet that before the incident between 250 and 300 gallons of water per minute were being pumped out of the mine. Roof bolters at the mine typically wore rain gear and in some sections of the mine all workers wore rain gear [MSHA(b)].

The wet conditions were attributed to the Freeport sandstone aquifer located above the mine. The sandstone was separated from the coal seam by a layer of shale. The shale layer acted as a barrier and prevented water from entering the mine roof. However, when roof bolters penetrated the shale layer, water would enter freely. In fact, when roof bolters drilled into the roof, substantial amounts of water often entered through the holes. In addition, a fault crossing the section that was being worked acted as conduit for water to enter the mine.

Given these conditions, as workers unknowingly approached the Harrison No. 2 mine, they were not alarmed by the increasingly wet conditions. Those interviewed after the incident reported they were unaware that they were mining so closely to a water-filled mine. The investigation team determined that any warning signs which existed were masked by previously encountered conditions, and concluded that training likely would not have prevented the incident.

Quecreek mine officials and the miners believed they were a safe distance from the adjacent abandoned mine. It was also assumed that the map of the older mine was a certified final map, which investigation revealed was not the case. Investigators eventually located two separate maps that showed Harrison No. 2 was substantially larger than indicated on the map used by Quecreek mine engineers. A final certified map of Harrison No. 2 has never located—such maps had not been required by law when operations ceased at the mine. Additional discrepancies were found in tax records for 1963 which stated that all coal near Harrison No. 2 had been exhausted. However, in 1993, sale records had been revised to indicate that coal was present in the area.

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Abstract: *The state of West Virginia is actively working to create databases to store historical coal production data and mine maps that will ultimately be available to the public and mining engineers to aid decision making about where to safely direct future mining operations. This article briefly describes inundation incidents in coal mines and reviews the progress of initiatives to improve mapping and data collection.*

Quecreek mine did not have a history of being cited frequently for violations. In fact, MSHA had completed a regular inspection of the mine on June 12, 2002; a subsequent inspection that began on July 1, 2002, had not been completed at the time of the accident. No citations had been issued. The mines nonfatal days lost rate in 2002 was 4.20—nearly half of the national average of 7.01—at the time of the incident.

Breakthroughs Not Uncommon

Quecreek is only the most recent inundation incident in the U.S. mining industry to capture national attention. Another prime example is the Hominy Falls disaster in 1968 at the Saxsewell No. 8 Mine located in Nicholas County, WV. Investigation of this incident found that at 9:40 am on May 6, 1968, a continuous miner broke through into an adjacent abandoned mine. At the time of the incident, 26 men were working in the mine. The resulting inundation of water killed four miners and left 21 trapped—only one worker was able to escape. Of the 21 trapped, 15 miners were rescued five days after the initial inundation; the remaining six miners were rescued 10 days later (USMRA) (Photo 1).

The investigators also found that the map of the Saxsewell No. 8 Mine was not current with the workings. The official map showed no abandoned or active mines within close proximity. Had recordkeeping been sufficient—that is, had records shown that an abandoned mine was nearby—this incident would likely have been avoided.

Photo 1: Hominy Falls Recovery Operations. In 1968, Hominy Falls focused national attention on mine inundations.

The Hominy Falls disaster prompted the first state laws requiring mine companies to submit a final certified map of operation. The federal government followed suit soon after, passing laws requiring mine companies to submit for catalog a final certified map of operation. In West Virginia, the law (Section 22A-2-1) currently requires all mining operators to submit a final, certified map of their operation to the West Virginia Office of Miners' Health, Safety and Training (WVOMHST). The federal government has similar requirements for certified maps in 30 CFR 75.1200 ("Requirement for Mine Map Maintenance") and 30 CFR 75.1204 ("Mine Closure Requirements"). In addition, since 1974, maps of all coal operations in the state of West Virginia have been forwarded to the Interior Dept.'s Office of Surface Mining's (OSM) mine map repository. Beginning in 1974, coal operators in West Virginia were also required to submit a final map to OSM when coal production ended. It should be noted, however, that while the maps had to be filed, they were not standardized nor were they available to other users in digital format.

Federal Initiatives

In response to the Quecreek incident, Senator Arlen Specter (R-PA) requested an investigation to determine the cause and to propose countermeasures. This investigation concluded that digitizing mine maps and use of void detection technologies could help to ensure safer mining near abandoned mines. It is believed that by making accurate maps of abandoned adjacent mines available online in statewide databases, engineers will be able to accurately assess how far a working mine can proceed without breaking into an adjacent abandoned mine. Where final certified maps are not available, void detection technologies can locate voids near working mines.

In addition, Senator Specter urged that federal funds be dispersed to support map digitizing projects, and research and development of void detection technologies. In his opening comments before a U.S. Senate Appropriations subcommittee hearing on the Quecreek incident on Oct. 21, 2002, Specter said, "This is an inquiry of the utmost importance. "We intend to find out what the facts are, identify the cause of the incident and take whatever steps are necessary to be as sure as we can that there is no recurrence" (Specter).

Before the same subcommittee, Pennsylvania Governor Mark Schweiker stated:

> Pennsylvania and the federal government must work together to make sure that all existing maps are readily available. Production records and mine maps must be archived and stored properly so that they are not vulnerable to deterioration over time. Scanning mine maps into a digital format will provide the access needed by federal and state regulatory officials, mining operators and the public. Due to the thousands of mining maps in existence, this effort may take years and will only be successful with the cooperation and financial backing of the federal government (Commonwealth of Pennsylvania).

Following these hearings, Congress appropriated $10 million to MSHA, which in turn awarded grants to several states to develop programs to provide information to mine operators electronically about the location of abandoned underground mines. "This is good news for the mining industry as we may now begin to tackle this serious problem in earnest," stated then-MSHA Administrator Dave Lauriski. "Missing or inaccurate mine maps, along with undetectable mine voids, present a significant threat to the safety of working miners in America today" [MSHA(a)].

Mapping Initiatives: West Virginia

Under that appropriation bill, MSHA awarded several grants, including a $1.2 million grant to WVOMHST to support a project entitled "Digitizing Mine Maps." WVOMHST has worked with the West Virginia Geological and Economic Survey on its coal bed mapping project since 1995 in an effort to digitize mine maps and make them available for use in and outside the mine safety community.

The process of digitizing maps can be time-consuming because old mine maps may be unavailable,

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in extremely poor condition (Photo 2) or held by deceased miners' family members who may not be cooperative. Other factors can also make this task more difficult. For example, in 2004, the day before the team working to collect and scan mine maps throughout West Virginia was to visit, a coal operator's map warehouse was flooded by rainfall. Of 200 available maps, all but 75 were lost.

West Virginia's Database Project

In early 2004, West Virginia University (WVU) agreed to work with WVOMHST on a parallel aspect of the mine-mapping project that involved creating a statewide database of coal mine production and operation as far back into history as possible. Matching production data with the maps will make the system even more beneficial. By comparing production data with the map in question, a mining engineer can better determine whether the map is accurate. For example, if a map of ABC Mine is dated 1950 and the production data state that operations ceased in 1952, the mine map is not likely a final map of operation. However, if the map is dated 1950 and production data show production ceased in 1950, the map is likely a final map of operation.

Simple in concept, but harder to execute, the project entailed gathering original data from the official West Virginia annual reports dating back to 1883. These data (often printed in small type and found in different locations within the reports) were entered into a spreadsheet. The spreadsheet was populated first by year, then county in which the mine was located, followed by company name, mine name and the amount of coal produced in tons. It was believed that production values would provide future spreadsheet users with an idea of how expansive the mine may have been.

Specific production values were not listed in the state's annual reports until 1895. Between 1883 and 1894, the reports stated only that a mine was in operation or had ceased operation within a given year. Beginning in 1895, however, the reports became much more detailed and specific production values were listed for individual mines. This was a significant development because mines from the late 1800s could produce as much as 100,000 tons or as little as 10 tons in a given year. Without specific production data, it was not known whether a mine was a large or small producer of coal.

The fact that many mines changed names—or worse, that different mines had the same name—presented another challenge. Another recordkeeping problem was the fact that around 1900, the state of West Virginia changed recording procedures to differentiate coal hauled by truck or horse wagon; this required researchers to look up data twice.

Over the project's lifespan, the database grew to be (in the words of one student researcher) "unbelievably huge." In the end, the three PCs used to create the database took 20 minutes to save the next version of the database.

The West Virginia Coal Production Database Project was completed in June 2004. At that time, the research team noted that 20,661 separate mines had been in operation in the state of West Virginia between 1883 and 1976. However, the research team acknowledged that this number could be slightly inflated because each time that a company name changed, the research team had to assume that a new mine had begun operation, even when the name was the same as a mine that had been in production the previous year but no longer showed production.

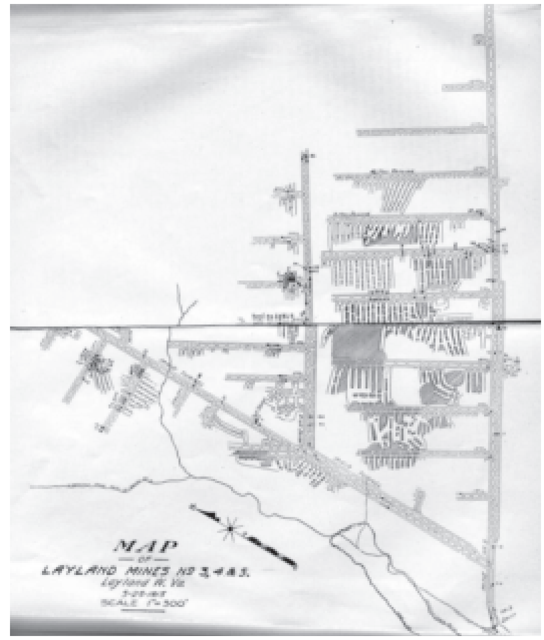

Photo 2: The process of digitizing old mine maps, such as that depicted here, is a long, arduous process being undertaken by the West Virginia Office of Miners' Health, Safety & Training.

That said, even at an inflation rate of three percent, the number of old mine workings in West Virginia is huge. It should also be noted that the project employed data entry personnel who had sufficient mining background to clarify some county, name or production values because they were familiar with those places or old workings. The next step in the project is to establish datasets on WVOMHST's official website for public inspection and use in preventing future underground mine conflicts.

Despite the problems with mine names and mines being in and out of production from one year to the next, the potential benefit of the database is significant because information on tens of thousands of mines is now available and readily accessible. The project may help determine how large abandoned mines are once the next layer of information is added—specifically, gathering older mine maps. For example, if coal production for a given mine is compared to the final map of operation, and reviewers see that production extended beyond the year of the last mine map, additional investigation would be required and no permits for future mining would be issued until the discrepancy is addressed.

Similar Problems Encountered in India

Breakthrough and inundation incidents are not unique to the U.S. mining industry. India currently ranks third in the world for coal production, mining about 325 million tons per year. Underground production accounts for 19 percent of total production, but, as in the U.S., coal is concentrated in certain geographic regions and these workings have been in production for many years (www.indiacore.com/coal.html). Unlike in the U.S., the majority of coal produced in India is state-owned and state-produced, mainly by Coal India Ltd. Like here, the industry is heavily regulated.

Modern mines in India also face the potential hazards of breaking through to abandoned mines. According to available statistics, 32 major accidents (involving four or more deaths) caused by water inundation have been reported since the beginning of the 20th century through September 2004. These have caused 816 fatalities. (Authors' note: Fatality and incidence rates for India and the U.S. are not exactly comparable because of differing definitions and thresholds for reporting.)

After each such disaster, the government of India has appointed a court of inquiry to find the causes and circumstances surrounding the incidents. Resulting recommendations have led to development of safety measures, an overall improvement of working conditions in coal mines and amendment of statutes. For example, in 1926-27, a new code of regulations/rules under the Mines Act of 1923 provided for mandatory appointment and preparation of mine plans by a qualified surveyor; submission of an abandoned mine plan; and maintenance of a barrier of at least 15 meters between two mines. In 1935, 11 miners drowned at Loyabad Coal Mine in Jharia Coalfield when a gallery was connected to a waterlogged area because the mine plan was inaccurate and lacked information on the actual extent of the workings. At the federal level, the inspectors recommended several additions to India's federal law:

> The colliery surveyor shall make such accurate surveys and levellings as the manager may direct or as may be required by the act or by regulations or rules framed under the act and shall accurately plot them on the plans with reasonable dispatch and shall sign the same and date the signature.

In addition, a new bylaw was added requiring that "all tracings and copies of colliery plans shall be signed and certified by the surveyor to be true copies."

Despite these advances, inundation incidents have recurred due to inadequate reporting systems and lack of legislation. For example, in 1975, the Chasnalla disaster occurred. In this case, 366 miners were killed when miners broke through into another mine with a 400 meter (vertical) head of water. It remains India's worst mining disaster.

Following a similar track to their counterparts in the U.S., India's federal mine safety agency recognizes that even with mandatory map certification and the use of high-tech improvements such as void detection, more must be done to reduce inundation and breakthrough incidents. These efforts must encompass additional training, engineering skills and management judgment. Indeed, considerable prescriptive legislation has been developed in India. For example, the government requires a minimum distance of 15 meters between workings and archived use of certified true maps.

However, in India, development of an improved system of work through self-regulation based on duty of care is required. Preparation of safety management plans based on a thorough risk assessment and implementation of calendar-based action plans are the best way to achieve this. In fact, recommendations for initiating a "risk management by risk assessment program" were made during India's 9th Conference on Safety in Mines in February 2000. It was reported that through improved work culture, heightened accountability measures and commitment to safety at all levels would prove to be important measures in preventing inundations in the future.

Conclusion

The Quecreek incident focused attention on the need for the collection of mine production records and mine mapping. It also caused federal funding to become available to speed these activities. The state of West Virginia, like many other coal mining states, faces a daunting task because of the sheer number of mines that have produced coal in the state over the last 150 years—a number far greater than any other state. And although the state began this important task almost six years before the Quecreek inundation, much work remains before the databases will be available to the public.

Mine safety officials and researchers alike are confident that these data, difficult as they can be to obtain, will provide a strong foundation for preventing similar problems in the future. Major coal-producing countries, specifically the U.S. and India, have traveled similar paths to protect miners against the hazards of breakthrough and inundation. The future promises a blend of data collection, technology solutions and behavioral improvements to reduce the likelihood of these occurrences. ■

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