

Inrush and mine inundation - A real threat to Australian coal mines?

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Abstract

In the last decade, more than 150 mine inrush and inundation accidents occurred worldwide in coal mines with one or multiple fatalities to wail over.

The author compiled cases and causes of mine inrush and inundation incidences reported in the press, journals, public accessible national mine incident registers and those compiled in mine disaster databases hosted on the Internet. Differences and similarities between conditions at historical accident sites and Australian eastern coal fields are discussed.

The analysed data suggest that in countries other than China, the greatest risk of inundation is from abandoned flooded workings or sudden inrush of surface water into the mine. Only very few reported inrush accidents in these countries are due to seepage from deep and shallow aquifers, fracture zones or the coal face itself.

Keywords: principal hazard, incident database, flooded workings

Introduction

Mine Work, Health and Safety regulations, guidelines and code of practice of the USA, Australia, Canada and UK (HSE 1993) consider inrush and mine inundation a principal hazard with the potential of causing multiple fatalities, having serious detrimental impact on mine production or mine abandoning.

An estimated 10,000 men or more have been killed in mine inundation and inrush accidents in the United States, United Kingdom, China and India since the beginning of the century (Chakraborty, 2008, EDI 2010, Powell et al 2010).

Most of these incidences, accidents and fatalities have occurred in underground coal mines. Australia being one of the five largest coal producing countries, the author has chosen to focus on inrush hazards to coal mines in this paper. However, references to inrush incidences at coal mines in other countries have been included where appropriate.

The objective of this paper is to examine causes of inrush and inundation accidents compiled from various sources including newspaper articles, journals, public accessible national mine incident registers and mine disaster databases hosted on the Internet.

The paper is therefore not a complete account of the issues and is more in the nature of an empirical segment of the larger work.

Incident Databases and Statistics

The comparison of coal mining accidents with that in other countries is beset with various difficulties. Accident definitions of official data bases and incident reporting requirements may change with time, varies from country to country and occasionally between states of a country. Governments do not maintain mine

accident registers, the registers are incomplete or access is restricted. In those countries newsagents may be the only source with little control on data quality. Information sources used for this study are listed in Table 1.

Historical mine accident data (Job 1986a, Job 1986b, MacNeill 2008) confirmed by the more recent data presented in Table 1 suggest that in countries other than China the greatest risk of inundation is from abandoned flooded workings and flooding caused by torrential rain. The primary cause of inrush accidents in China and India is frequently negligence, ignoring of safety regulations and illegal operation of dangerous mines that have been shut down (Powell et al 2010).

Table 1 *Inrush and inundation accidents and incidents of top coal producing countries for the past decade*

Category	China	United States	India	Australia
Flooding	8 (196)	24 (0)	1 (200)	3 (0)
Intersecting well	-	45 (0)	-	2 (0)
Intersecting mine void	11 (143)	38 (0)	3 (47)	1 (0)
Strata water	5 (103)	19 (0)	-	1 (0)
Dam failure/levee breach	1 (172)	9 (0)	-	0
Leaking/failing but seal	-	7 (0)	-	0
Mine fill inrush	-	1 (0)	-	0
Pump failure	1 (23)	1 (0)	-	0
Unknown	120 (1536)	19 (0)	1 (17)	0
TOTAL	146 (2173)	163 (0)	>5 (>264)	7 (0)

Notes: fatality numbers in brackets

Sources: United States – US Mine Accident database for the period between 2000 and 2012, China and India - www.usmra.com last accessed March 2012, disaster and fatality numbers are gathered from mine disaster news reports since January 2004 and may not represent the actual total number of accidents and miners killed., Australia - Queensland Mining Hazard Database, Serious accident and high potential incident reports, Queensland Government, Mining and Safety (2004 – 2012) and MacNeill P (2008)

Cases and causes of water inrush at East Australian collieries

In 1996, four miners died in the Gretley disaster in the Hunter Valley when water rushed at a water head of approximate 140 meters into the headings from a hole in the face made by the continuous miner connecting the operating mine with the flooded Young Wallsend Colliery mine, closed over 80 years earlier. The mine was working to old plans of the Young Wallsend mine, which showed the historic mine workings more than 100 meters away from the point of holing-in.

Consequently, mine safety legislations have been revised to help prevent such disaster to happen again in Australia. However, as we had learned from the recent mine disaster at the south Wales Gleision colliery in September 2011 inrush from historic mine workings is still causing disastrous accidents not only in Asian coal mining countries but also in countries with stringent mine health and safety regulations.

There are numerous such historical coal mines across the Hunter Valley which possess the hazard of inrush. With increasing numbers of underground coal mines

planned to go operational within the next 5 to 10 years and current and future expansion of existing underground operations the potential of inrush from historical mine workings has to be taken seriously.

Besides abandoned mine workings, other subsurface voids possess an inrush hazard if water or liquefiable material is accumulated in the void. There have been a number of incidents over the past 15 years where workings have intersected previously drilled holes.

When drilling a blast hole for the development of a Queensland coal mine heading in August 1999, the hole intersected an exploration bore hole containing groundwater that had built up a hydrostatic head of 150 metres and approximately 2 metres cubed water was released onto a drill rig placing a number of persons at risk (QDME 1999). More than 45 incidents of similar nature have been reported to have occurred in USA coal mines alone during the years between 2000 and 2011.

Pooled water or accumulation of liquefiable materials in close proximity to drives and shafts have the potential to flood the interconnected drives and can present a real danger of inrush into surrounding underground mines being worked. Two recent incidents in Australian coal mines draw attention to the risks associated with pooled groundwater and surface water.

An inrush of water and mud occurred at the base of a raisebore hole in a NSW coal mine in January 2011. Groundwater was entering the approximately 270 metres deep raisebore hole that may have been choked off or partially blocked and as a result, a quantity of mud and water had built up (MSA 2011).

In March 2011 three miners of the Grasreeve coal mine escaped dead when 36 mega litres of water gushed into the mine near Middlemount after an on-site storage dam broke its banks.

Mine inundation and climate change

Prolonged rainfall over Queensland's mining regions during the 2007/2008 and the 2010/2011 wet seasons caused severely flooding and prolonged inundation of numerous open cut operations. On 19th January 2008 the embankments of the Ensham mine in Central Queensland were breached by the floodwaters of the Nogoia River. Two of five pits were filled in a day or so, after water volumes of between 110,000 and 150,000 megalitres a day rushed into the pits at the initial breach (Ensham 2008).

Following heavy rains throughout November and beginning of December 2010, flooding of the Dawson River in late December resulted in the breach of a bund wall at the Baralaba open cut mine on 29 December 2010. Within half an hour the pit filled with approximately 18,000 megalitres (Overdeveest 2011).

Even though extreme weather situations are thought to affect surface mines the most an inrush incident in 2011 at a Queensland underground coal mine has been directly linked with prolonged rainfall creating a large surface accumulation of water. Substantial water percolated slowly into old underground workings

through fractures connecting the workings with water ponding at the ground surface (DME 2011).

Although there are still uncertainties surrounding the potential climatic changes that may occur in Australia, climate change projections for the coal fields at the east coast suggests that changes in rainfall patterns will cause longer dry-spells interrupted by heavier rainfall events, increasing the potential for flooding events and inundation of open cut mines (CSIRO-BoM 2007) and inrush to underground mines. There is currently no evidence of significant change in the number of tropical cyclones in the Australian region. However, there is some evidence suggesting that the more intense cyclones will increase in intensity.

Inrush and inundation hazard management

The risks associated with inrush and inundation can be reduced by the rigorous consideration of potential inrush sources and mechanism and the systematic design, implementation and maintenance of appropriate preventive, mitigating and control measures using the Hierarchy of Controls. Inrush and inundation hazard management should be understood as an iterative process starting at mine planning and revisited at each stage of the project life cycle.

Key elements of the management process include:

- A risk assessment to identify and analyse potential inrush sources and mechanism and to evaluate the effects of inrush and inundation on mine operations and personnel,
- Prudent mine design aiming at elimination of the inrush and inundation hazards identified so far as is reasonably practical,
- Implement and maintain appropriate engineering controls where not reasonable practical to eliminate the hazard,
- Establishment and maintenance of an inrush and inundation management plan defining inrush control zones,
- Implement procedures to ensure that the location of any underground void and surface water accumulation is transferred onto operating survey plans, and sections in a proper and timely manner.
- Monitor meteorological observation and forecasts both prior to and during wet season to adjust operational planning and resource allocation appropriately

General guidelines and Code of Practice detailing processes, procedures and/or controls for inrush and inundation management are developed by government authorities of some coal producing countries. For Australia, these include the Code of Practice on Inundation and Inrush Hazard Management (SWA 2011) and the New South Wales Guideline for Inrush Hazard Management (NSW DPI 2007). Similar codes and guidelines are provided in the United Kingdom (HSE 1993).

Conclusion

Compiled coal mine inundation data suggest that in countries other than China, the greatest risk of inundation is from abandoned flooded workings or sudden inrush of surface water into the mine. Only very few inrush accidents in these countries

are due to seepage from deep and shallow aquifers, fracture zones or the coal face itself.

Inrush and mine inundation is a risk that should be taken seriously and considered at all stages of mine planning and managed with caution during operation. This is in particular when existing and planned underground coal mines are at close proximity to rivers, pits, water and tailings storage facilities and severe weather may cause mine voids to fill with water rapidly.

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