



**Trade &
Investment**
Mine Safety

Investigation report

Serious inrush incident at
Cadia East mine 21 February 2010

Extract of report prepared by the NSW Mine
Safety Investigation Unit

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Serious inrush incident at Cadia East mine on 21 February 2010 v2

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Introduction

The incident that prompted this report

This investigation report sets out the events and examines the causes of an incident that occurred on 21 February 2010 at Cadia East mine. The Cadia East mine is an underground gold and copper mine near Orange in central NSW.

The incident was the result of an inrush of mud and water from a near-completed ventilation shaft that partially flooded the underground workings. The ventilation shaft was being formed by raiseboring. The inrush material travelled 814 m along a roadway to the top of a second ventilation shaft where it continued to fall 375m down a shaft to a second level in the mine.

The inrush pushed a 57 tonne manned bogger (front end loader) for 30 to 40 m along a roadway and pushed a 5.7 tonne unmanned mini excavator an unknown distance along a roadway. There were seven people exposed to the risk of serious injury or death.

The department's authority

The Department of Trade and Investment, Regional Infrastructure and Services administers the *Mine Health and Safety Act 2004* (MHSA).

Under the MHSA places of work, which are called mines, are defined. The places of work to which the MHSA applies are listed in section 6 of the MHSA.

The department has authority to investigate the incident because it occurred at an underground mine as defined by the MHSA.

The companies

Newcrest Mining Limited

Newcrest Mining Limited is Australia's largest gold producer and the fourth-largest gold company in the world by market capitalisation. It is also a top-15 ASX-listed company with a market capitalisation of around \$A29 billion.

Cadia Holdings Pty Limited

Cadia Holdings Pty Limited is listed as the main holder of the leases for the Newcrest Mining Limited Cadia Valley Operations. Newcrest Mining Limited is the ultimate holding company of Cadia Holdings Pty Limited.

The Cadia East mine

The Cadia East mine is part of the Cadia Valley Operations and is 100% owned by Newcrest Mining Limited.

The Work

Activity

At the time of the incident, the mine was constructing a 5 m diameter ventilation shaft with a raiseborer. The 271 m deep ventilation shaft was a critical part of the mine's long term ventilation infrastructure and was designated as VR5A.

RUC Cementation Mining Contractors Pty Ltd (RUC) was contracted to excavate the ventilation shaft. RUC did not have any direct control of the underground bogging activity at the bottom of shaft.

The standard raisebore cutting rate was set at 4.5 m per shift (9 m per day).

During the reaming process cuttings and water from VR5A shaft formed a slurry that continually flowed down the roadway.

In the week before the incident the cutting rate was increased to expedite the completion of the shaft, in part to accommodate other contractors who were behind schedule to install ventilation equipment.

At the time of the incident, a mine technician was engaged in operating a bogger to clear built-up cuttings from the floor below the bottom of the shaft.

Equipment

A raiseborer is a machine used to excavate a circular hole between two levels of a mine.

The raiseborer is set up on the upper level of the two levels to be connected, on an evenly laid platform. A small-diameter hole (pilot hole) is drilled to the level required; the diameter of this hole is typically 230–350 mm, which is large enough to accommodate the drill string.

Once the drill has broken into the opening on the target level, the bit is removed and a reamer head is attached to the drill string and raised back towards the machine. The drill cuttings fall to the floor of the lower level where a bogger removes them from beneath the shaft.



Picture 1: Representational view of the reaming process. Illustration only. Does not depict mine's actual bogging procedure.

Image taken from Shaft Drillers international website – http://www.shaftdrillers.com/raise_bore_drilling.php

The incident

What happened?

The incident occurred on Sunday 21 February 2010, at 10.30pm, during the process of bogging the material generated by the reaming of a ventilation shaft.

In the weeks before the incident, a pilot hole was drilled from the surface to about 271 m below the surface. The pilot hole had intersected an aquifer or other water-bearing area during drilling and a significant amount of water ran continuously from the hole.

A 5 m diameter reaming head was attached to the drill string and began back-reaming the drill hole to excavate the shaft.

As a result of the water, the reaming process produced a slurry-like material (a mixture of reamer cuttings and water), instead of the usually dry, fine, clearly defined cuttings (muck) pile.

At the time of the incident, a bogger was clearing the reamer cuttings from the floor below the bottom of the shaft.

A supervisor had been in the area to inspect the cuttings in the shaft half-an-hour before the inrush and had instructed the driver to continue bogging. After removing three or four buckets the driver was heading back up to the base of VR5A shaft and felt his ears pop. He stopped the machine and suddenly the bogger was covered in mud and was being pushed back down the drive.

The inrush of material pushed the bogger 30 to 40 m back down the drive. The material from the base of the shaft flowed 814 m to the top of the VR5B ventilation shaft. The top of VR5B was about 100 m vertically below the base of VR5A.



Photograph 1: Dried mud on the wall near VR5A shaft shows the height the material reached as it flowed to the base of the shaft.

Note: Photographs 1, 3, 4 and 5 in this report were taken by NSW Mine Safety investigators.



Photograph 2: Rear view of the bogger that was pushed down the drive below VR5A shaft. The mud material coated the bogger up to the cabin level. Photograph courtesy of Cadia East mine.



Photograph 3: Ventilation wall about 350 m from the base of VR5A shaft. The two outer red lines show the approximate height of the inrush flow. The centre red line shows the height of the turbulent flow when it splashed on the ventilation wall.



Photograph 4: The roadway intersection 550 m from base of VR5A shaft showing the height of the turbulent flow on the wall beyond the ventilation structure.

The inrush material travelled through the holes in the ventilation structure and continued along the ventilation drive. It washed a 5.7 tonne, unmanned, mini excavator that was close by to the structure along the drive and close to the top of the open VR5B shaft. See image below.



Photograph 5: The mini excavator that was washed along the drive and close to the top of VR5B shaft. The excavator is on its side with one track visible. The top of VR5B shaft is in the drive to the right of the buried excavator.

Seven people were at risk as a result of the material flow. Two were bogger operators whose machines were engulfed by water and mud. Three other people were trapped in a light vehicle for a short period. They had been in a roadway at a level higher than the material flowing past them. They attempted to escape from the roadway but became trapped in the inrush material. They waited until the flow subsided and when attempting to leave in the light vehicle it became bogged and they walked out in the slurry.

Two other workers were servicing a jumbo drill machine in a blind ended crosscut at an elevation above the inrush material. They were about to enter the drive below VR5B shaft, which was subsequently filled with inrush water and mud.

Circumstances that led to the incident

Nightshift Saturday 20 February 2010

The raiseboring machine was isolated and locked out at 2.30pm the day before the incident to allow bidders to get to the bottom of the hole and bog out the heaped fines that had accumulated below the hole. At 2.30am on Sunday 21 February 2010 the heaped fines were inspected. The shaft was not then choked. Later at 5am it was observed that the raisebore hole was blocked by the heaped cuttings.

Day shift Sunday 21 February 2010

A supervisor on the next shift carried out a Job Safety and Environmental Analysis (JSEA). While he identified the risk of an inrush occurring, he did not establish controls to ensure that people working nearby or on lower levels in the mine were not exposed to risk of injury or death in the event of an inrush.

Another supervisor also recognised the potential impact of an inrush on people in levels below the VR5A shaft but did not take appropriate action to ensure that the exposure of those people to an inrush was addressed in the risk assessment that is part of a JSEA.

Night shift Sunday 21 February 2010

The supervisor on shift at the time of the incident was made aware of the blocked shaft when he came on shift. He was told by the day shift supervisor to make sure the bogger operator signed off the JSEA. The night shift supervisor had a brief look at the JSEA and told the bogger operator to be aware and take it easy.

When bogging recommenced on the night shift to remove the cuttings and mud that had accumulated along the drive and at the base of the raisebore shaft, the inrush occurred.

Employees put at risk

While no-one was injured during this incident there was a high potential for serious injury or for a fatality to occur. The dried mud left on walls by the inrush was, in places, higher than a person. The height of the flow and the force would have had serious consequences for anyone caught in its path.

After it was reported that the bottom of the shaft was blocked, a number of employees went into areas where they were in the path of the potential inrush.

The system of work

Standard Work Procedure requirement

The Cadia Valley Operations system of work for bogging at the base of a raisebore shaft was contained in a Standard Work Procedure (SWP) document.

The SWP stated that a 2 m gap was to be maintained at all times between the heaped cuttings beneath the hole and the shaft lip. When the gap at the shaft lip was 1 m or less, it was to be treated as a serious incident and reported as such. The raiseborer was to stop work and the area barricaded until a JSEA was undertaken.

At the time of the incident the raisebore reamer was within 10 m of the surface and close to completing the VR5A shaft.

Reaming rate

The standard raisebore cutting rate was 4.5 m per shift (9 m per day). A decision was made by mine management about a week before the incident to permit the raisebore to cut as quickly as possible in order to complete the VR5A shaft.

The following table demonstrates the additional reaming metreage on six shifts during the week before the incident.

Date	Metres Reamed		
	Day	Night	Total
13/02/10	4.55	4.55	9.1
14/02/10	4.55	4.55	9.1
15/02/10	4.52	4.56	9.08
16/02/10	4.55	3.03	7.58
17/02/10	6.03	6.03	12.06
18/02/10	3.01	6.01	9.02
19/02/10	6.02	7.54	13.56
20/02/10	6.08	0.00	6.08
21/02/10	0.00	0.00	0.00

Reconciliation of reamed and bogged material

A reconciliation of metres being cut by the raiseborer and the number of buckets of material removed per shift was being maintained to provide information to shift supervisors. The cutting material encountered in VR5A shaft was wetter than normally experienced at the mine. The rate of flow of water down the hole was unconfirmed.

A series of tell tale holes (usually three) can be drilled up into the raisebore shaft. In the event that the bottom of the shaft becomes blocked and water builds up in the shaft, it will run out of the tell tale holes to indicate that the shaft is blocked. Installing drain holes is not mandatory but is recommended in departmental guidelines and is practised throughout the mining industry.

The VR5A shaft did not have any tell tale holes installed at any time during the excavation process.

Lack of awareness of departmental guidelines

The department has two publications available on its website which address the potential of an inrush. These publications were available on the website at the time of the incident. The publications are:

- MDG 1030 - *Guideline for Raiseboring Operations*, and
- MDG 1030 TR – *Technical Reference Material for Raiseboring Operations*

The technical reference document advises pre-drilling of drain holes into the brow as part of control measures.

During interviews with investigators some supervisors said they had no knowledge of this document.

A further departmental publication, MDG 1024 – *Guideline for Inrush Hazard Management* was referenced in the Cadia Valley Operations Inrush – Underground Mining Operations Major Hazard Management Plan, yet a number of supervisors told investigators they had no knowledge of the document.

Of note is the following quotation from MDG 1024 under the section on Controls for an Emergency Response:

'... remember that a conservative approach is best, especially if the nature and the magnitude of the worst case event is not clear.'

This approach would have been appropriate to the circumstances during the course of the lead up to the inrush event on 21 February 2010.

A supervisor told investigators that the drilling of tell tales holes was a normal process used at Cadia East mine. The supervisor said the process was not written into any procedural document and that there were no tell tale holes drilled up into the bottom of the VR5A shaft.

Cause of the incident

The inrush was the result of an excessive build-up of reamed cuttings choking the raisebore shaft at its base and the subsequent build-up of water and cuttings in the shaft releasing in an uncontrolled event from the bottom of the shaft.

Contributing factors

At the time of the incident employers had an obligation under the *Occupational Health and Safety Regulation 2001* to identify any foreseeable hazard that might arise in the workplace and to assess the risk of harm arising from the identified hazards. Employers are then obliged to eliminate the hazards. If elimination of the hazard is not reasonably practicable, they must control the risks by implementing measures to lessen the risk of harm to the lowest possible level.

A documented risk assessment was developed for Cadia East RB1 raisebore hole (an earlier raisebore shaft where back-reaming began in July 2006). This document was not updated for the raiseboring activities taking place at the time of the incident. It did identify the risk of potential inrush from a blocked hole but the residual risk was classified as insignificant and rare.

This risk assessment document did not address the risk from wet reamed material. There was no assessment of catastrophic failure of the material pile and subsequent inrush potential and consequently a failure to identify the build-up of water in the shaft once it was blocked.

There was no inspection of the bottom of the VR5A shaft by a qualified engineer. Instead, inspections were conducted by supervisors with no formal qualifications in geotechnical matters.

The area where the shaft was excavated was known to be a wet area. When the pilot hole was completed, water was seen flowing from the hole. It appears no specific arrangements were made to accommodate the reaming of a wet shaft.

A reconciliation document provided by Cadia East mine failed to identify that there were less cuttings taken away than were created during the raiseboring process.

Flawed reconciliation process

An engineer was given reaming data from the raiseborer contractors (RUC) and data of tonnes bogged from beneath the raisebore shaft by Cadia East mining operators. He provided a reconciliation document of the tonnes reamed against tonnes removed from beneath the bottom of the shaft.

In the absence of water, a bogger is able to scoop up a considerable amount of dry reamed cuttings from beneath a shaft, to the extent they may pile up above the bucket.

Where water does exist and mixes with the reamed cuttings to form a sloppy mix, the bucket can only fill to the lip of the bucket.

Under these circumstances it would be a guess as to how much water and how much reamed product is in the bucket each time and therefore what amount of the reamed cuttings were removed by the bogger.

The engineer calculated reconciliation on the basis that a bucket full of dry cuttings weighed 20 tonnes. This figure was then used for every bucket taken from the bottom of the shaft whether it was wet or dry.

Failure to follow SWP

A safe work procedure (SWP) should be developed or reviewed after identifying a need for corrective action in an incident/hazard report or as a risk control measure following a risk assessment of the task/activity.

All SWP's should be reviewed periodically as a matter of course and audited to ensure proper implementation. A Cadia Valley Operations SWP for the raisebore hole bogging and isolation was approved on 3 July 2006, the following quotation is an extract.

'Raise drill cuttings at the base must never be allowed to encroach to the point where there is a risk of choking the hole. The cuttings must not be allowed to build up to a point where there is less than 2 m of vertical gap between the cuttings and the brow. The CED (*refers to Cadia East Development*) Shift Supervisor is accountable for managing this. The hazard presented by choking the brow of a wet raise drill hole is substantial. In the event that a gap of 1 m or less is identified then this shall be treated as a serious incident and reported as such. In such an event the Raise drillers must stop work and the area barricaded until a JSEA has been completed.'

The above extract identifies that management personnel recognised that the blocking of a wet raise drill hole was a substantial hazard. Cadia East mine supervisors had information concerning issues with bogger availability that had delayed the bogging undertaken in the week before the incident.

No action on blocked shaft

The slurry material from the reaming process was causing blockages in radiators, and the bogger to be used on 21 February had broken fan belts.

Supervisors were aware that material had blocked the shaft.

There were a number of verbal reports on 21 February that the material had blocked the shaft:

- A bogger operator reported the shaft was 'hung up' at 5am
- A supervisor indicated the shaft was 'choked or blocked off' at 8am
- A second bogger operator said it was 'blocked' at 4pm.

The mine surveyor when consulted by investigators after the incident estimated that approximately 1500 tonnes of material remained in the pile at VR5A shaft.

JSEA approval process

Mine documents that addressed the potential of inrush advocated the use of a remote controlled bogger. The supervisor who completed the JSEA did not include the use of a remote bogger as a means of reducing the risk.

The JSEA did not identify safer systems of work other than using the bogger on the lower side of the material pile when the material was known to be wet.

A number of supervisors confirmed during interviews that the JSEA was not completed correctly.

Cadia Valley Operations has a training document that addresses JSEA training. It takes four-and-a-half hours to complete JSEA training.

A completed JSEA document is subject to an approval process.

Tasks are given a JSEA risk ranking from low to extreme. The risk ranking determines the level of approval required to carry out the task. The risk potential of an inrush from the bottom of a raise while bogging was identified in Cadia Valley Operations documents as an extreme risk.

The supervisor who completed the JSEA on 21 February 2010 did not ensure the document was signed off by the appropriate person.

Actions post-incident

A Mine Safety inspector attended Cadia East mine after a late notification from mine management on the afternoon of 22 February 2010.

A prohibition notice was issued to stop the bogging activity from beneath the bottom of raisebore holes until all safety controls and systems involved in removing material below raisebore holes had been reviewed.

The inspector noted that communication regarding high risk activities may be relevant to the continued safe operation of the mine or the safety of people working at the mine.

Pursuant to section 131 of the MHS Act the inspector advised the mine that communication was inadequate when dealing with high risk safety issues as evidenced in the activities leading up to the inrush incident.

NSW Mine Safety also developed and published a Safety Alert: SA11-01 *Water inrush from Raisebore Hole*.

The Safety Alert recommends a number of control measures to be considered for minimising consequences of an inrush and reminds operators of the department's MDG 1030 *Guideline for Raiseboring Operations*.

The MHSa required this incident to be notified to the department immediately once the operator became aware of it and by the quickest available means. The incident was not notified to the department until 14 hours after the incident.

There was no formal risk assessment carried out before entering the area to clean up and reinstate the ventilation structure.

The prohibition notice issued to the mine provided directions about measures to be taken. As required by the prohibition notice, the company developed a presentation that was viewed by department inspectors. In the presentation, the company addressed the communications issue raised by the inspector in the notice issued pursuant to section 131 of the MHSa.

A letter dated 31 March 2010 from the inspector advised mine management that the department was satisfied that the review of the safety control systems had been completed satisfactorily and they had complied with the prohibition notice.

Findings

- When the pilot hole intersected the VR5A shaft, mine management failed to ensure that an adequate JSEA was completed for the task of bogging the accumulated reamed cuttings at the base of VR5A in circumstances where the shaft was blocked.
- Cuttings from the reaming process of the shaft piled up beneath the bottom of the shaft.
- An unknown quantity of water and cuttings built up in the shaft.
- Water and cuttings flowed from the shaft and eventually blocked it.
- As a bogger removed material from the area below the shaft, the inrush of water and cuttings into the mine workings occurred.
- Seven people were placed at risk as a result of the inrush.
- A decision was made to place the ventilation installation on hold and concentrate on the completion of the shaft. To expedite the completion of the shaft the raiseboring contractor was instructed to increase the reaming rate.
- The reconciliation system with regard to the amount of material reamed and the amount of material bogged from beneath the shaft failed. There was no allowance for the reduced amount of cuttings in a bucket because of the water content.
- The system of drilling drain holes into raisebore shafts was practised at Cadia East mine but not included in any standard work procedure. Drain holes had not been drilled into the VR5A shaft.
- The Cadia Valley Operations Inrush Underground Mining Operations Major Hazard Management Plan detailed the hazard management requirements for those hazards assessed as high or extreme with respect to an inrush incident in underground mining operations at Cadia Valley Operations.
- In the Inrush Underground Mining Operations Major Hazard Management Plan, for the risk of an inrush, remote bogging was a planned response when there is a critical mixture of fines and water. It was known at the breakthrough of the pilot hole that VR5A was a wet hole yet the mine made no provision to set up systems to enable remote bogging in the event of a blocked shaft.

Conclusions

Identifying risk

The cuttings mixed with water formed a slurry that appeared to flow continuously down the drive leading management to presume this would continue and was unlikely to build up to block the bottom of the shaft.

There was a failure to review the risk when the reaming rate was increased. This was a lost opportunity to assess the change in characteristics of the slurry.

Suitably qualified geotechnical personnel did not personally inspect the material conditions at the base of VR5A in the week leading up to the incident.

Inspection of the material pile was conducted by the person who created the JSEA. The person did not have the competency to properly assess the geotechnical status of the material pile.

Information

There was a lack of information available to supervisors to assess the potential of an inrush as a result of a blocked raisebore shaft.

The JSEA did not adequately identify the risk and controls even though one of the supervisors had considered the potential of inrush.

Instruction

At the changeover of day shift to night shift, the production supervisor of the day shift told the next supervisor to carry on from where the previous bogger operator was up to, he was to be observant and keep his eye on it. The second supervisor was not instructed to keep staff clear of the potential inrush path.

Supervision

Senior mine management did not attend the underground workings to assess the risks associated with the blocked VR5A shaft. A supervisor informed mine management of the blocked hole by telephone and they discussed how to manage it. They discussed bogging their way up to the brow for further identification. They were to continue on rather than to carry out an engineering assessment. There was no discussion about any alternative method of unblocking the shaft.