# Mary Kathleen Uranium Mine – Blasting and Slope Stability Initiatives

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## Summary

Mary Kathleen Uranium Mine is located east of Mt Isa in Queensland. The mine had 2 operating phases, the first between 1958 and 1963 and the second phase between 1976 and 1982. The author was employed as Mine Engineer, Drill and Blast Engineer, then Assistant Superintendent from 1979 to 1982. The rock mass had significant geotechnical challenges with multiple adversely dipping joint sets that threatened the economic viability of the operation.

This paper records the initiatives that were undertaken to improve blasting practices and slope stability. The mining engineers and blast crew developed new techniques that contributed significantly to the operational success of MKU including:

- The first open cut cable dowelling program in Australia and
- The first 24m high final batters in Queensland.

## Introduction

The Mary Kathleen Uranium Mine (MKU) is located 60km east of Mt Isa. Production commenced in 1958, however the mine was placed on “care and maintenance” after only 5 years. A second operating phase commenced in 1976 until the Ore Reserves were depleted in 1982.

*Figure 1 Mary Kathleen Open Cut – 1978*

By 1979 it had become evident to mine management that significant improvement in the condition of final slopes was required to recover of the projects Ore Reserves. The solutions that were proposed included the adoption of new technology and development of implementation strategies. This paper records some of the methodologies and initiatives that contributed to the successful completion of the MKU operation.

The author was employed as Mine Engineer, drill and blast engineer, then assistant superintendent between 1979 and 1982. During this time his principal role was supervision of drilling and blasting activities.

## Geotechnical Conditions

The Mary Kathleen deposit was hosted in garnetite, a highly competent granitic rock with high garnet content. Its high compressive strength allowed for steep final pit slopes. Multiple open joint sets, though pervasive, were not considered continuous enough to cause major slope failures.

The joint orientations however had major implications for safe operations, grade control, waste fragmentation, loading and mining costs.

*Figure 2 North- South Production Bench showing multiple open joint sets*

The joints dipping at approximately 45$^{o}$ were particularly problematic resulting in production bench crest failures. This in turn resulted in excessive burdens on blast holes, poor fragmentation, secondary breaking, toe drilling, and poor distribution of grade control data. At considerable costs bulldozers were engaged to assist front end loaders maintain production bench RL. Bulldozer track grouser plates were replaced every month due to the highly abrasive rock.

Joint orientation also resulted in wedge failures along final safety catch benches. On occasion final safety catch benches were too narrow for equipment to complete clean-up operations. The removal of loose material from safety catch benches was an important procedure for the semi-circular 300m high east wall as rain events during the summer wet season caused any loose material on benches to wash over bench crests and cascade to the bottom of the pit. During wet weather mining operations would be stopped and workers removed from the open cut.

## Slope Design

Final slopes were designed by Golder Associates. The design included 9m wide safety catch benches every 16m with a 15m wide catch bench for clean-up every 48m.
While Queensland Mining Regulations permitted vertical batters overhangs were not permitted. To prevent the possibility of an overhang drill holes were started at 85°. The 9m catch benches allowed for spillage to be pushed off with a Cat D6 bulldozer, while Cat 980 Front End Loaders and 35t Euclid Trucks were used to clean-up the spillage on the 15m wide benches. This concept was reliant on the design bench widths being achieved and maintained. Thus the retention of bench crests was critical to the success of the design.

*Figure 3 Looking North, Joint sets resulting in production bench crest and wedge failures - 1980*

## Ore Grade Control

The ore in the Mary Kathleen deposit consisted of lenses of allanite containing finely disseminated uraninite. Each blast hole was classified into A, B, C, D, E, or F grade ore by averaging the 1m downhole readings of calibrated wireline scintillometers. After each hole was graded the holes were charged and initiated in particular sequence to separate ore and waste in the blasted rock piles. After Cat 980 Front End Loaders filled the 35t Euclid trucks the trucks were dispatched to a Discriminator for further ore grading prior to stockpiling ahead of crushing and radiometric ore sorting.

**Production Face Orientation**

Stable production bench crests were important for safety and to facilitate grade control and selective blasting. It was observed the south dipping joints were slightly more stable than West dipping joints so by maximising the number of faces orientated in the East-West direction reduced the number of bench crest failures. Figure 3 shows drill rigs working on an East-West oriented production face. Crest failures can be seen on the North-South faces.

## Drill Patterns

Production blasting was completed by Air Track drills drilling 89mm diameter blast holes in ore zones spaced 2.3m apart. Due to broken ground conditions holes tended to be over drilled to allow for some fall back prior to charging at least 1.5m of sub-drill was required. For larger waste areas 127mm blast holes were drilled with Gardner Denver HDCF drills with a 2.6 X 2.6m pattern.
Holes were charges were:

- 1m Molanite toe charge
- 5.5m ANFO
- 2.5m of drill cutting stemming.
- 9, 15 or 25 millisecond surface delays
- Powder factors 0.2 to 0.25kg/t of rock.

Due to blocky ground rock movement tended to cut off adjacent holes if longer than 25 Ms surface delays were used.
Multi row waste blasts were undertaken at every opportunity to improve fragmentation. (Foreground in Figure 1.)
Production blast patterns were stopped 8m from the final batters to prevent explosive gas pressure from opening or creating movement along the joint sets. To maintain ore supply multiple patterns were fired every day between day and afternoon shift. The mine worked on a 4 panel 3 by 8 hour shift roster.

*Figure 2 Looking south east – Centre of picture is the first 24m high final batter in Queensland. - 1980*

## Cable Dowels

To prevent crest and bench wedge failures Golder Associates proposed the use of cable dowels to prevent the movement of the open joints. The dowel design required a relatively stiff fully grouted cable. The concept was to stop the joints lifting apart during blasting, thus maintaining friction along the joint plains. Figure 3 shows a major wedge failure in progress on the 1032 RL bench with bench access being restricted above and below the wedge failed.

**Spacing and Orientation**

The designs were completed by and the first installations supervised by Golder Associates. The dowels were installed in the crest of the 1016 RL bench in the area of the problematic wedge. Trim blasting practices were also changed as discussed below. The result was successful with retention of the wedge. On the back of this success it was decided to dowel the crest of the next major catch bench on the 1000mRL. Two rows of crest dowels at 1.5m centres on a staggered pattern for all final crests was planned. The rows of dowels being 15m long 1m below and 12m long 2m below the crest line. The initial design was for the dowels to be drilled at 45º, being at right angles to the joint orientation however, this proved impractical due to the frequent collapse of drill hole collars. Holes drilled at 60º were more stable so this was adopted as the design standard.

**Cleaning and Installation**

Purpose built cable bolts were not available at the commencement of the dowelling program so 50 tonne breaking strain hoist rope was purchased from the Mt Isa Mines Salvage Yard. Steam cleaning of grease from the outside of the rope proved ineffective as the heat also mobilised grease from the centre of the rope. To ensure good bond between the grout and the rope a better method of cleaning was required. The rope was cut into the design 12m and 15m lengths, then 10 lengths at a time were clamped into a harness. The ropes were then towed behind a 4WD on the mine roads until external grease was removed.

Cables were lowered down the holes and then encapsulated in grout. The grout was mixed in a cement mixer with a cap full of detergent. The grout was simply poured down each hole with the aid of a large funnel. Cable dowels were placed at least 4 weeks in advance of trim blasting. Twin strand 50t cables became available over time and these were quickly adopted to replace the winder rope.

## Final Batter Trim Blasting Trial

The decision to cable dowel crest lines meant significant improvement in final batter blasting was required to ensure joint sets were not opened during blasting. It was agreed that a 3 week trial, without any cost constraints, would be undertaken to establish the best possible batters. Once the trial was completed it was planned to continue with more cost effective practices.

The batters that were achieved in the trial exceeded all expectations and the trim blasting costs were never questioned.

## Trim Blasting - Post Splits

Final batter trim blasting was undertaken on every batter. Two production benches were combined for a 16m high final batter. 16m holes were considered the maximum length that could be drilled to the required accuracy with top hammer drill rigs and 89mm diameter drill bits. Though collared at 85º the holes would progressively flatten toward the bottom of the hole. The drill hole flattening or “run out” was typically less than 1m so toe lines were generally within design. To maintain bench widths the toe areas that were more than 1m out of design were trimmed with short stab holes.

The 8m buffer zone from the last production blast to the crest of the design batter was progressively reduced with single row trim shots. Many charge and spacing combinations were trialled with each trim blast marked with paint for identification and evaluation.

In good ground conditions double row blasting was possible however, for best results a single row of holes was fired at a time. The holes were spaced at 1.75m centres and drilled 18m deep to allow for fall back.

The holes were charged with:

- Full hole length of Shear Cord
- 1 to 2m Molanite depending on toe burdens.
- 8m of decoupled ANFO in 50mm diameter polyethylene tubes.
- No stemming
- 5 millisecond surface delays

Figure 5 shows half barrel hole traces on the batters and the reduced wall damage below the 1000mRL bench.

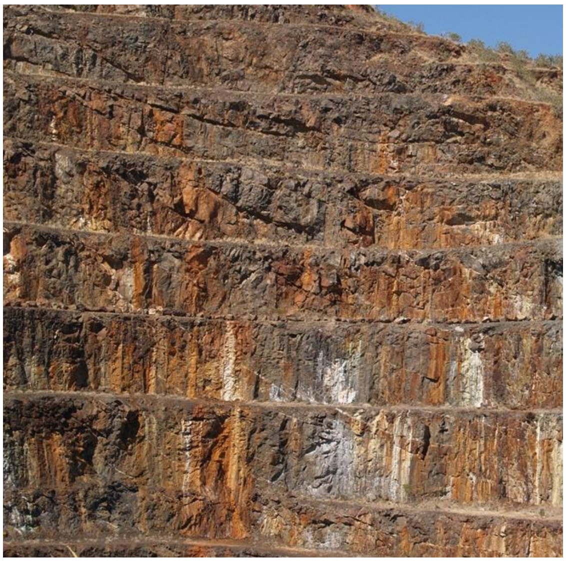

*Figure 5 Looking South East final batter showing Rock Fence on the 1000mRL bench and 24m face - 2012*

Though there was a fair scatter in the accuracy of the 5 millisecond surface delays the results were significantly better than instantaneous blasting. It was found 2m deep intermediate holes helped crack propagation along the crest line. These holes were charged with a single line of Shear Cord without any additional delay. It was observed that the initiation hole for each line of Post Split holes damaged the wall. It was concluded there was pressure release between holes reduced wall damage. To prevent wall damage from the initiation hole, lines of Post Split holes were designed with a “Z” shape to keep the initiation hole away from the final batter. The 5 millisecond surface delay connectors were observed to develop a wedging effect that propagated a crack along the crest line, on occasion well beyond the last Post Split hole, so care was needed to ensure splits were contained within the pit design.

## Trim Blasting - Presplits

The blasting and dowelling initiatives significantly improved the condition of the final batters. At the time the Queensland Mining Regulations limited batters to a maximum height of 20m. Approval to increase the final batter height from 16m to 24m was sort and granted. The base of the 16m high trim blast was first dowelled with 6m long dowels then the final 8m was Presplit. Drill hole spacing and charges were developed over time with results comparable to Post Splits as can be seen in Figure 5. Holes were initiated with detonating cord and delayed with 5 millisecond surface delays.

## Batter scale down

Following every final batter blast the face was chained down with an anchor chain. The scaling removed any loose wedges of rock. The anchor chain was attached to a swivel on the blade arm of a Cat D9 bulldozer. An old truck tyre was attached to the end of the chain which added weight and did not jam in rock crevices. The dozer ran backward and forward until all large loose rocks were dislodged. After chaining fine loose material was hosed of the batter face with a water cannon used for production excavation dust suppression.

## Rock Fence

To improve loose rock retention on the major catch bench rock fences were install on the crest of the bench.
The fence consisted of boulders over 1m in diameter placed in a single row along the crest of the bench. To prevent the boulders from falling a hole was drilled into each boulder and then the bench. A short length of cable was grouted in the boulder and the bench.

## Secondary Breaking

The post-split results while significantly improving the quality of the final batter face, also created large blocks of rock that required secondary breaking. The blocks were in some cases similar to dimension stone being 12m long and 2m thick


*Figure 6 Open Cut at Mine Closure - 1982*

## Outcomes

The blasting program improvements exceeded all expectations.
The cable bolting and final batter blasting trials improved the crest lines of the 16m benches to such an extent that the mines department approved 24m high final batters. The resulting steeper overall slope angle significantly improved the mine economics and enabled the recovery of the stated Ore Reserve.
The operation achieved some notable firsts.

- The first open cut cable dowelling in Australia.
- The first 24m final batters in Queensland.

The costs of trim blasting were considered to be a good investment and reduced overall mine operating costs.
The open cut east wall remains a stable structure some 25 years after mine closure.

*Figure 7 Mary Kathleen Mine 1986*