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Drawbell drill and blast recovery at New Afton mine

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Abstract

New Afton mine consists of 4 mining zones: Lift 1, B3, C-Zone, and East Extension. The C-Zone block cave is currently the only active mining area, with commercial production having begun in the fourth quarter of 2024. In block caving operations, drawbell construction is critical to production, allowing the flow of caved ore through drawpoints. During the C-Zone production ramp-up phase, open brows at drawpoints resulting from incomplete drawbell breakage were first identified. LiDAR scans and drone footage confirmed that the upper portion of drawbells were intact with no connection to the undercut. At the height of open drawpoint occurrences at the beginning of 2025, draw could not be achieved from approximately half of the drawbells following primary blasting.

The high location of unfragmented drawbell material did not meet the criteria for standard hung-up drawbell treatment, requiring a recovery drill and blast approach. Experience in recovery drill and blast methods was limited to the undercut levels of Lift 1 and B3; therefore, the C-Zone drawbell recovery strategy was iterated throughout the process to optimise results. By the second quarter of 2025, 10 drawbells had successfully returned to daily draw using drill and blast recovery methods. This paper discusses the C-Zone drawbell recovery strategy and the revisions made to the drill and blast design and operational practices to improve future blast performance.

Keywords: *block caving, recovery, drill and blast*

1 Introduction

The New Afton mine, operated by Coeur Mining, Inc (formerly New Gold Inc), is an underground copper–gold mine located approximately 10 km west of Kamloops, British Columbia, Canada. The underground mine consists of 4 mining zones, with the C-Zone block cave currently being the only active mining area.

1.1 Overview of underground mining areas

Lift 1, comprising the East Cave and West Cave, was mined from 2011–2022 and is now depleted. B3 operated as a producing block cave from 2021 to the first quarter of 2026 and is now closed. East Extension is planned as a longhole stoping area. Construction of the C-Zone block cave was completed in the fourth quarter of 2025, with commercial production having begun in the fourth quarter of 2024. The C-Zone extraction level is located approximately 390 m below the B3 extraction level and 1,150 m below surface, as shown in Figure 1 (New Gold Inc 2025).

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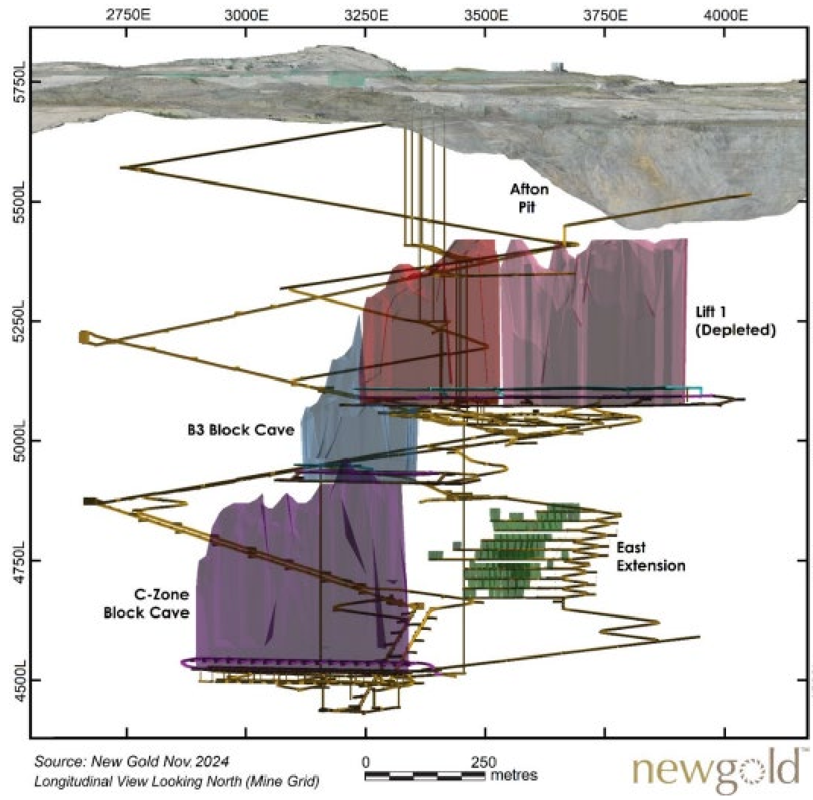


Figure 1 New Afton underground mining areas (New Gold Inc 2025)

1.2 C-Zone geology

The New Afton deposit is an alkalic copper–gold porphyry, with copper–gold mineralisation typically occurring in east–west sub-vertical tabular zones of dissemination, stringers, and fracture-filling sulphides within volcanic rocks of the Nicola Group and Pothook Diorite (New Gold Inc 2025). The C-Zone block cave occurs within this 'Main Zone' of mineralisation, where Lift 1, B3, and C-Zone caves occur, with mineralisation bound to the south by picrite. Host rocks have been altered and mineralised by multiple phases of monzonite intrusions and dykes and have been transversed by regional-scale brittle–ductile fault zones. The combination of structure, alteration, and lithology results in a rock mass that is amendable to caving. The southern half of the deposit is particularly fault affected and has a weaker rock mass than the north. This is illustrated by Rock Quality Designation (RQD), as shown in Figure 2.

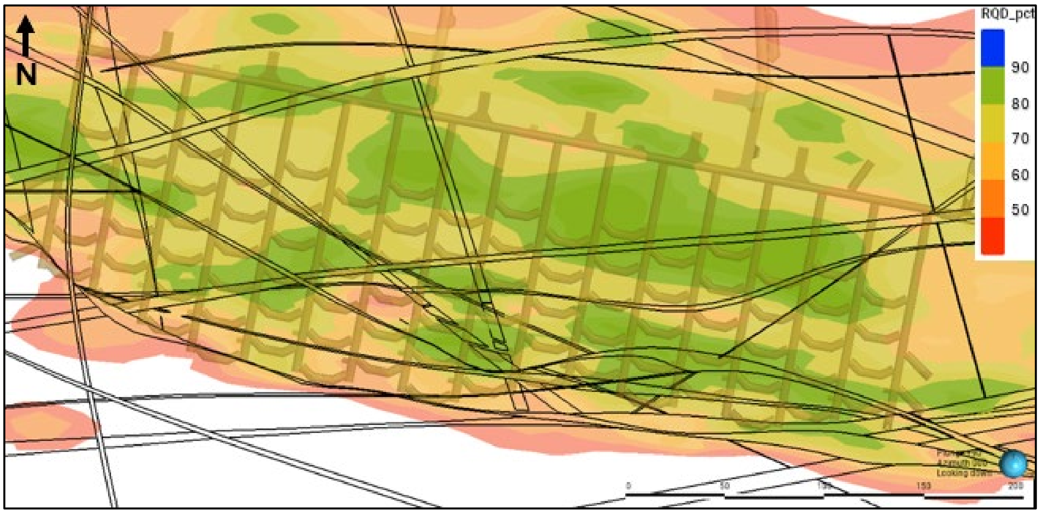


Figure 2 Plan view of the Rock Quality Designation at the undercut level

1.3 C-Zone level design

The C-Zone footprint is approximately 460 × 120 m, providing an approximate caving area of 55,000 m^2. The layout consists of a footwall access and conveyor decline as travelways, and 5 levels listed from highest elevation to lowest elevation: undercut, extraction, haulage, ventilation, and dewatering. The undercut level is designed 20 m above the extraction level, with 18 undercut crosscuts arranged parallel to and in between the extraction crosscuts. The extraction level utilises a herringbone layout with a drawbell spacing of 18 × 27 m. The level design includes 17 transverse crosscuts, 91 drawbells, and 177 drawpoints (New Gold Inc 2025).

C-Zone employs a modified version of advanced undercutting. The modification is that undercut advancement is planned ahead of all extraction level footprint development, including the extraction crosscuts and drawpoint drives. The purpose of this modification is to ensure that extraction level development is always completed within the stress shadow of the undercut. As such, the lead-lag rules were considerably loosened compared to previous lifts to achieve rapid completion of the shorter, transverse undercut sections. An apex level was omitted from the C-Zone design due to the success of the reduced apex level in B3, as well as providing cost-reduction and scheduling advantages. The reduced apex level in B3 resulted in the design of a 'high-w' undercut, which was maintained for the C-Zone undercut design. A cross-section of the undercut and extraction levels is contained in Figure 3. Undercutting begins by blasting slots, followed by rings along the length of the undercutting crosscuts to initiate caving. Following undercut advancement, the extraction level is developed, where drawbells are blasted to extract ore from the cave above.

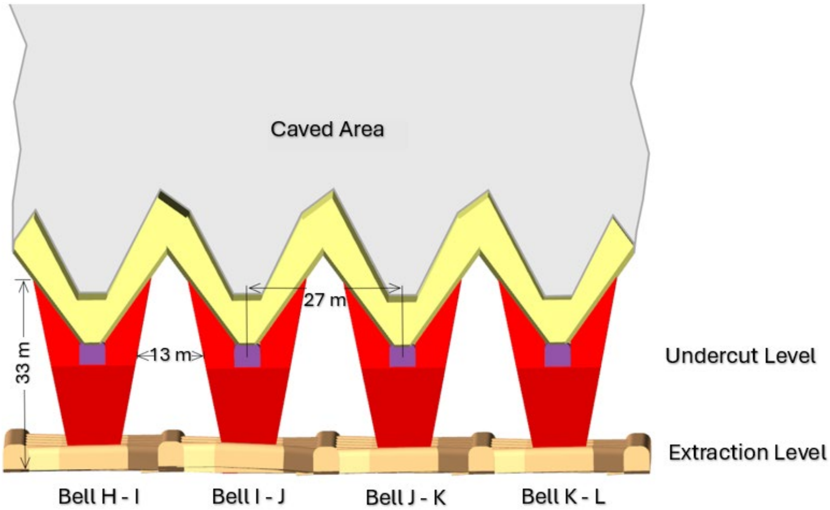


Figure 3 Cross-section of C-Zone extraction and undercut level design, looking north

2 Background

The drawbell design at New Afton is intended to facilitate easy, initial connection to the undercut by positioning the drawbell central to the trough of the undercut shape. The high sides of the drawbell shape use the undercut as a free face for blasting, requiring successful blasting of both the undercut and drawbells to establish ore flow.

2.1 Initial drawbell drill and blast design

The C-Zone drawbell drill and blast design was developed based on the success of the Lift 1 and B3 block caves, where over 230 drawbells were successfully blasted. The C-Zone drawbell volume is 5,500 t greater than that of a B3 drawbell. To account for the larger drawbell volume, 8 drillholes were added to the initial C-Zone design. Drillhole spacing and ring placement were also modified to accommodate for the herringbone layout.

The drawbell drill and blast design is designed as a concentric circle of drillholes. At the centre of the drawbell is a 762 mm diameter raise drilled with a Cubex drill rig. The surrounding drillholes are designed across 11 rings with dumps varying from 79–90°, forming the drawbell shape within the steel sets at either drawpoint. The initial drawbell design consists of 55 drillholes with a diameter of 102 mm, drilled with a top hammer longhole drill rig. The maximum true burden between drillholes is 4 m.

Drawbells are blasted in a single shot using dynamic blast sequencing, where initiation begins in the blastholes surrounding the centrally located raise and progresses outward through the successive concentric rings of blastholes. Short interhole delays of 25–50 ms maximise material angular velocity, assisting in forming the funnel effect to open the drawbell at the top and channel material to the drawpoints and down the extraction crosscuts. The explosive used is Subtek Charge, which is a pumped emulsion explosive specifically designed for uphole loading in underground operations. An electronic initiation system is utilised.

2.2 Defining ‘open’ versus ‘hung-up’ drawbells

For the purposes of this paper, a drawbell is classified as ‘open’ when there is a lack of connection between the blasted drawbell and the undercut. Following the primary blast, portions of the drawbell either remain intact or blast material becomes compacted, resulting in an open brow at one or both drawpoints. Hang-ups are defined as a rock arch formed above the brow caused by oversize. Large rocks reporting in drawpoints and forming hang-ups are planned for when designing a block cave mine and determining production potential (Laubscher 2000). Both open and hung-up drawbells disrupt steady material flow, delaying production and increasing the risk of sudden rockfalls near personnel and equipment in the area.

The open drawbells identified at New Afton mine were characterised by intact rock remaining above the typical hang-up height, at 15–20 m above the brow. Given the height of the intact rock and the available resources, recovery drilling was determined to be the most feasible solution. Information on drawbell recovery onsite was limited to experience from the New Afton Lift 1 and B3 block caves. Recovery drilling was implemented in the previous caves for the purpose of undercut ring recovery. A similar recovery strategy was implemented in C-Zone, where open drawbells were recovered either from an adjacent extraction drive or from the undercut.

3 Open drawbell assessment

Several drawbells were reported as open during the ramp-up phase of the C-Zone cave. The first open drawbell was identified in November 2024. At the height of open drawbell occurrences in January 2025, 13 of 27 blasted drawbells were reported as open. A total of 16 drawbells have been reported as open at some point, with the status of material flow periodically changing.

An open drawbell is first reported by the load–haul–dump (LHD) machine operator who is unable to safely achieve the assigned draw due to an open brow at the drawpoint. A field inspection is conducted either by a shift supervisor or a member of the engineering team to provide an initial assessment of the open drawbell. In cases of significant underblasting, there is a clear view across the muck pile between opposing drawpoints. A confirmed open drawbell is stuffed with muck and barricaded to mitigate sudden fall of material into the crosscut and disruption to ventilation flow. Drawbells identified as open are frequently inspected to monitor for changes in material flow. An open drawbell is pictured in Figure 4a.

The extent of unblasted material is evaluated using LiDAR scans and drone footage. LiDAR scans provide confirmation that the edges of the drawbell design do not connect to the blasted undercut. Drone footage supports that the drawbell is intact, with visible drillholes confirming incomplete blasting. For instance, the post-blast drone footage of the drawbell pictured in Figure4b shows that the holes that are first initiated in the blasting sequence did not break to the initial void.

(a) (b)

Figure 4 (a) Open drawbell with a berm and barricade; (b) Drone footage of an open drawbell from the drawpoint, showing that initial blastholes did not break to the initial void

4 Recovery drill design

Recovery drill designs were developed for each drawbell using their respective LiDAR scans. Drillholes were strategically placed to target the intact portions of the drawbell with the purpose of restoring material flow. The recovery drill design underwent iterations throughout the recovery campaign. Further details regarding the design modifications are discussed in the following section.

4.1 Recovery from the undercut level

The C-Zone layout is arranged such that 18 undercut crosscuts are positioned above and parallel to 17 extraction level crosscuts (Figure 3), and the access drives on both levels run parallel to each other. The layout allowed for recovery drilling of the northernmost drawbells from the undercut access drive. The B3 extraction level design consists of 4 longitudinal crosscuts with drawpoints arranged in an El Teniente style pattern, and 5 parallel undercut crosscuts positioned above extraction. Compared to the C-Zone layout, the reduced number of undercut crosscuts in B3 would have limited recovery drilling access from the undercut level. It is important to note that recovery from the undercut access, named UWD-800, was only feasible for the northernmost drawbells, since the undercut was advanced beyond the southern drawbells at the time of recovery drilling.

Three of the northernmost drawbells were recovered from the undercut access drive. Drilling from the main drive allowed for both sides of the drawbell to be targeted at once, providing coverage along the entire length of the drawbell, while requiring minimal adjustments to the drill setup. The initial recovery design from the undercut consisted of drilling one ring of 3 114 mm drillholes on either side of the drawbell, with a toe spacing of approximately 2 m. The design for the KL-02 drawbell is shown in Figure 5, with the initial open drawbell scan shown in orange against the drawbell design. The recovery design was successful in initiating material flow for 2 of the 3 open drawbells drilled from the undercut level.

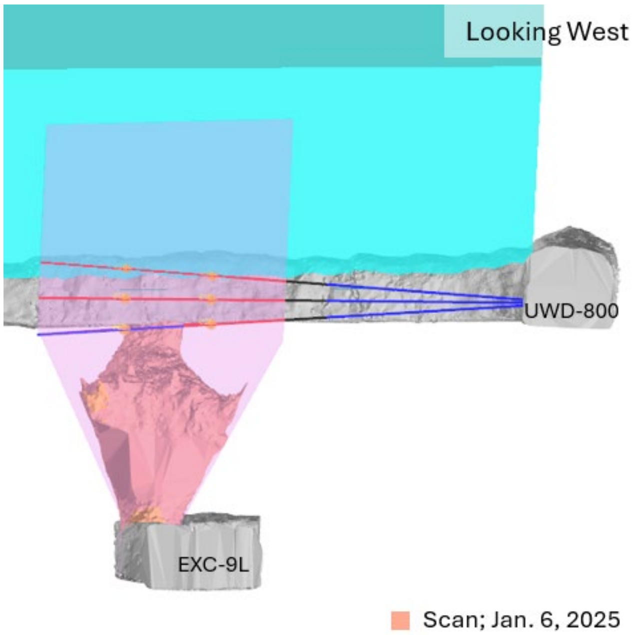
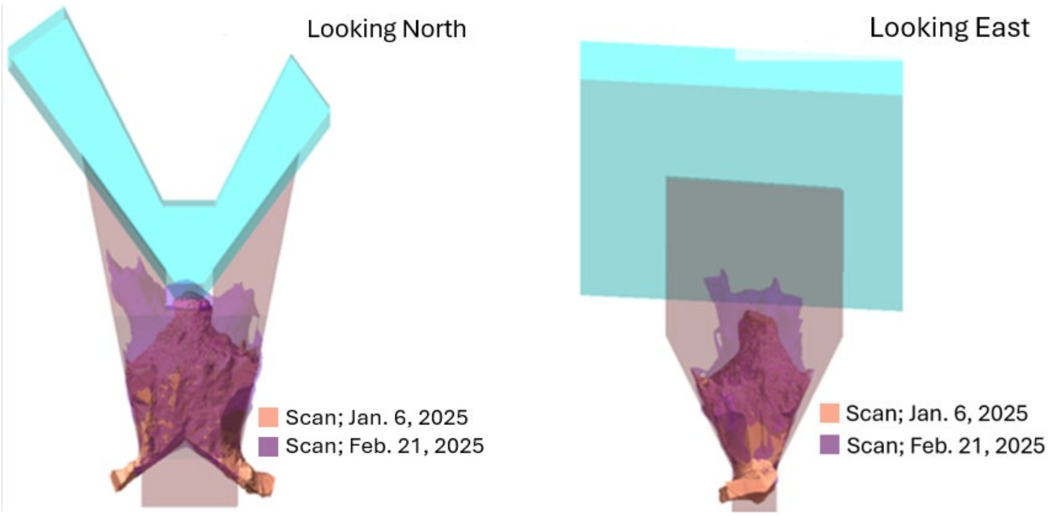


Figure 5 KL-02 drawbell recovery design from the undercut access, looking west

Recovery of the KL-02 drawbell was attempted twice from the undercut level. The first attempt followed the previously mentioned design, with all holes loaded to the specified design lengths. The drawbell re-opened about a month later, after approximately 1,300 t had been extracted. LiDAR scans support that there was some material displacement following the first recovery attempt, but the edges of the drawbell did not connect fully at the undercut. The LiDAR scan following the first recovery attempt is shown in Figures 6a and 6b. The second recovery design was modified to include 5 additional drillholes, which targeted the upper portions of the drawbell that remained intact. Since the second KL-02 recovery blast, the drawbell has experienced steady material flow with occasional hang-ups.



(a) (b)

Figure 6 (a) KL-02 drawbell looking north; (b) KL-02 drawbell looking east

4.2 Recovery from the extraction level

Recovery drilling was primarily planned from the extraction level due to drilling constraints in accessing the southern drawbells from the undercut. Recovery from the extraction crosscuts was limited to one side of the drawbell at a time. Consideration was given to drilling each side of the drawbell from the extraction level, followed by simultaneous blasting. This approach was not implemented due to concerns regarding drillhole stability and loading challenges due to the delay between drilling both sides.

The initial recovery designs from the extraction level prioritised minimal drilling while achieving sufficient drawbell coverage to initiate material flow. As such, early recovery designs consisted of only 4 drillholes from one of the adjacent extraction crosscuts, with a burden of 2.5 m. The drillholes extended beyond the drawbell shape to confirm that the undercut above fully blasted. See Figures 7a and 7b for the initial recovery design from extraction level. The design proved effective in recovering 3 drawbells, including JK-07, IJ-04, and KL-08, all of which were recovered at the beginning of February 2025.

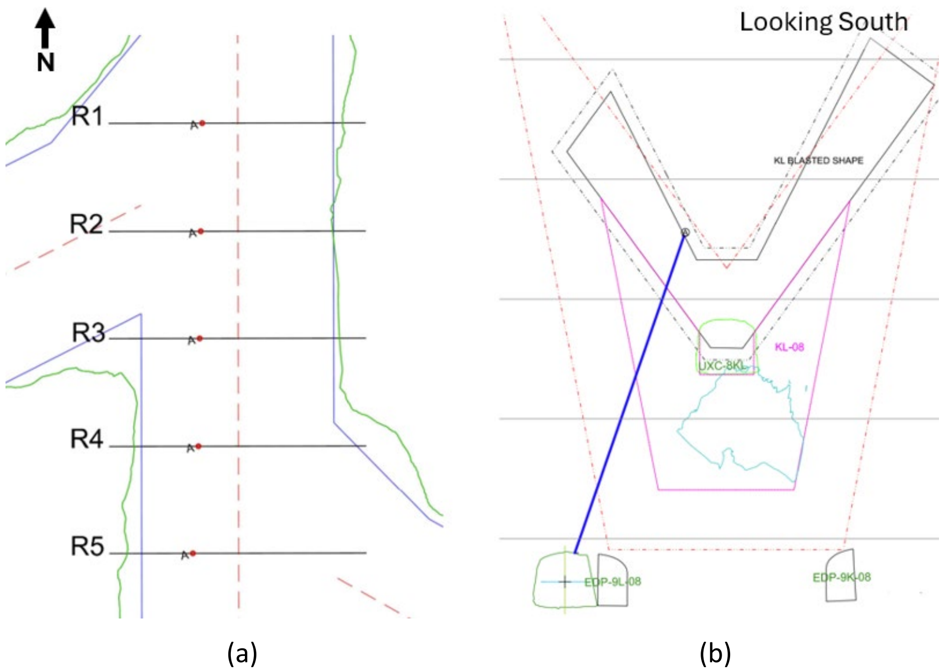
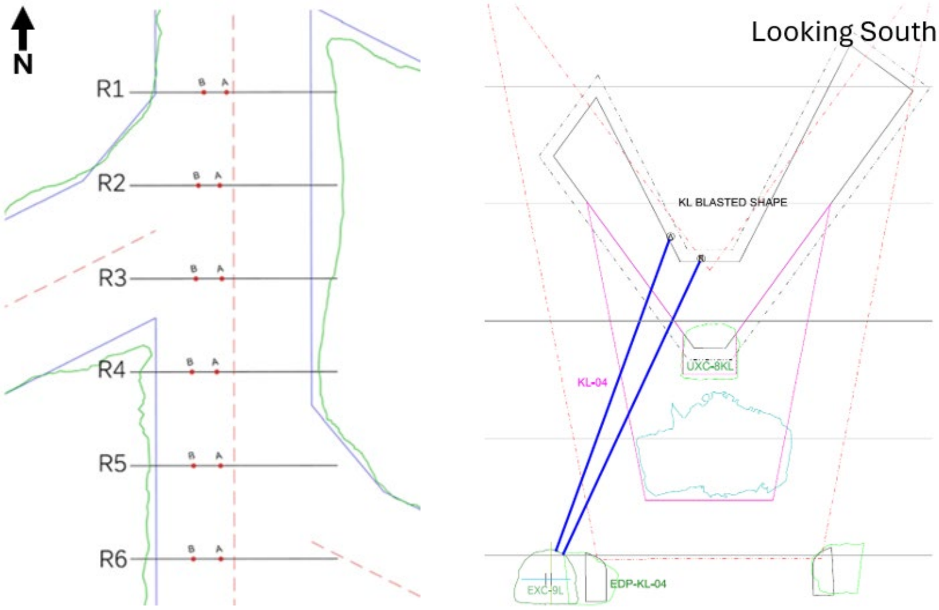


Figure 7 (a) Plan view of drillhole collars for initial recovery design from extraction level; (b) Cross-section of initial recovery design from extraction level

The initial drill design was less effective in recovering the JK-05, JK-03, and KL-04 drawbells. The JK-03 drawbell underwent 2 other recovery attempts using the initial drawbell design; none of the drillholes were viable for loading in the second attempt, and the drawbell re-opened after mucking only 200 t following the third attempt from the adjacent crosscut. The KL-04 drawbell re-opened after taking approximately 100 t following the first recovery attempt.

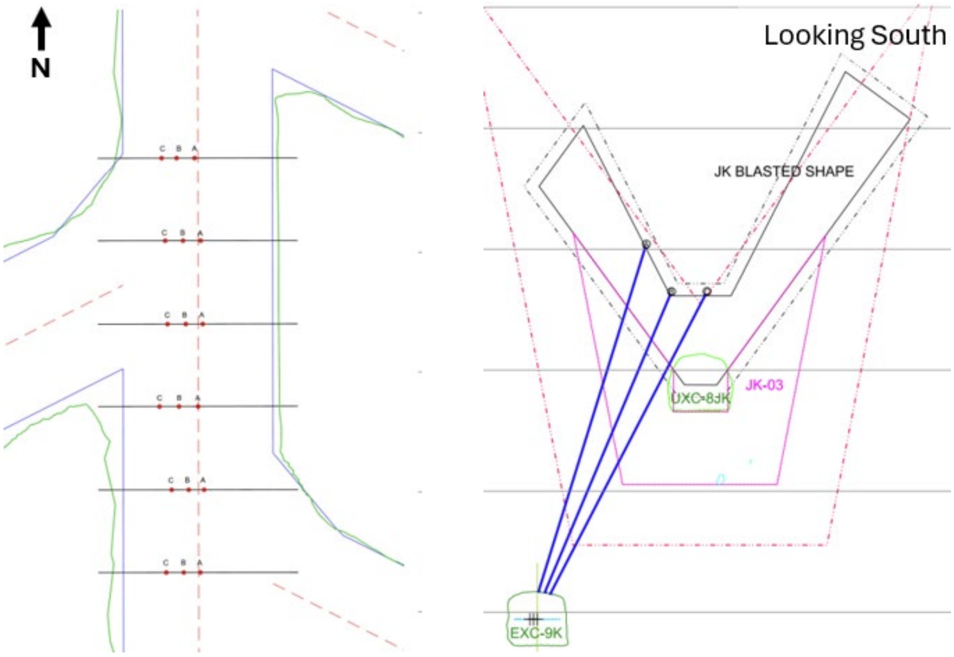
The recovery drill design was revised in March for JK-03 and KL-04 with the purpose of increasing drawbell coverage. An additional ring was added to the design, along with a second hole to each ring, for a total of 12 drillholes. The second recovery drill design from the extraction level is pictured in Figures 8a and 8b. The drilling results were more successful than previous recovery attempts; however, there were still several holes that were not viable for loading. Following the third recovery design, both drawbells first opened again after extracting approximately 100 t. Their status alternated between open and flowing throughout March to June.



(a) (b)

Figure 8 (a) Plan view of drillhole collars for second recovery design from extraction level; (b) Cross-section of second recovery design from extraction level

LiDAR scans showed that JK-03 and KL-04 experienced minimal displacement from previous recovery attempts, leading to a more aggressive recovery design. The final recovery design included an additional hole on each of the 6 rings for a total of 18 holes, as shown in Figures 9a and 9b. The fourth attempt at recovering JK-03 was successful in restoring steady material flow. The same drill design was planned for KL-04, but the drawbell naturally established steady material flow after periodically opening between the months of March and June.



(a) (b)

Figure 9 (a) Plan view of drillhole collars for third recovery design from extraction level; (b) Cross-section of third recovery design from extraction level

A summary of the modifications made to the recovery designs from extraction level is contained in Table 1.

Table 1 Summary of recovery design modifications

	Rings (#)	Drillholes (#)	Spacing (m)	Burden (m)
Initial design	5	5	2.5 – 3.0	2.5 – 3.0
Second design	6	12	2.7	2.0 – 2.5
Third design	6	18	2.5	1.8 – 2.5

5 Recovery load and blast design

The load and blast design was adapted based on the drilling success of each recovery drill design. In most cases, the actual drill metres achieved were less than designed. This is due to early breakthrough into the drawbell that had been previously fragmented in the primary blast. Any drillholes that extended at least 1 m into the designed drawbell shape was deemed loadable. As such, the success of the recovery blast was dependent on the success of drilling. A summary of the planned drill metres against the actual drill metres achieved is summarised in Table 2.

Table 2 Summary of planned versus actual drill metres for all drawbell recovery attempts

Drawbell	Drilling location	Planned drill metres (m)	Actual drill metres (m)	Designed explosive amount (kg)
HI-01	UWD-800	154.0	105.9	489.4
HI-05	H-05	128.6	96.1	–
IJ-04	I-04	138.8	103.6	253.3
JK-01	UWD-800	160.7	160.7	1,395.6
JK-03	J-03	154.0	83.3	–
	J-03	266.4	139.8	671.3
	K-03	139.9	83.3	46.0
JK-05	J-05	138.0	103.2	737.8
	K-05	139.6	109.9	322.2
JK-07	K-07	145.2	140.2	574.6
KI-02	UWD-800	215.6	215.5	1,298.1
	UWD-800	310.1	302.3	1,328.6
KL-04	K-04	136.4	119.9	335.2
	L-04	335.0	258.3	1,565.5
KL-08	L-08	138.7	129.3	525.9
Total	–	2,701.0	2,151.3	9,543.5

Since uphole drilling is employed for drawbells, it is important to distinguish that the collar is the start point of the drillhole and the toe is the end point of the drillhole. Successful recovery drillholes were loaded with Subtek Charge from the toe downwards and one or 2 primers, depending on the length of the hole. If the charge length was 10 m or less, only one primer halfway up the charge length was deemed sufficient. For holes with a charge length greater than 10 m, one primer was positioned 2/3 from the toe of the charge length, and the other 1/3 from the toe of the charge length. This is consistent with the modified primer placement, which is further discussed in Section 6.3. Two air bags are applied at the base of the emulsion to secure the explosive column.

For the initial recovery designs from the extraction and undercut levels, delays were consistently 25 ms between blastholes, similar to the drawbell blast delay design. As more blastholes were added throughout the design iteration, longer delays were implemented to allow for better material flow. It is difficult to assess the effectiveness of modifying delays, but the drawbells which used increased delays were successfully recovered.

An important consideration in the load design was grouting the blasthole collar to minimise blast-induced damage to adjacent pillars and confine the blast. Once recovery blastholes were charged, all recovery holes drilled in the extraction level were grouted at least 6 m from the blasthole collar. This distance was chosen to correlate with embedded long support distances. Due to the fractured nature of New Afton groundmass, this grout column length also mitigates potential for ground movement initialisation near the drift excavation. To confine the blast, recovery holes in both extraction and undercut were grouted at least 3 m from the explosive column. These minimum distances were recommended by the engineering team, but the entire collar was often grouted for operational efficiency.

Casing the drillholes with PVC pipe was also considered to assist with the loading process, but was ultimately not implemented in the recovery design. Loading drillholes in previously blasted ground often proved challenging due to the presence of loose rock, which could be mitigated by casing the holes. The use of PVC pipe could also have benefits in confining the blast by preventing blast energy from dissipating into the existing fractures. PVC pipe has previously been used in Lift 1 for loading drawbells. Due to the near-vertical orientation of the holes, challenges included anchoring the casing and retention of the emulsion.

6 Drawbell design optimisation

The New Afton technical services group collaborated with Orica technical service and field operation teams to review the C-Zone drawbell design. The effectiveness, or success factor, of each blasthole was assessed by Orica to make design improvements and reduce the risk of open drawbells for the remainder of C-Zone construction.

6.1 Drill pattern

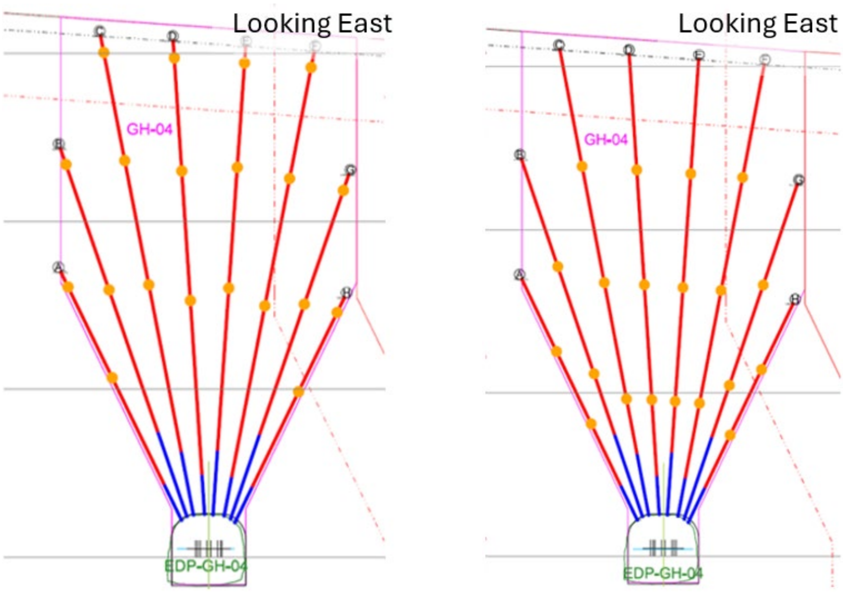
The true burden of several drillholes was deemed too large to effectively break to the free face, which could result in poor fragmentation or freeze the blast. To reduce the true burden between drillholes with the highest risk of blast failure, 7 drillholes were added to the drill pattern for a total of 62 drillholes. The true burden of the drillhole with the highest risk of blast failure was reduced from 4 to 1.95 m. Minor adjustments were also made to the position of drill rings and drillhole collars, so that they are evenly spaced apart. These changes are meant to improve material flow, as well as assist with the logging process.

6.2 Delay timing

The modifications made to the delay timing are to account for the greater blast volume of a C-Zone drawbell relative to the previous caves. The delay timing of the initial 6 holes increased from 35 to 50 ms to allow greater void formation around the central raise, while still allowing for short interhole delays to maximise material angular velocity. The delay timing for subsequent holes is between 25 and 35 ms. A 1,000 ms delay was added between the second outermost ring and the outermost ring on either side of the drawbell to improve void formation on the high sides of the undercut where the drawbell typically freezes. The blastholes in the corners of the high sides were also designed to fire simultaneously due to close blasting proximity.

6.3 Loading and priming

The hole length of the C-Zone drawbells is much longer than the Lift 1 and B3 drawbells, specifically on the high sides that connect to the undercut. Previously, the top primer was placed 1 m from the toe of the charge length, as shown in Figure 10a. The primer placement was revised, so that either 3 primers are evenly spaced at 1/4 of the charge length or 2 primers are spaced at 1/3 of the charge length, depending on the hole length, as shown in Figure 10b. This change was made to ensure that the top primer was fully enveloped in emulsion in the case that the blasthole becomes dislocated from a previously fired blasthole. All holes are traced with 200 grain detonation cord to ensure that the entire explosive column detonates if there is dislocation.



(a) (b)

Figure 10 (a) Cross-section of initial C-Zone drawbell primer placement; (b) Cross-section of modified C-Zone drawbell primer placement

7 Operational improvements

In addition to technical design changes, operational improvements were made to improve the success of drawbell blasting.

7.1 Clean and measure

Drillholes are cleaned and measured following the completion of drawbell drilling. The cleaning process involves using a combination of water and air by means of an emulsion charging unit to remove debris, so that emulsion can better adhere to the blasthole walls. The drillholes are also measured to verify their lengths. Once it is confirmed that all drillholes have been drilled to length, steel sets are stood at both drawpoints. Between cleaning, measuring and standing the steel sets, there is a 5 day period prior to loading.

To ensure the integrity of drillholes prior to loading, a second clean and measure is now included in the drawbell construction sequence after steel sets are installed. The purpose of the second clean and measure is to ensure that no holes have become blocked or collapsed in the time it takes to install steel sets. The underground drill and blast crew is provided with dedicated clean and measure prints from the engineering team which provide information from the drillers, including actual drill lengths, re-drills, and ground conditions.

7.2 Production mucking strategy

Production mucking data was analysed to identify draw patterns for the drawbells that froze, and support process improvements. Table 3 summarises draw information for each drawbell that was reported as open (i.e. lack of fragmentation due to unsuccessful primary blasting), including the number of idle days before consistent draw began, and the amount of material drawn between the draw start date and the date the drawbell was first identified as open. Note that the reported tonnage only includes what was mucked directly from the drawbell in the extraction level, and does not include material drawn from the undercut rings located above. Also note that the total tonnage does not account for material that is cleared from the extraction crosscuts following the blast, also known as swell material, which is approximately 2,000 t per crosscut.

Table 3 Production mucking data for drawbells that have been reported as open. Tonnage is based on a bucket factor of 8.9 t/bucket

Drawbell	Drawbell blast date	Draw start date (from extraction only)	Days idle	Date of open status	Draw prior to open status (from extraction only) (t)
IJ-06	5 Feb 2024	4 Sep 2024	212	28 Jan 2025	4,000
IJ-04	15 May 2024	4 Sep 2024	126	31 Dec 2024	2,700
IJ-02	21 May 2024	26 Aug 2024	117	8 Jan 2025	2,500
HI-09	28 Jun 2024	29 Aug 2024	62	23 Jan 2025	3,000
HI-05	25 Jul 2024	4 Sep 2024	12	23 Nov 2024	1,800
HI-03	14 Aug 2024	26 Aug 2024	41	31 Dec 2024	2,700
HI-01	16 Aug 2024	26 Aug 2024	10	20 Nov 2024	2,000
JK-07	28 Sep 2024	13 Oct 2024	15	25 Jan 2025	3,000
JK-05	1 Oct 2024	9-Oct 2024	8	28 Dec 2024	2,400
JK-03	18 Oct 2024	5 Nov 2024	18	2 Dec 2024	2,100
JK-01	18 Oct 2024	5 Nov 2024	18	28 Dec 2024	2,600
KL-10	11 Nov 2024	23 Nov 2024	12	25 Jan 2025	2,400
KL-08	17 Nov 2024	23 Nov 2024	6	21 Jan 2025	1,800
KL-04	30 Nov 2024	22 Dec 2024	22	29 Dec 2024	900
KL-02	9 Dec 2024	22 Dec 2024	13	31 Dec 2024	1,300
GH-06	1 Jan 2025	2 Jan 2025	1	17 Jan 2025	1,400

The production mucking data provides that the majority of drawbells were not consistently mucked from the extraction level until at least 2 weeks following blasting, with IJ-06 remaining idle for 6 months. Production drive access was limited during the first half of 2024 to allow for drawbell construction activities, limiting draw until ramp-up in November 2024.

The C-Zone cave management plan includes a requirement that 2,000 t be drawn from each drawpoint, either quickly following blasting or slowly over a number of months to verify that the drawbell blasted to the undercut as intended. Following the challenges with open drawbells, the C-Zone draw strategy was revised to include open to inspection (OTI) draw for all future drawbells immediately following blasting. Mucking the 2,000 t target draw quickly also provides void for the adjacent drawbell blast. Once OTI is achieved, the drawpoints are placed on regular draw control, which varies based on the maturity of the drawpoint.

8 Discussion

The objective of the initial recovery drill and blast design was to achieve sufficient drawbell coverage with minimal drilling and explosive usage to restore ore flow. The initial recovery designs from the extraction and undercut levels were successful in restoring steady material flow for 6 drawbells. The remaining 4 drawbells where the initial recovery design was attempted re-opened, leading to a more intensive drill and blast approach. The revised recovery designs include additional drillholes and reduced burden. A total of 10 drawbells were recovered using drill and blast methods. There are 6 other drawbells that alternated between open and flowing but ultimately achieved steady material flow without drill and blast recovery methods.

There are several potential contributing factors to open drawbells in C-Zone. With regards to the C-Zone geology, the southern half of the deposit is particularly fault affected and has a weaker rock mass than the north, where some of the most persistent open drawbells have occurred. The initial C-Zone drawbell design was adapted from the B3 design to account for the increased blast volume, but after thorough review of the success factors of each blasthole, it was determined that there was still excess burden, and further adjustments were required. There is little correlation in the production mucking data between the number of idle days and the amount of tonnage drawn prior to opening; however, any amount of compacted blast material in either the undercut or drawbells could have restricted material flow. Undercut ring blast performance was evaluated based on achieving a minimum required tonnage. The addition of an apex level may have helped identify areas of unsuccessful blasting in the undercut, so that any undercut issues could be rectified prior to blasting the drawbells below.

The recovery campaign resulted in optimisation of the C-Zone drawbell drill and blast design, including modifications to the drill pattern, blast delays, and loading practices. Clean and measure practices were improved, so that they take place directly prior to loading. The mucking strategy was revised to include OTI mucking directly after primary blasting, so that drawbell connection to the undercut can be confirmed early on and to provide void for the adjacent drawbell blast. While the exact cause of open drawbells cannot be confirmed, the technical and operational revisions made have prevented any further occurrences.

9 Conclusion

The recovery drill and blast campaign at New Afton mine's C-Zone successfully addressed the open drawbells that emerged while the cave was still maturing. Through drill and blast design optimisation and operational improvements, 10 drawbells were restored to steady material flow, enabling cave production.

The lessons learned from the recovery process provide insights that have since been applied to optimise both drill and blast design and operational practices. Key improvements include revisions to the drill pattern, refined delay timing, primer placement, and the enforcement of OTI draw strategy. These measures not only reduced the frequency of open drawbells but also improved the reliability and efficiency of C-Zone's overall drawbell construction strategy.

Looking forward, the experience gained from this establishes a foundation for managing similar challenges in future cave construction. Recovery drilling demonstrated that, while it is an effective remediation tool, the long-term solution lies in proactive design optimisation, operational practices, and continuous monitoring.

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