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Management of the Kalgoorlie Consolidated Gold Mines East Wall Slip

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Abstract

In 2018 and 2020, failures in the East Wall of Kalgoorlie Consolidated Gold Mines' operations in Kalgoorlie-Boulder, Western Australia, generated a combined ~1.2 Mt of material, causing production delays and loss to the available ore located in the Golden Pike pit below. Back-analysis identified that the Australia East Secondary Splay, the EWD3 Fault and the Fiji Fault formed a wedge that was mobilised by high porewater pressure. The wedge was approximately 180 m in length and 100 m at its widest.

In 2021, the plan for mining the slip material via a mine cut back behind the failure started to be developed and implemented. A risk assessment of the in situ wedge left behind found that it could be potentially unstable and thus unsafe to work on top of. A control zone was created using structural data, and additional rockfall protection was built below. The control zone was designated a 'no feet on the ground' zone. To manage the project, an area controller role was created to oversee operations and liaise with all stakeholders.

This paper will present the methodology adopted to safely mine the first horizontal 40 m of the East Wall Slip from the -150RL to the -190RL. This includes:

- Specific blasting approaches used.
- Management of interactions.
- Rockfall modelling and catchment.
- Mining methods using a shovel.
- Use of remote-controlled equipment within the control zone.
- Monitoring and alarming.

Keywords: *slope failure, slope remediation, open pit, cutback mining*

1 Introduction

This paper provides an update on the risk assessments, controls and mining practices utilised to mine the first vertical 40 m of the East Wall Slip (EWS) that occurred at Northern Star Resources Limited's (NSR) Kalgoorlie Consolidated Gold Mines' (KCGM) operations in 2018, as shown in Figure 1.

The project started in late 2021 with initial discussions and planning. By August 2022 the first production blast had occurred, with shovel mining beginning shortly after. During that period the mining surface progressed from -150RL to -190RL.

A control zone and additional rockfall catchment was constructed to ensure this mining process was executed safely. Work within the control zone was completed either out of a cage or by remote equipment.

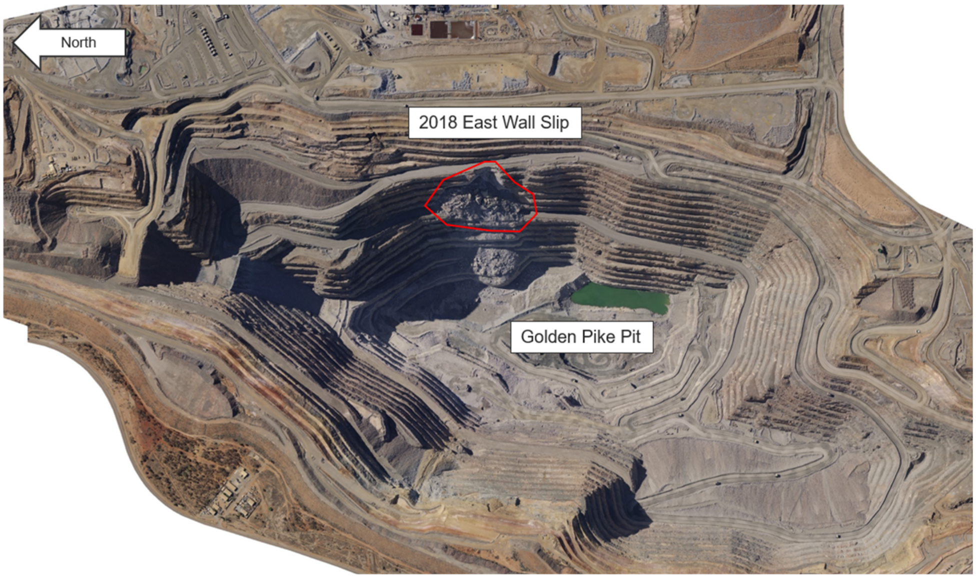

Figure 1 Location of the 2018 East Wall Slip within the KCGM Super Pit (Darbritz 2023)

2 KCGM pit overview

KCGM is situated east of the township of Kalgoorlie-Boulder, 600 km east of the capital city of Perth in Western Australia. KCGM was formed 1989 as a 50/50 joint venture (JV) between Normandy Australia and Homestake Gold of Australia Limited to manage all mining leases in the area. NSR took full ownership of the JV in 2021, bringing the assets and operations into both Australian and single company ownership for the first time. The dimensions of the current pit, known as the Fimiston open pit (or Super Pit), are approximately 3.5 km long, 1.5 km wide and 710 m deep. A section of the pit referred to as the Golden Pike cutback is currently being mined and will extend the ultimate pit depth to 780 m when complete. The Fimiston operation currently produces about 700,000 ounces of gold per year. Local geology in the Fimiston open pit consists mainly of dolerite and basalt with shale bands.

3 Description and history of the East Wall Slip

Between 2011 and 2022 a series of failures were observed around the East Wall. Each failure was associated with major structures exposed in the pit walls and identified by slope stability monitoring radar, and was then managed operationally and safely. The key observations of each event were as follows.

In March 2011 approximately 140,000 t of material fell off the wall after a heavy rainfall event. This blocked the ramp below until the failed material was removed.

Two failures occurred on 14 and 15 May 2018, with approximately 1 Mt of material falling from the wall. The ramp above was rendered unusable and the ramp below was blocked, with material also reporting to the pit floor. The failure was identified by the slope stability monitoring radar, which provided an early warning and facilitated a safe evacuation, and there was no impact to personnel or equipment. The structures that created the release planes for the wedge were the EWD3 Fault (EWD3), the Australia East Secondary Splay (AESS) and the Fiji Fault (FF) acting as the basal plane (Figure 2).

On 25 February 2020, approximately 70,000 t of material fell after heavy rainfall. The pit was already closed due to rainfall. The material landed on the rill cone left from the 2018 wall failure.

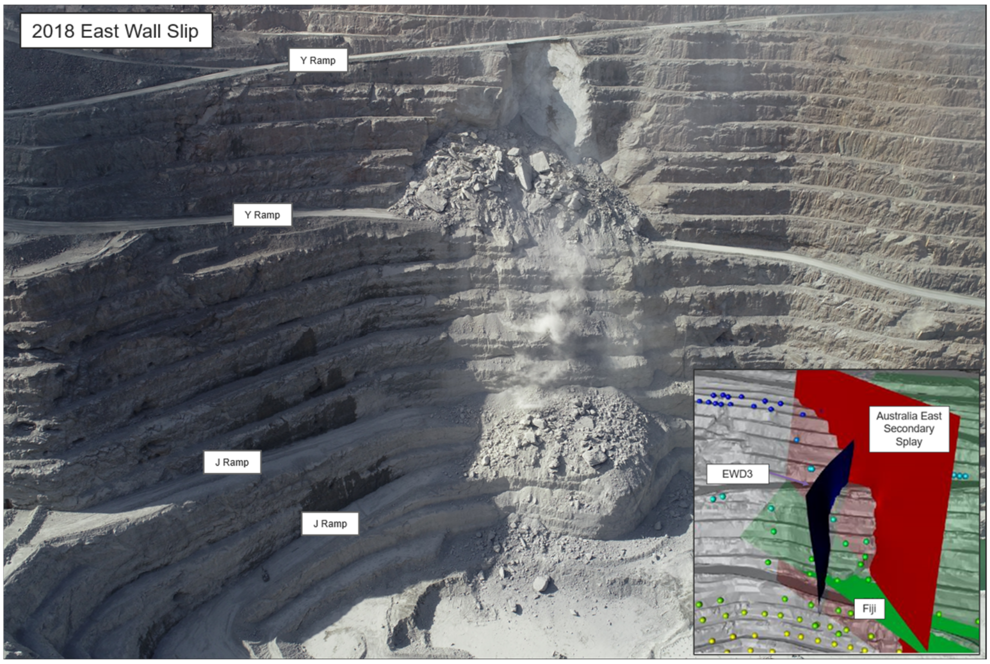

Figure 2 An image of the 2018 East Wall Slip, the EWD3, Australia East Secondary Splay and Fiji Fault (Darbritz 2023)

4 Initial risk assessment and controls

A defined work area was required before mining activities were planned and executed. The initial boundary was defined via the projection of the key structures supporting the remaining wedge onto the working bench. This boundary was then offset by 5 to 10 m (Figure 3). The survey team marked the boundary with red and white tape on the pit floor. At the start of the project, it was made clear that no personnel could access the control zone while on foot.

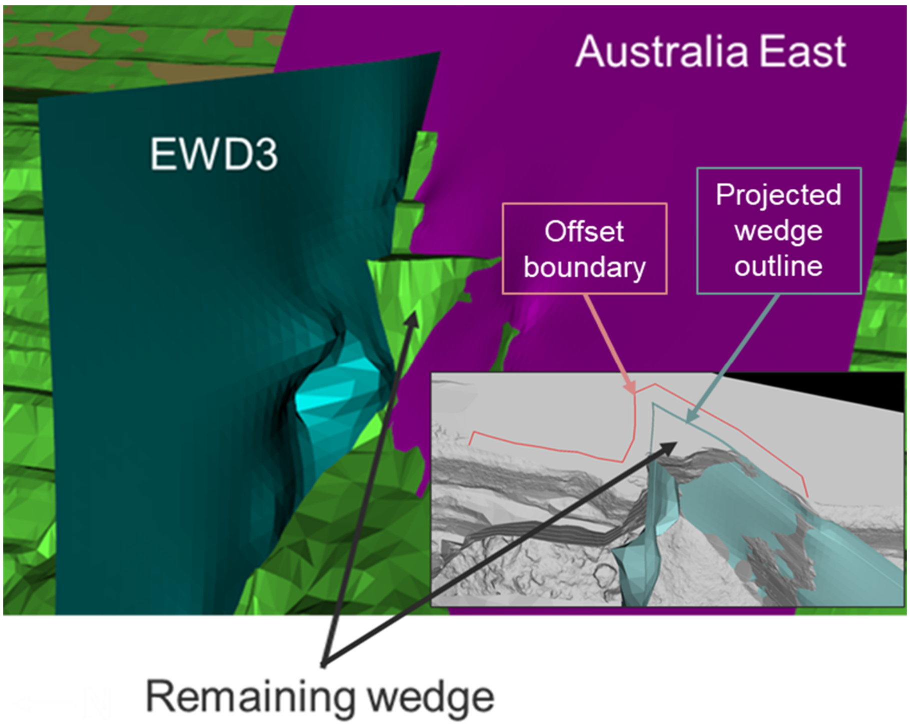

Figure 3 Remaining wedge formed by the EWD3 and Australia East structures after the 2018 East Wall failure

Rockfall modelling indicated that 1.1% of all rockfalls from the top of the EWS breached the lower exclusion zone. Trajec3D (Basrock 2022; Basson 2012) was used to model the rockfall. In the modelling, rocks were seeded from the crest on the failure scarp with no initial velocity. The rock properties included shapes such as cubes, flat boxes and flat elongated boxes, and varied between 0.5 to 50 t. The size of the rocks found to breach the exclusion zone the most frequently varied between 25 to 50 t. The rockfall modelling indicated the upper rill cone would direct most rocks towards the to the south. A catchment bund was therefore required on the pit floor to reduce the risk, and the energy absorption bund (EAB) was designed and constructed (using waste material) to increase this catchment capacity. The construction took four months and used 2 Mt of waste material. The rockfall modelling indicated the percentage of rocks breaching the exclusion zone to be 0.3% (Figure 4).

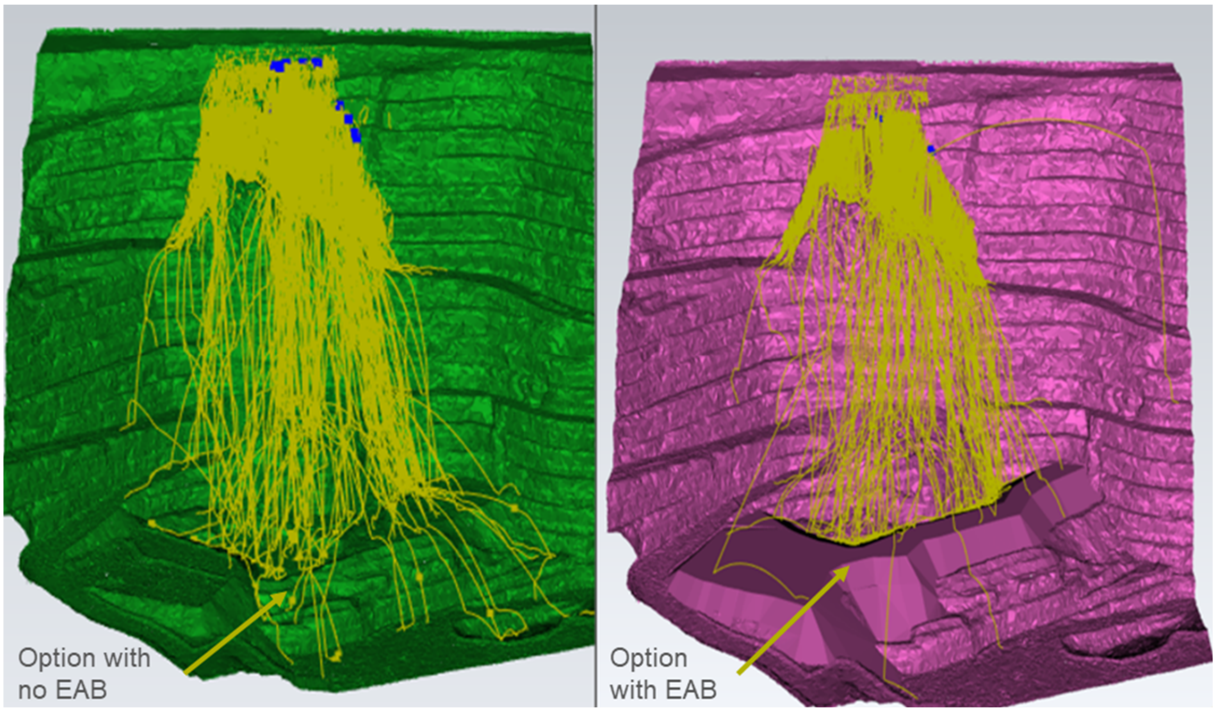

Figure 4 Rockfall modelling from East Wall Slip with and without the EAB (Wooley 2021)

5 Remediation of the East Wall Slip

5.1 Pattern design

As the EWS was to be removed via blasting and mining, the bulk material, blasting methods and blastholes within the control zone were reviewed and designed bench by bench. Hole designs were treated as a standard trim shot with a burden of 4.5 m and a spacing of 5 m. The powder factor averaged around 0.9, with a maximum instantaneous charge of around 250 kg. Specialised holes were used to target the bull nose and any unfavourable wedges and blocks found in situ on the slope face. Holes targeting these outcrops were drilled at angles of up to 65 degrees at a depth of up to 15 m and with a hole diameter of 165 mm (Figure 5).

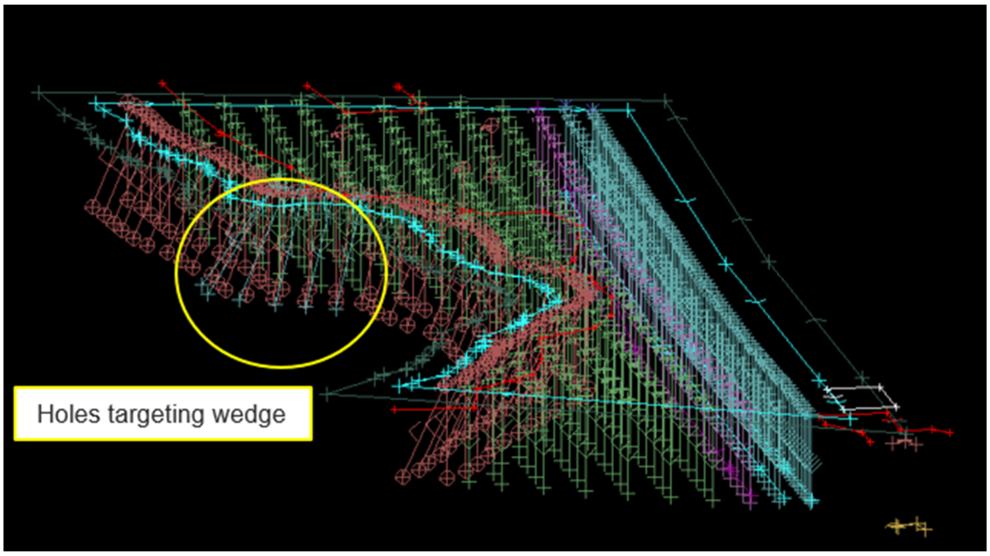

Figure 5 Example of a drillhole pattern above the East Wall Slip (looking north)

5.2 Drilling

Drilling of blastholes outside of the control zone was completed using a DRA 330 Rock Commander Drill Rig. A DRA PR350 MK2 Probe Drill Rig completed drilling blastholes within the control zone (Figure 6). A trailer-mounted hut was parked 50 m away and a driller operated the Rock Commander via remote control. The reach of the drill rig is 9 m. Any drilling within the control zone was undertaken with the pit below closed and/or required additional restrictions to be put in place.

Figure 6 Probe rigs drilling holes outside of the control zone and a remote rig drilling blastholes within the control zone

5.3 Blasting

The blasting product used to fragment the rock was bulk ammonium nitrate fuel oil, pumped with a mobile mixing unit truck. A loader with a modified bucket was used to stem holes outside the control zone. Holes within the control zone were stemmed and tied-in using either a custom-built workbasket and crane or elevated work platform. All shots were fired using Orica i-kon™ electronic detonators.

The custom workbasket was designed and built to allow the shotfirers to pump bulk explosives, pour stemming and tie-in the shot without setting foot within the control zone. The basket had a safe working load of 800 kg (400 kg of stemming, 200 kg of equipment and 200 kg for personnel). The hopper in the basket's centre could hold 0.2 m³ of material. A lever at the base opened the chute, pouring the material directly into the blasthole. Personnel in the basket were secured via a harness and one of eight anchor points inside the cage (Figure 7).

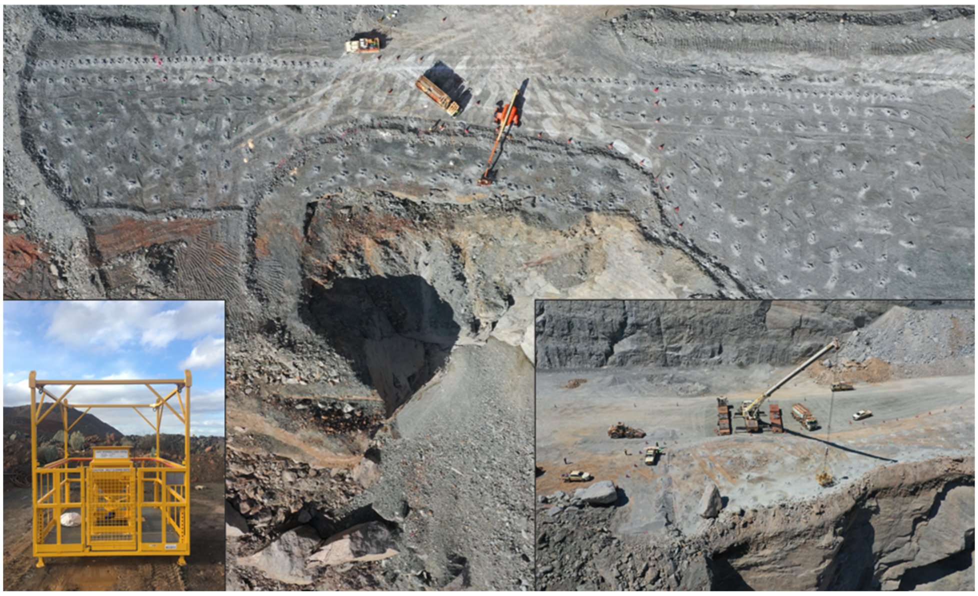

Figure 7 (Left) Image of the work cage; (Middle) The elevated work platform loading ammonium nitrate fuel oil; (Right) The work cage loading stemming within the control zone

Before blasting, all personnel within 200 m and directly below the work area were evacuated. Blasting could only occur on days when the wind was blowing away from town, for dust management purposes (Figure 8). Once blasted, there was a minimum settling period of 12 hours followed by a visual inspection using drones and a review of radar data before mining activities could resume.

Figure 8 Dust generated by blasting above the East Wall Slip

5.4 Mining

A total of 1.8 Mt of rock was blasted over the 40 m vertical progression. The bulk of this material was mined using a PC8000 face shovel, which has a reach of 13 m. A control zone of 10 m was marked-up on the heave with red and white tape and added to the bench manager system: a GPS tracking system that displays the shovel's location in real time. Any mining work conducted within the control zone or along the pit edge would shut down mining below.

Material within the control zone that was out of the reach of the shovel was mined using a remote-controlled Sandvik 621 front-end loader (Figure 9). A work area was constructed to segregate the loader from the rest of the mining traffic. This consisted of 1.8 m-high windrows, laser barriers and trip wires. A mobile tele hut containing the operator and equipment was positioned between 100 and 200 m away, and connected to an external generator. Material from within the control zone was relocated 50 m away and separately mined out using a front-end loader.

Figure 9 Image of a shovel and remote-controlled front-end loader relocating material above the East Wall Slip

6 Ongoing controls and considerations

6.1 Area controller and the interaction management plan

The position of area controller was created to be a single point of contact for the project. The key areas of responsibility were managing the tasks, coordinating with work groups and communicating with stakeholders. In addition, the area controller would manage the interaction between mining activities above and below the EWS. As a result, an interaction management plan was developed to facilitate communication of activities, task durations and the task locations. It also included systems and protocols to identify key personnel and their authorities, accountabilities and responsibilities. Scheduled and authorised tasks were communicated the day before scheduled work.

6.2 Control zone

The control zone varied from level to level depending on the footprint of the two main structures, the current pit edge and the current geometry. After each blast the control zone was updated using 3D survey scans. This was then uploaded into a 2D visualisation package utilised to view historical voids and workings, and general information such as pattern boundaries, drill locations, current dig faces and ore boundaries.

6.3 Slope monitoring

Two IDS slope monitoring radars continuously scanned the area over a 24-hour, seven day period. Specific alarm thresholds were set and would alert the geotechnical engineers and dispatch operators in the event of elevated displacement or velocity. The alarms were based on velocity threshold over a one-hour period. The alarm settings were based on previous experience with slope displacement in the area. Any radar alert deemed real would trigger an evacuation as per the local trigger response action plan (TARP). In addition to radar alerts, the TARP outlines controls for wet weather events and re-entry requirements.

6.4 Water management

As the area is susceptible to water (Figure 10), hydroscaling and dust suppression were managed with strict controls including:

- Day shift can only operate between 0600 and 1600.
- Water carts can spray water for a maximum of 30 minutes.
- After a water cart has finished, no additional water may be sprayed for two hours.
- Radar monitoring must be active at the time of spraying.

Figure 10 Image of the wall to the south of the East Wall Slip showing water recharge on the slope post-hydroscaling

7 Conclusion

The EWS of the KCGM Fimiston Open Pit (Super Pit) has shown a history of significant structurally controlled wall failures between 2011 and 2020 caused by the AESS, EWD3 and FF. In 2021 a plan to remediate this slope began. Between August 2022 and June 2023 over 1.8 Mt of material was blasted and removed from above the EWS from the -150RL to the -190RL. Due to the work area's size, location and complexity, several unique mining techniques were adopted to meet the challenge. These included:

- Modified work areas that included control zones.
- Remote drilling.
- Custom-built cages for loading bulk explosives and stemming.

- Using a remote loader to relocate material.
- Managing interaction with other mining activities and work groups.
- Establishing a single point of contact for the coordination of all activities.

These unique techniques were developed and challenges overcome due to the skill and experience of team members from all areas of the mining cycle and, as a result, were completed safely and without injuries, equipment damage or incidents.

References

BasRock 2022, *Trajec3D*, version 1.7.2.8, computer software, BasRock, Perth, https://www.basrock.net/trajec3d

Basson, FRP 2012, 'Rigid body dynamics for rock fall trajectory simulation', in A Bobet, R Ewy, M Gadde, J Labuz, L Pyrak-Nolte, A Tutuncu & E Westman (eds), *Proceedings 46th US Rock Mechanics/Geomechanics Symposium*, Curran Associates Inc., New York, pp. 1438–1444.

Wooley, C 2022, *Mine Method, and Controls, to Cut Back a Failed Slope at KCGM's Fimiston Pit (KCGM), Geotechnical Review Of East Wall Cutback 2022*, report, Andrews Rock Mechanics, Perth.