WHAT ARE THE BENEFITS OF PRECONDITIONING?

The benefits of preconditioning are as follows:

- minimised/eliminated faceburst" hazard (no faceburst incident has been reported from panels where preconditioning was regularly and properly implemented);
- reduced damage by distant seismic events;
- reduced accident/injury rate (seismicity, f.o.g.);
- improved H/W conditions (Figure 5);
- better stoping-width control;
- improved face conditions (clean and straight break, no sockets);
- improved hangingwall fracturing (less shallow dipping fractures);
- increased face advance per blast, therefore greater productivity and production bonuses;
- increased drilling rate;
- reduced fragment size of blasted reef, therefore easier cleaning;
- reduced dilution;
- reduced stoping cost; and
- improved worker morale.

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Rockbursts in the deep gold mines of South Africa continue to present a safety problem. The working faces are particularly prone to rockbursts and the exposure of personnel in these working areas is high. The result is that in the event of a rockburst in a stope face, fatalities and serious injuries may occur.

Considerable research has been conducted, first by COMRO and more recently by SIMRAC, to understand and combat facebursts. The work has shown with correct implementation of the preconditioning technique the incidence of facebursting decreases and conditions in general improve in the stope. However, it is clear that a high level of diligence and commitment is required to correctly apply preconditioning. Part of the success of preconditioning is related to a well-informed workforce regarding the technique. The research efforts from the researchers are effectively and comprehensively covered in major research reports. However, those working at the rock face need the critical ingredients to make the preconditioning effective rather than all the fundamentals behind the technique. The booklet lays out the essential facts regarding preconditioning and is presented in a format that underground workers can carry with them underground was a reference.

I commend the use of this booklet by those using preconditioning techniques so that mining may be carried out more safely.

May Hermanus

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This booklet has been produced to assist senior mine personnel (shift boss to mine manager) in the correct implementation of preconditioning on mines in order to reduce the risk of rockbursts that occur at the stope face.

RECOMMENDED IMPLEMENTATION PROCEDURE

1. **Preliminary evaluation**: Mine rock engineering personnel together with the senior production personnel have to investigate rock-related problem areas on the mine, determine their causes, and identify possible solutions. These could include applying preconditioning to the identified workplace. The preconditioning research team may be called to help at this phase.

2. **Planning of the implementation programme**: The implementation team has to plan the implementation programme in terms of the roles and responsibilities of individual departments, the timing of the activities and the tools to be used to assess how effective preconditioning has been. Additional machine operators are not necessarily required for preconditioning. However, additional drilling has to be done and equitable payment or bonuses for this work need to be decided upon before preconditioning is started. In the past, the extra work involved in preconditioning has not been well recognised, and this has led to problems. One of these problems has been the poor implementation of preconditioning.

3. **Education and training seminars**: It is essential for the preconditioning research team, together with mine training personnel, to educate the production personnel before attempting to introduce preconditioning in the underground environment. Education must come before training, so that the concept of preconditioning can be explained to the workforce. The education phase will involve discussing rock-related problems that workers experience underground and showing how preconditioning is a part of the solution to these problems.

4. **Risk assessment**: Prior to the actual implementation of preconditioning, a risk assessment must be carried out. It is strongly recommended that production personnel take part, as risk assessment reveals how important it is for preconditioning to be correctly applied and what the dangers could be if it is not applied correctly.

5. **On-the-job training**: An expert team must assist the production personnel during the initial stages of implementation. Proper training on positioning, drilling, charging-up and tying-up procedures for preconditioning holes should be provided.

6. **Follow-up and assessment of the results**: This phase involves establishing regular follow-up and control mechanisms to ensure that regular and correct preconditioning is applied throughout the mining activities on a particular stope. These mechanisms should continue until mining activity on the stope has ended. While safety control officials and senior production personnel are ensuring the regular and proper application of preconditioning, the rock engineering department, with the help of production personnel, is responsible for the assessment of the results.

(a)Without preconditioning

(b)With preconditioning

Figure 6. A comparison of hangingwall conditions in unpreconditioned and preconditioned parts of a panel

PROBLEM

The mining of reefs at great depths induces extremely high stresses on the rockmass near any stope excavation. The high stress and related increase in strain energy stored in the rockmass results in instability. Gravitational forces and strain changes in the rockmass create violent or non-violent displacement of pre-existing discontinuities or extend the fracture zone ahead of the stope face. The violent release of accumulated strain energy can be described as a seismic event that may result in a rockburst. Factors that determine whether a rockburst will occur or not are: 1) the magnitude of the seismic event; 2) the distance between the source and the excavation; and 3) existing ground conditions around an excavation. If a rockburst occurs, it can cause extensive damage to underground workings, and may cause injuries and even fatalities.

WHAT IS A “FACEBURST”?

A “faceburst” is defined as the ejection of rock from mining faces at a very high velocity into the mine workings due to the violent release of accumulated strain energy.

WHAT IS PRECONDITIONING?

Preconditioning, also called “destress blasting”, is a rockburst control technique that regularly involves setting off designed blasts ahead of the stope face. The blasts dissipate energy by promoting slip on fractures, which transfers the stresses further away from the stope face (Figure 1). This is achieved by remobilising the existing fractures in the rockmass so that strain energy is not accumulated immediately ahead of the working face. When the preconditioning blasts redistribute stress away from the working face, a cushion of stress-relieved rock ahead of the stope face is provided, and this is able to absorb energy from distant events.

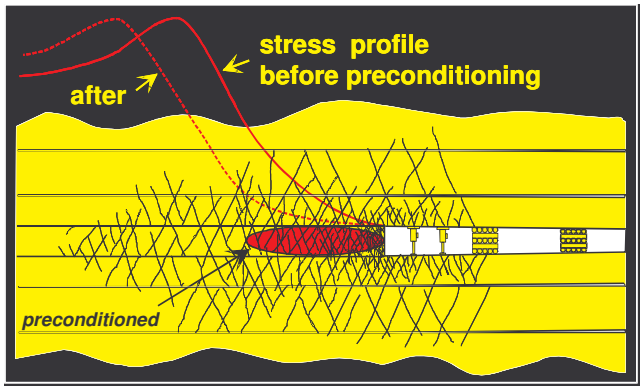

Figure 1. Idealised stress profile ahead of a stope face before and after preconditioning

FACE-PARALLEL PRECONDITIONING

The face-parallel preconditioning technique involves the drilling and blasting of a large-diameter hole (75 – 90 mm) parallel to a panel at a pre-determined distance ahead of the panel face. The technique was designed for an overhand mining layout where holes are drilled in an up-dip direction from the leading panel as shown in Figure 2. In order to keep delays to production short, a panel lead/lag of about 7 m must be in place to accommodate the drilling of the preconditioning holes. The holes are drilled using a dedicated percussion drill rig that can complete a hole in less than a shift.

WHERE CAN WE USE FACE-PARALLEL PRECONDITIONING?

Face-parallel preconditioning is recommended for use in special areas, such as remnant or pillar extraction, as it can be more effective than the face-perpendicular method for dealing with the exceptionally high stresses encountered in these areas.

POSITIONING THE PRECONDITIONING HOLE

The actual hole positioning will be site-specific and will depend on both the state of stress ahead of the face and the size of charge being used. Experience has shown that blasts from 89 mm-diameter preconditioning holes have been effective when the holes are positioned at 3.5 m to 5.5 m ahead of the stope face. (76 mm holes to be drilled 3 – 4 m ahead of and parallel to the face.) The holes should be drilled below to the reef horizon along the reef/footwall contact. Each hole should be inspected after drilling is completed so that the hole direction can be checked. Severe deviations will tend to curve the holes down and can cause inconsistent blast results.

PANEL LENGTH

It is recommended that individual panels should not be longer than 20 m in order to ensure that the drilling of the face-parallel preconditioning holes can be completed in one shift.

PRECONDITIONING HOLE LENGTH

The preconditioning hole should be drilled a few metres (e.g. 5 m) longer than the panel length.

DETONATION SEQUENCE

Since the face-perpendicular preconditioning holes are blasted as part of the production blast round, the timing sequence of these holes relative to production blastholes is very important. Any mistiming may lead to ineffective preconditioning and/or misfires.

No matter what type of initiation system is used, the common rule is that each preconditioning hole must be initiated a minimum of 1 m ahead of the burning face of the stope-front production holes.

HANDLING OF MISFIRES

The production holes must be examined for the possibility of misfires, and the sockets of the preconditioning holes must be examined after each blast. Every preconditioning hole should be identified, marked in the case of a misfire, blown out, and plugged in the case of a socket.

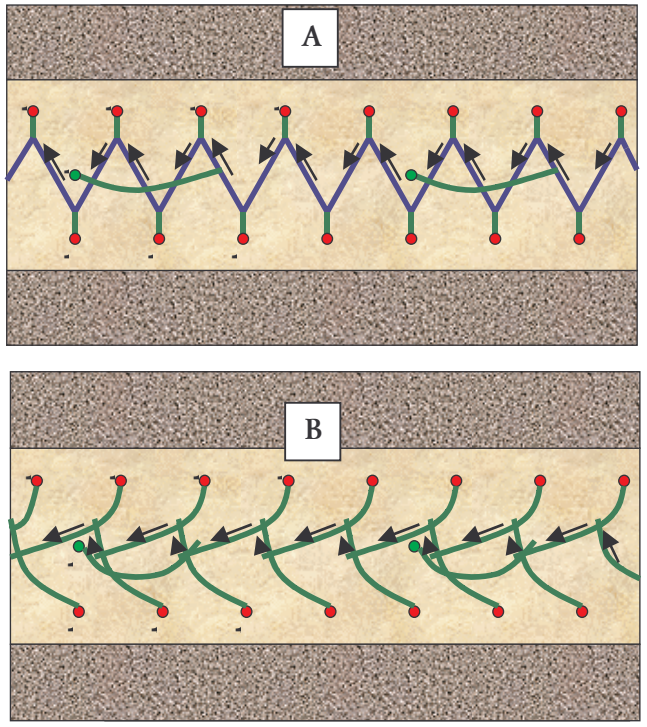

Figure 5. Initiation Systems A) Normal Initiation system B) Nonel Initiation System

POSITIONING THE PRECONDITIONING HOLES

The preconditioning holes must be drilled at right angles to the face and should be 60 cm below the intended hangingwall if the stoping width is greater than 1.2 m. If the width is 1.2 m or less the holes should be drilled in the middle of the stope face. Figure 4 illustrates the relative positions of the preconditioning and production holes. The closest point between the production and the preconditioning holes is at the collar and, when properly drilled, the production holes are drilled away from the preconditioning holes.

If the support is too dense or too close to the face to accommodate 3 m long drill-steels, as might be the case when using backfill, extension steels will be required.

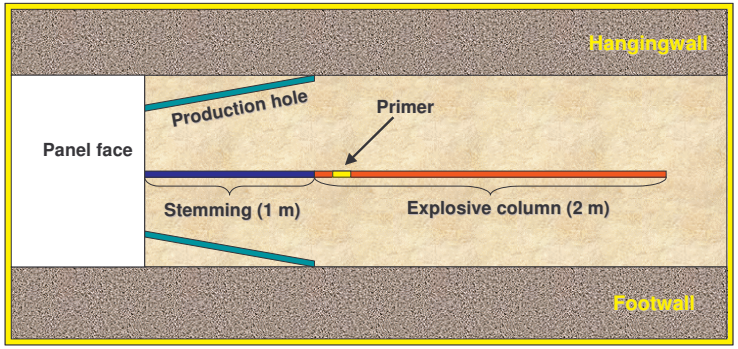

Figure 4. Cross-section ahead of the stope face, illustrating the relative positions of the production and a 3 m preconditioning hole

CHARGING

Explosives must be charged in the back 2 m of the hole, with the remaining 1 m being stemmed as shown in Figure 4. The detonation of preconditioning holes should be by top-priming the explosive charge, so that primers can be more easily removed from misfired preconditioning holes. One emulsion cartridge is recommended as a primer and should be initiated with a Nonel or electronic detonator (or whichever detonating system the mine is using). It is recommended that an extra explosive cartridge should be placed next to the primer. (Please check this last sentence. Does it make sense?)

STEMMING

As only 2 m of the preconditioning hole is charged with explosives, the remaining 1 m should be tamped with a competent stemming material. Clay, bentonite, angular sand or a combination of these could be used for tamping the preconditioning holes. Stemming is very important, as effective stemming will maximise the gas pressure retention time, so that the explosive energy can be contained within the hole as long as possible. The stemming also helps to protect the downline to the detonator and ensures that the primer cartridge remains in place while neighbouring holes are firing.

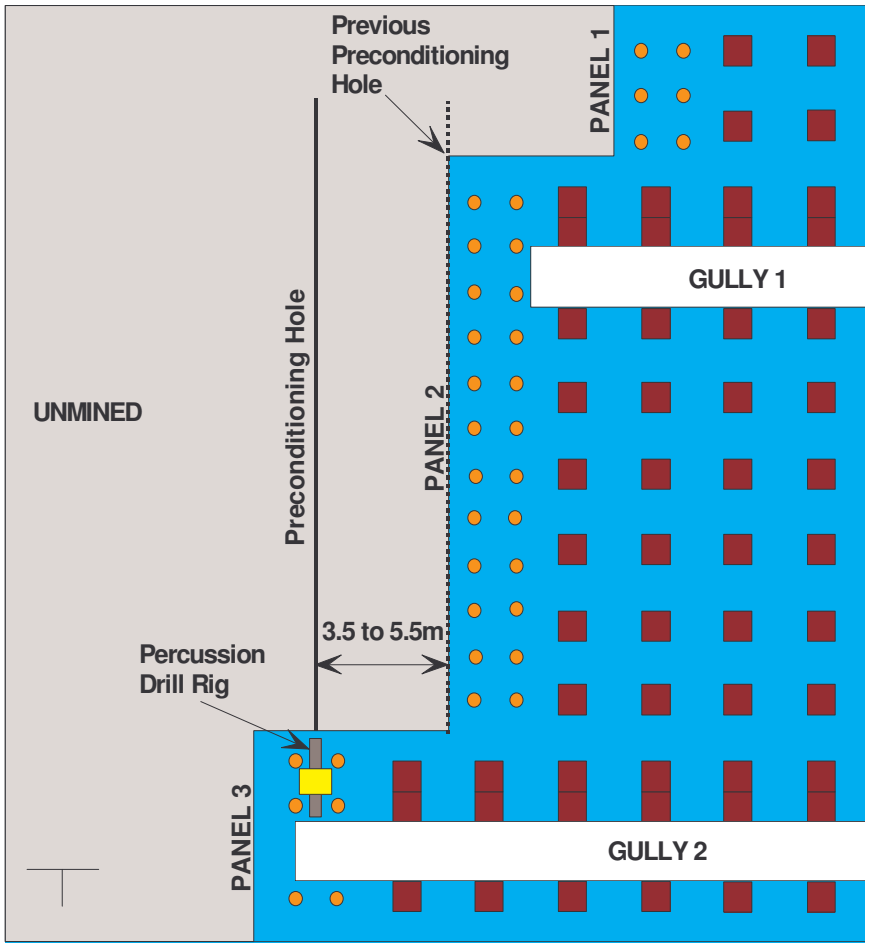

Figure 2. Face-parallel preconditioning layout in an overhand mining layout (not to scale) As shown in this figure, Panel 2 has been mined to the limit of effective preconditioning, i.e. the position of the previous preconditioning hole. The next hole must be drilled between 3.5 m and 5.5 m from the current face. The hole must be kept parallel to the face to ensure a consistent preconditioning effect along the entire length of the face

CHARGING

Research has shown that the more gaseous explosives such as ANFO should result in better preconditioning results. However, the two explosive types (ANFO and emulsion) have not shown any significant difference in terms of the results of actual preconditioning blasts.

The detonation of preconditioning holes should be by top-priming the charge to facilitate removal of primers from misfired preconditioning holes. An emulsion cartridge is recommended as a primer and should be initiated with a Nonel or electronic detonator.
Two detonating fuses may be used as a safety precaution: if the first fuse fails to initiate, the second fuse would be detonated. The primer should be placed about 6 m into the hole, with an additional metre of explosive behind it and ahead of the stemming.

STEMMING

It is recommended that a minimum 5 m of the hole should be stemmed in order to avoid a blowout from the collar of the hole. Best results have been achieved when 1 m of clay adjacent to the explosive column is followed by 4 m of crushed rock. The crushed rock should have a particle size of between 1/30 and 1/15 of the hole diameter and should be grit rather than sand. Grit particles are angular and can increase stemming retention. Cartridges of clay and crushed rock can be pneumatically loaded.

However, the length of stemming required (at least 5 m) results in the transfer of stress onto this stemmed portion of the panel. The solution to this is to drill additional holes that are shorter and of smaller diameter (either parallel or perpendicular to the face) between the main hole and the panel face to precondition the area that the main preconditioning blast will not reach.

PRECONDITIONING SEQUENCE

As the preconditioning process involves stress transfer from one portion of the rockmass to adjacent regions, a systematic sequence of preconditioning is important. The best results to date have been achieved when the sequence begins with the lagging panel in the stope, and progresses down-dip towards the leading panel. Out-of-sequence preconditioning should be avoided as it can result in increased stress concentrations on adjacent panel faces.

FACE-PERPENDICULAR PRECONDITIONING

The face-perpendicular preconditioning technique involves the drilling and blasting of face-perpendicular holes as an integral part of the actual production blast cycle. Face perpendicular preconditioning is suited to normal production faces as it integrates well into the mining cycle.

LAYOUT

Face-perpendicular preconditioning uses standard diameter 36 – 40 mm blastholes drilled perpendicular to the stope face to a depth of 3 m and fired as an integral part of the production blast. This allows utilisation of the drilling machines and drill steels currently available on most mines. There is, therefore, no need to purchase special drilling equipment. The recommended spacing between preconditioning holes is 3 m.
The schematic plan view of face-perpendicular preconditioning layout is shown in Figure 3. Assuming the panel face will be blasted once every day and advanced a minimum of 1 m, this technique is based on a three-day cycle. On day one, the preconditioning holes (blue lines) are drilled together with the production holes and blasted. On the second day, once the face has been cleaned and prepared for the drilling of the next round, the drilling of new preconditioning holes (red lines) commences. For this round, the preconditioning holes are offset down dip from the previous day's preconditioning holes by about 50 cm. The preconditioning holes on the third day (green lines) are offset from the sockets of the previous day's preconditioning holes by about 50 cm.

Using this system, the panel face is advanced at least 3 m during these three blast cycles. Thus, the preconditioning holes on the fourth day (blue dotted lines) are drilled in the same relative positions as on the first day, as the face has at this stage advanced beyond the ends of the original holes.

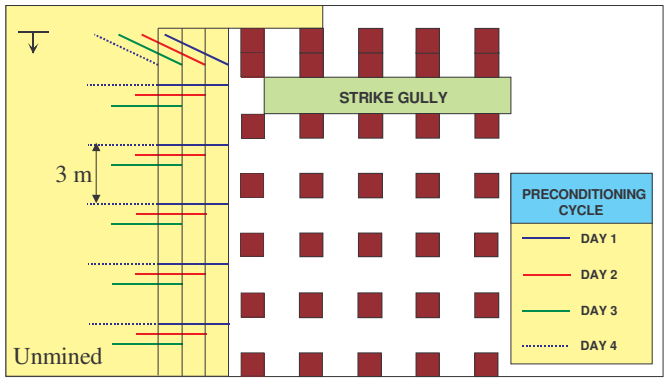

Figure 3. Face-perpendicular preconditioning layout. Note that the first preconditioning hole at the top must inclined 25° - 50° up-dip perpendicular to the face.