PROFILING TECHNIQUE USE TO OPTIMIZE THE BLASTING OF SLOT AND LONG STOPES

Hello everyone, today we will bring a successful case in the underground mining area. In all underground mining there is a need for an initial free face opening, and this is usually done through detonated slots or through small raise boring boxholes (see figure 1). In this article we will discuss in more detail the first type of opening and the newest technologies for this

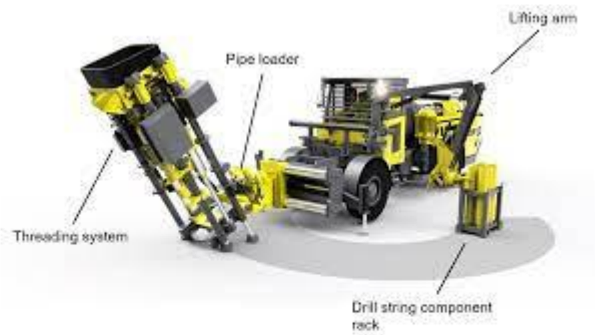


Figure 1: Easer L for relief holes

This initial free face must be open so that all productive fans are detonated into it, as we have discussed here before, every blast needs a free face to be effective.

The slot, burn or chimney are operational nomenclatures given to this first free face. It is obtained through a geometric combination of empty holes with productive (loaded) holes. This configuration varies mainly according to slot length and rock type. (see figure 2).

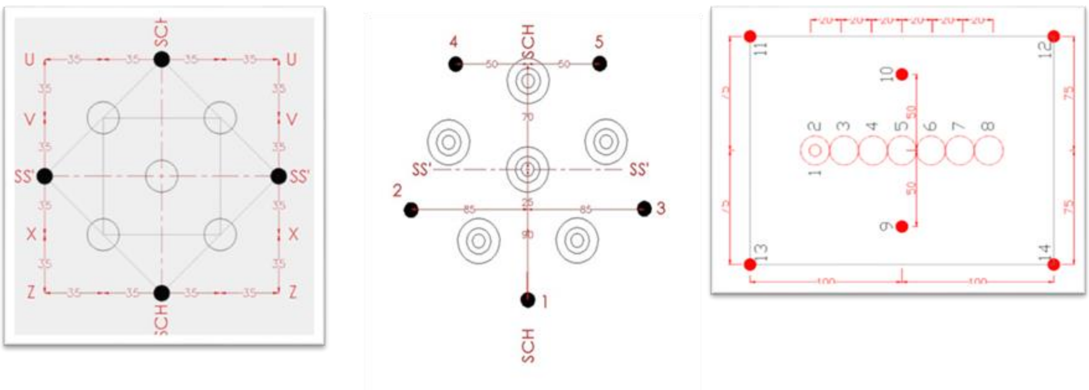


Figure 2: Free face opening for slot types.

The detonation of these slots in the past was done gradually and demanded so mucho from the blasters even in the physical, operational and safety aspects, due to this there was a need for single detonations of the slot to avoid such exposures and risks, however, the rate of failure increased significantly. (see figure 3)

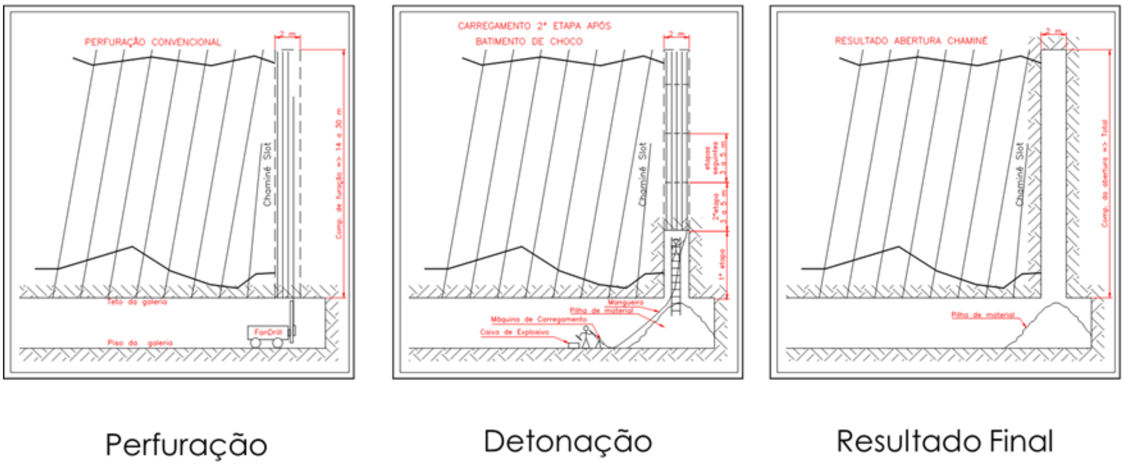


Figure 3: Steps in the blind free face opening process.

The process of opening a blind chimney to obtain the free face is undoubtedly the most risky activity and has always represented the greatest challenge in the underground mine, both from a technological and safety point of view. Such openings are called blind precisely because they are not communicated with an upper level and, therefore, limit access only through the lower gallery, as shown above.

In the gold mine located at the interior of Bahia where the tests were carried out, not unlike the other mines, this was always one of the most significant factors. In order to reduce the exposure of man, blaster, during this opening process, raise boring equipment is used. However, this equipment has some limitations in relation to the drilling inclinations of shafts with angles of 45°, which often makes the stope economically unfeasible because the stope conformation to 60° considerably increases its dilution, that is, there is not always possibility of free face drilling with raise boring with the need for the detonated method.

With conventional top hammer equipment, the underground mine can drill holes with variable inclinations with large diameters and guaranteed precision up to the required length (30 meters). However, for these lengths, even with

too much caution in the operation, the drilling presents significant deviations. However, with the relief and production holes surveying, it becomes possible to carry out a spatial analysis of the distribution of these holes and, using this information, plan loading on decks, that is, in load intervals, together with a adequate exit timming, allowing these slots to be detonated in a single fire, obtaining recoveries above 90%.

Profiling in this context works as an “x-ray” of the drilling because, many times, we only observe the hole opening and we do not know how it is distributed within the rock, how much deviation it had. This investigation of the hole through profiling provides us with important information for the next steps, detonation.

In this article, we are going to emphasize a successful case in a gold mine with the application of this methodology in which it uses the technical information of survey for become economic viability of the stopes through optimization of the blasting timming, that is, the blast is optimized from this “x-ray” of the drilling.

METHODOLOGY

In order to identify the vertical orientation of the holes, the survey process was used with a profiling equipment, digital and magnetic, which is used for measuring the trajectories of the holes. Its main function is to map the direction and inclination of the holes. After carrying out these measurements, it was possible to define a pattern of deviations, thus enabling the adequacy of customized loading projects and, in this way, increasing the recovery of detonations.

The survey of long holes in sublevel mining (Slot, Counter Setbacks and Normal Fans) with the measuring instrument, Profiling REFLEX EZ-AQ / EZ-TRAC (Palmtop and/or Tablet), aims to determine possible deviations and variations of length of holes drilled in mining sections; prioritizing narrow mines, long holes and critical stopes, improving the recovery and dilution percentage of the mine.

The methodology adopted for the execution of this work can be listed below:

- Preparation of drilling plan and topographic set up;
- Field monitoring of the execution of the drilling through angle measurement, regulation of advance and percussion pressures;
- Profiling of all holes drilled by the DL421, including 203 mm holes;
- Treatment of survey data and identification of the best hole time blast sequencing;
- Decision-making on the type of loading and timming to be adopted (eight meter charging lenght for production holes);

- Use of spacers around 60 cm to discontinue loads of 8 meters from the three decks of each hole;Controle de tampão para preservação do brow do slot (ou boca do slot);

Blast design and topographical set up

Considering the versatility of the vertical drilling equipment (DL421) in relation to drilling angles, it was determined that the slot should be drilled with this equipment for a better inclination of the designed stop and optimization of mining.

For this type of equipment, a new configuration of the drilling design was necessary, in which there was enough free face for the blistering of the entire detonated slot section. Therefore, a new drilling plan was established with the addition of new relief holes, increasing the void area inside the slot.

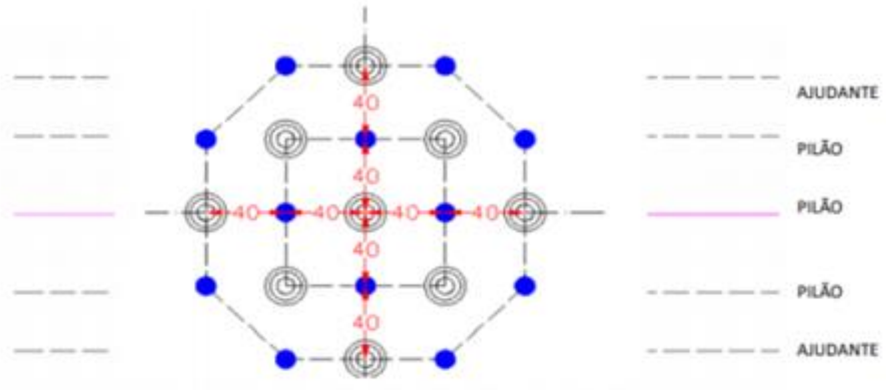


Figure 4: Slot drilling plan with relief and production holes.

Execution of the drilling plan

Once the mesh has been defined, it was necessary to carry out an effective follow-up of the begining of holes and their respective angles in the field. The calibration of the equipment was also a fundamental factor for the good performance of the begining hole to avoid large dispersions.

Advance and rotation pressures were monitored at all times in order to avoid unwanted operational deviations.

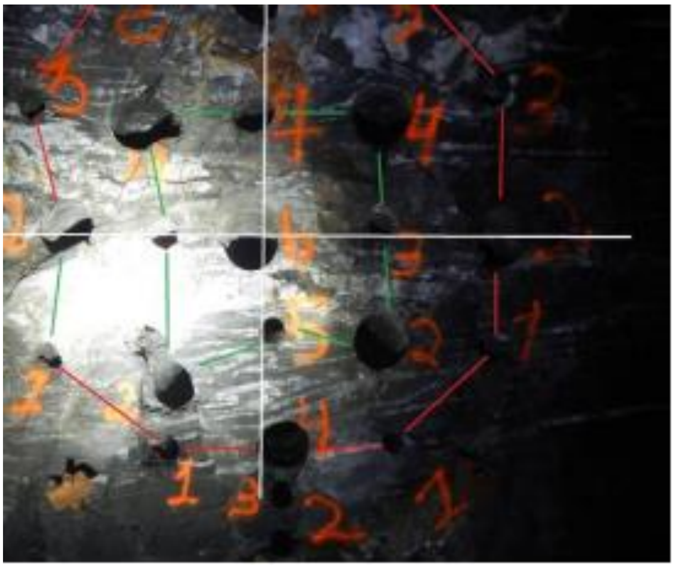


Figure 5: Execution of slot drilling with DL 421 at a lateral angle of 45°.

Survey of all drilled holes

Once all the holes drilled through the drilling plan were identified, profiling of all of them was carried out. There was a need to investigate even the relief holes because the identification of their spatial distribution is essential for a good free face generation sequence.

The equipment used for this purpose was the Reflex profiler model EZ-AQ and Palmtop/Tablet models EZ-TRAC. The materials used to carry out the activity were: profiler, bar with 1 meter profiler sensor, hole centralizers, spray for set number up marking of fan-drilled holes, set of 20-meter articulated rods and drill plan design..

The profiler is an electronic device (Palmtop or Tablet Reflex) that makes its coordinates known in a given reference system associated with the topographic survey of the bore hole. In the case of profiling applied to fan mining, the profiler measures the distance from the mouth of the hole to the bottom of the hole using the principle of electromagnetism.

Figure 6: Survey equipment: Palmtop, Reflex Case and Rod Set

Processing of profiling data

Downloading the data from the Palmtop/Tablet in the Sprocess program, the measurements were compiled together with the file that contains the coordinates of the entrances of each hole of the profiled fans in ".txt" format so that the holes surveyed are georeferenced. Once this first treatment of the data was concluded, a new treatment was necessary, this time using the Vulcan and/or Deswik planning software. After this second treatment, ".csv" files were generated, modeling and analyzing the results.

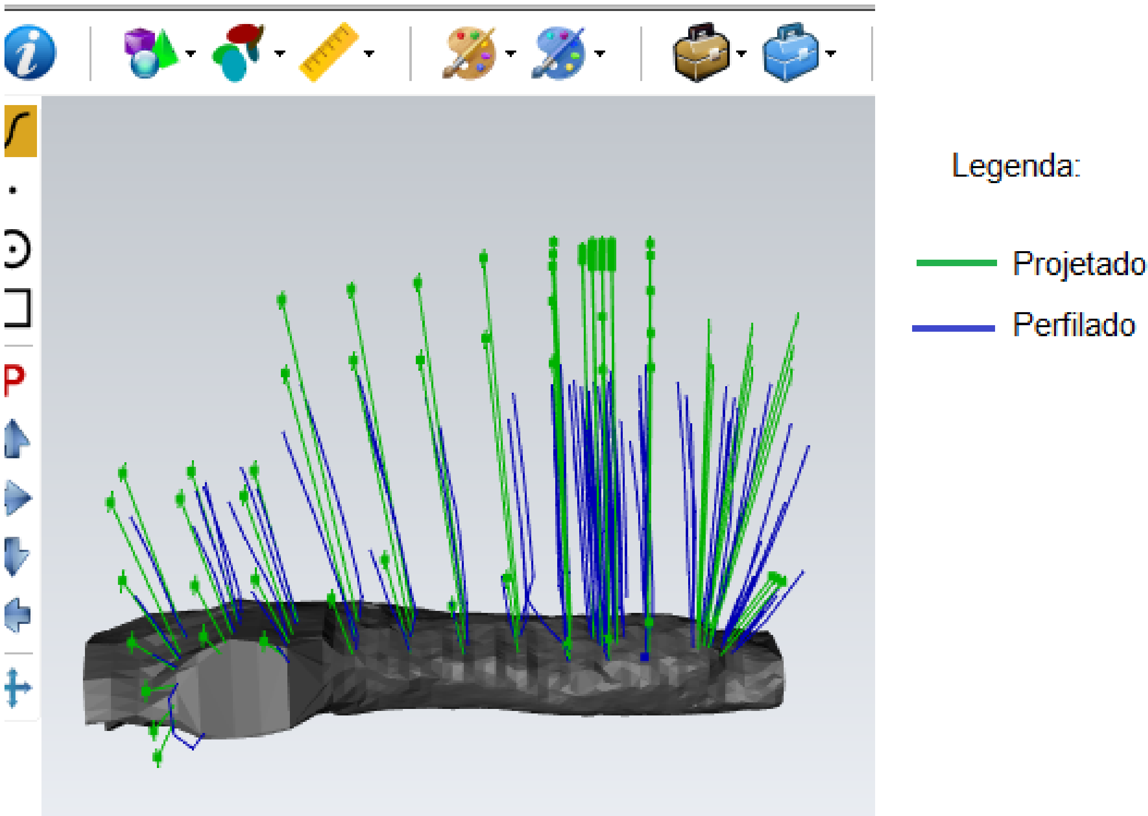


Figure 7: Graphic output of drillhole profiling data.

It is important say that the profiled footage (blue color) is below the projected footage (green color) because the planned stope had a height of 26 meters and due to the limitation of the length of the set of rods that the company had disponible (20 meters), the final 6 meters were not profiled. A problem that was soon corrected by replacing the set of 20 meter rods with a 30 meter hose roll.

Charging and eletronic time delay

For lengths above 20 meters, several factors add up to potentialize possible drilling deviations. Even in the face of execution monitoring and even with more robust equipment, long drilling deviations become inevitable.

This information can be well evidenced when we look at the profiling data in horizontal planes, that is, in an XY view.

Through the figures below we can clearly see the high dispersion of the holes in the first 8 meters and 15 meters of depth, respectively.

Figure 8 shows the projected design of the slot and how the distribution of holes should be from the beginning to the end of the drilling, the sections and their colors will help in identifying the holes along the drilling.

Seção	Cor
814.0	Vermelho
814.4	Verde
814.8	Rosa
[illegible]	[illegible]
815.6	Azul claro

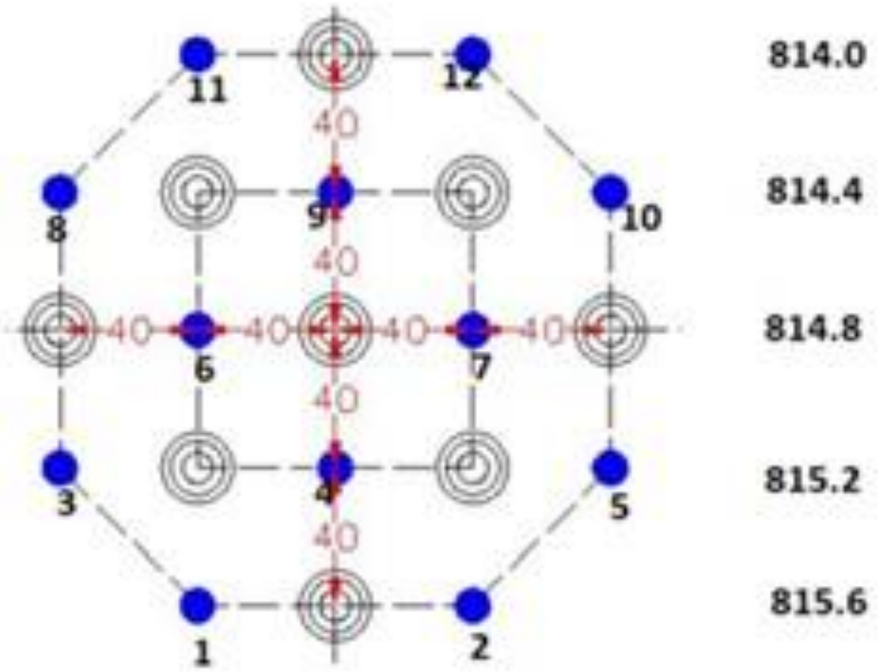


Figura 8: Design do projeto do slot

In the images below, we can already see the total disorganization of the project in the first 8 and 15 meters drilled into the rock.

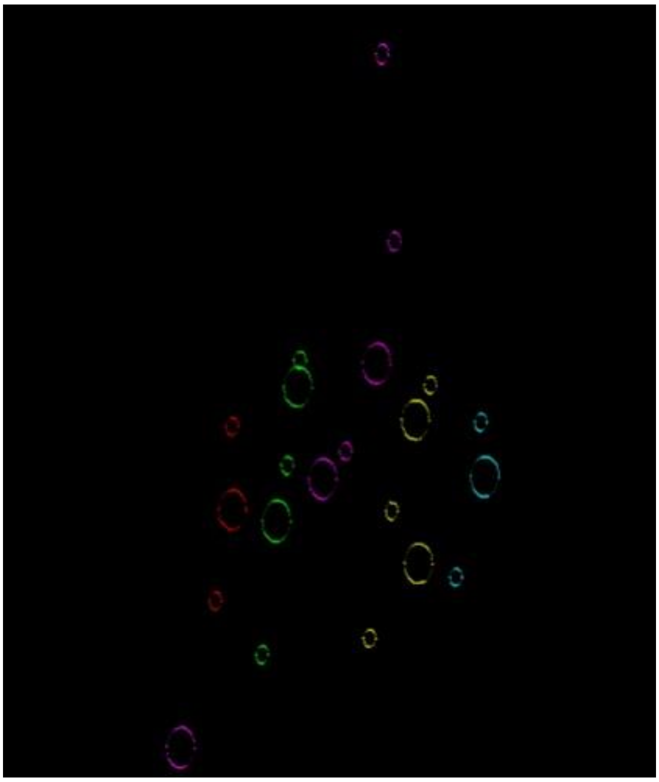


Figure 9: Dispersion of relief and production holes along 8 m.

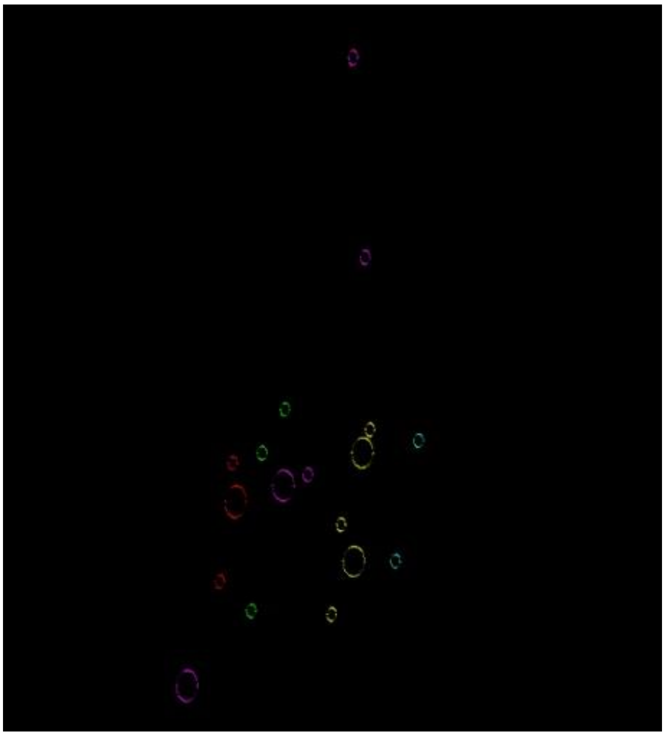


Figure 10: Dispersion of relief and production holes along 15 m.

Faced with the high slot configuration, that is, large deviations in drilling, planned versus carried out, it was decided to charge on decks of 8 meters in length. In this way, it was possible to optimize the best distributions along these lengths and, through a sequence of exit holes, obtain a better generation of subsequent free face.

Charging was done with pumped emulsion and two electronic fuzes per deck (in backup form) were used. This procedure aims to reduce the possibility of any failure in connectivity and lack of fuze communication during the charging process.

In order to guarantee the discontinuity of the loads and to guarantee the existence of the decks, it became indispensable a sharp control of the gasification of the emulsion and controls of plugs, as well as the use of air pockets to generate the spacing between loads in order to avoid the detonation of the neighboring deck by sympathy effect.

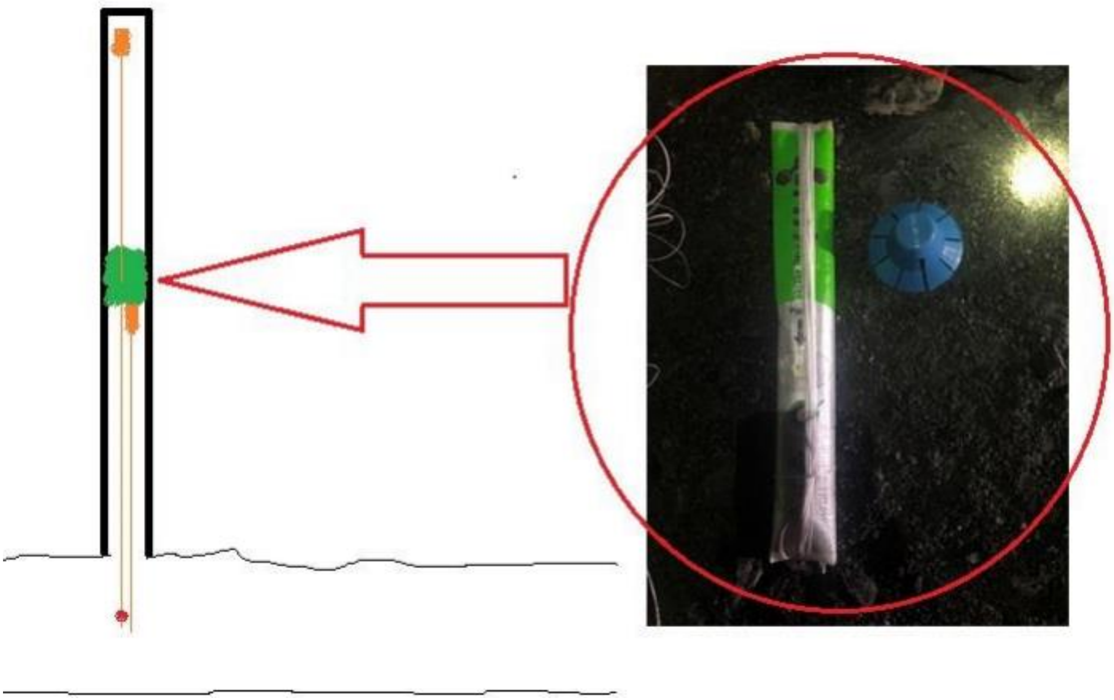


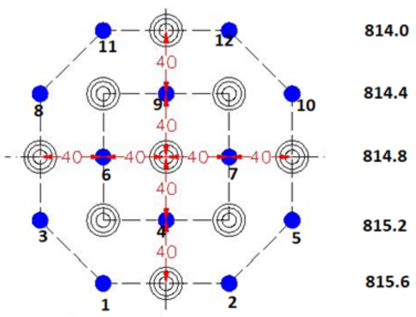
Figure 11: Illustration of deck loading and use of air pockets as separators.

In this type of operation, knowledge of the gasification of the explosive is essential because, if there is excessive gasification, the emulsion will percolate and the charge will continue. Therefore, knowledge of stop stemming, in this case, is of utmost importance.

Timing of charged decks

As previously mentioned, the timing was all based on the distribution of holes respecting the free face that each hole generates for the next hole. In this way, reading the profile helps in choosing the timing so that there is effectively an optimization of this opening and the degree of release of the slot is complete, that is, that the yield of its detonation is satisfactory, providing a large empty area capable of receiving all blistered material from slot section detonation.

In view of this, it is also essential to use electronic fuses in this type of operation, as only through them is it possible to distribute personalized times.



SLOT			
815.6			
Furo	Deck	Espera	Tampão
1	1	3600	
1	2	8400	1 m
1	3	13000	
2	1	3800	
2	2	8800	1 m
2	3	13400	

Usar duas escorvas nos decks 2 e 3.

Deck 1 = 0-8 m
Deck 2 = 8-16 m
Deck 3 = 16-24 m

SLOT			
815.2			
Furo	Deck	Espera	Tampão
3	1	4000	
3	2	8600	2
3	3	13200	
4	1	3400	
4	2	8000	2
4	3	12600	
5	1	3200	
5	2	8200	2
5	3	12800	

Usar duas escorvas nos decks 2 e 3.

Deck 1 = 0-8 m
Deck 2 = 8-16 m
Deck 3 = 16-24 m

Figure 12: Timing used on each deck according to the drilling plan.

Blasting

Once all the holes were loaded, the entire procedure for testing the detonators was carried out and after approval, the detonation was done.

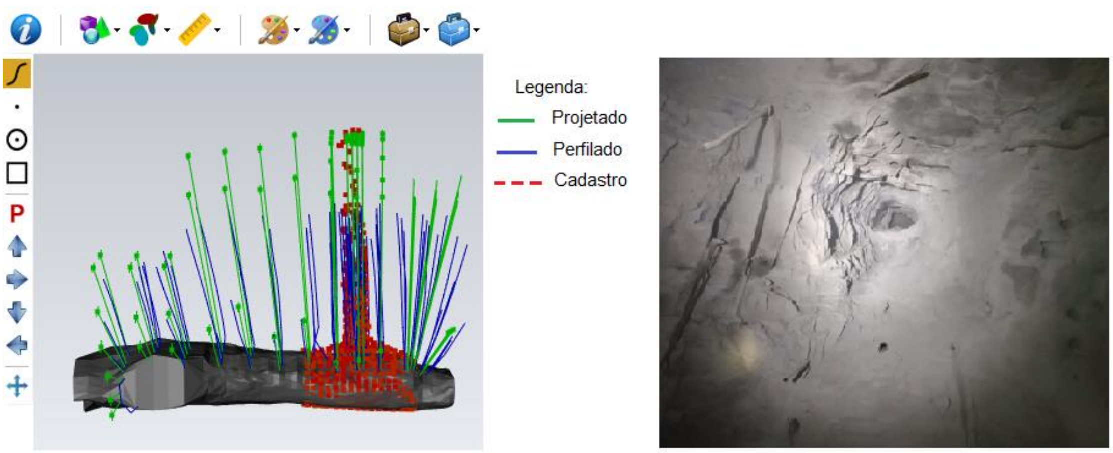


Figure 13: Topographic registration performed with scanner and photo after blast.

It can be seen through the images above that there was a yield of 100% of the dismantling generating all the free face necessary for the detonation of the section and total opening of the stope.

DISCUSSION AND RESULTS

With the application of this technique, it became possible to mine some stopes that, if designed for raise borer equipment, would be economically unfeasible due to the high planned dilution and low stope content.

In view of the information obtained by profiling, it was possible to better understand the distribution of the holes and to perform an optimization, combined with the technology of electronic detonators, timing and consequently the dismantling.

Mine planning performance indicators confirm the information contained in this article and show, without a doubt, the effectiveness of the vertical hole profiling technique in recovering from long stope detonations.

Given the success of this case, this same methodology was applied to other long stopes in which there were also gains through the reduction of planned dilution, increase in stope content and gain in recovered ounces.

Finally and most importantly, the survey of the holes brought to light several operational malpractices with regard to drilling, such as: incomplete footage, that is, holes that were not drilled or drilled in the wrong footage, holes drilled at the wrong angle, fans drilled at wrong meshes;

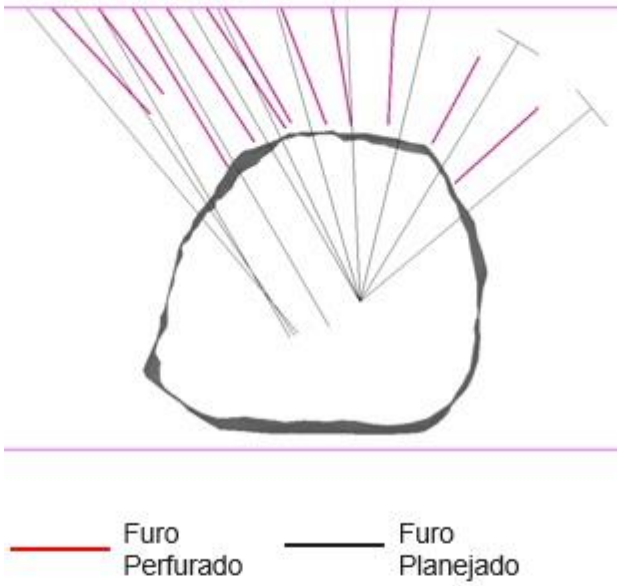


Figure 14: Execution of holes with an angle and length different from the Project.

The method of investigation of the holes also helps in identifying blind bits, calibration and altered pressures of the equipment, since there is also a tendency of type of deviations for these types of situations.

Therefore, through profiling and a solid database generated by the daily information of this activity, it was possible to review all the operational procedures of the rock drilling activities and significant gains were obtained with the implementation of this activity in the operational cycle.