Dilution control in open-pit Blasting

By Bruno Pimentel.

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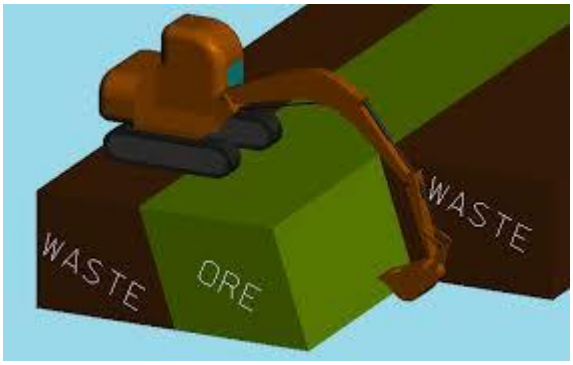
In today's article we will be talking a little about dilution control, which is a very interesting topic and applies mainly to metal mines, but which can be of great importance for several operations, whether underground or open pit.

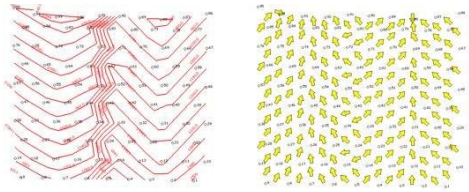
This theme is very broad and there are several possibilities and techniques, which will depend on the scenarios and resources available, but in order not to make our article too long, we will direct our comments around a case study that we are carrying out these days, but it is worth noting that the general comments we will make apply to most cases of dilution control.



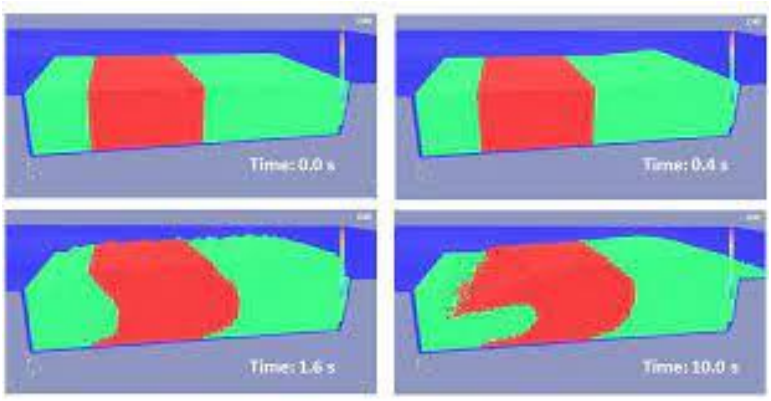
Before sharing a little about the technique we are using, it is important to understand that in a very brief way, the "dilution" represents the percentage (%) of mixture between two elements that we do not want to mix, where the simplest example we have in mining are the contacts between ore and overburden, the ideal scenario being that they do not mix, so that we can remove all the ore without it being contaminated by the overburden. This is very important in some metal mines, such as gold or copper, where grades are really limiting factors for the economic viability of operations and small variations can strongly affect the recovery of the mineral of economic interest.

So when we talk about dilution control, what we want is to ensure that the sterile material does not mix with the ore (or materials of different contents), so that the original content of the material can be maintained. When we apply this concept to rock blasting, we can usually do it in two ways/techniques:

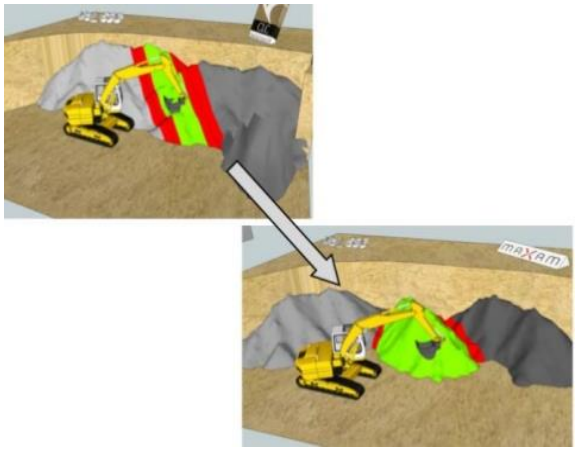
1. Separation: where during detonation a real separation of materials of different types/contents is carried out, directing them in the opposite direction, where the expected result is that we have "separated" piles.



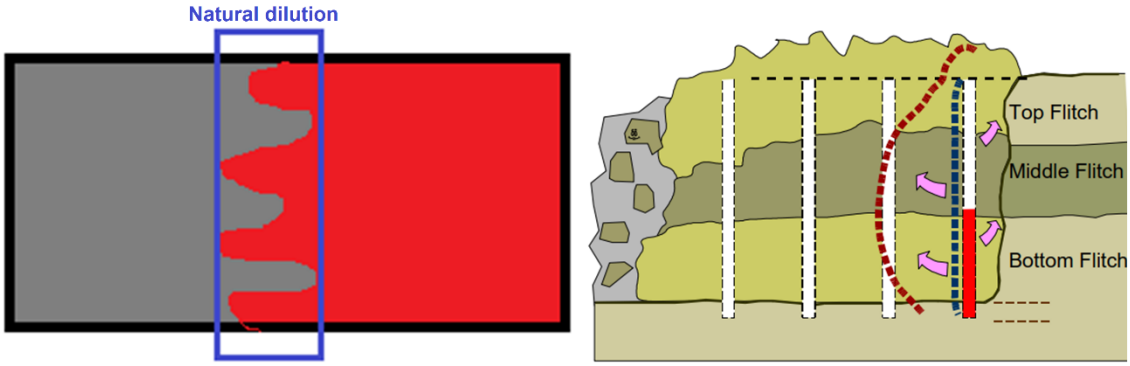
2. Preservation (Do not mix): when, during detonation, one seeks to maintain the natural conditions of contact, without the material mixing, that is, leaving them in the same original configuration after dismantling, with no or minimal movement during the detonation.



An important observation is that the “perception of separation” is not always as clear as in the illustrations above, as the materials may have the same color or similar characteristics, making it difficult to visually identify the dilution of the materials, which is why normally one considers the techniques of more “effective” separations than those for reducing material mixing.



Another point that we have to keep in mind is in relation to natural dilution, which consists of the state in which the material is already diluted/mixed at its origin, where it is hardly possible to reduce this degree of dilution, as soon as the main objectives normally they are aimed at maintaining the natural dilution of the material or cutting the naturally diluted portion, preserving as much as possible the content of the complete ore mass.

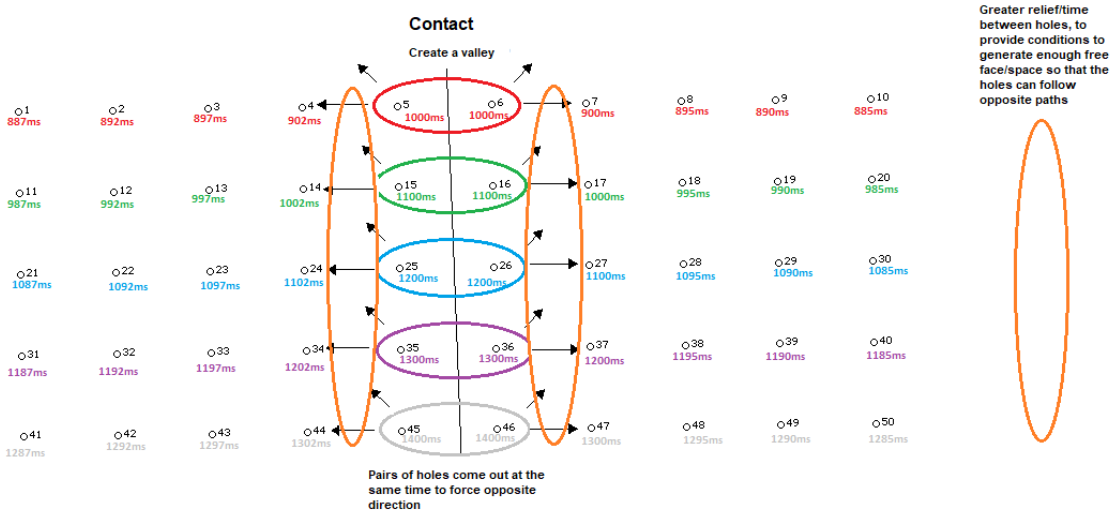


Normally, the necessary dilution controls will vary according to the characteristics of the material and the needs of each operation, and this is a fundamental point for determining the best blasting technique to be applied to guarantee good control.

- **<u>Separation technique used</u>**

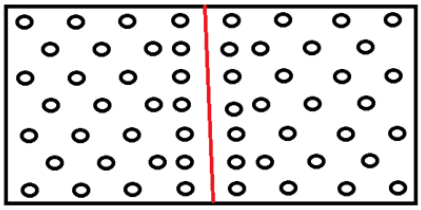
As we said, there are several dilution control techniques, ranging from special loading configurations to timing adjustments, and most of them do not have a specific “name” and can be easily combined to ensure better performance in each case. So at another time we will try to bring more examples, but today we will focus on a conceptually very simple technique, but which ideally depends on the design being made to favor its execution.

This technique is classified as a "separation technique" and the main objective is to guarantee a separation barrier to limit the movement of the material in the contact region, causing the materials to be preferably directed to opposite sides and finally to carry out the detonation. of this barrier/wall generating a valley of separation between the different materials. The figure below tries to illustrate the basic concepts of this technique.:

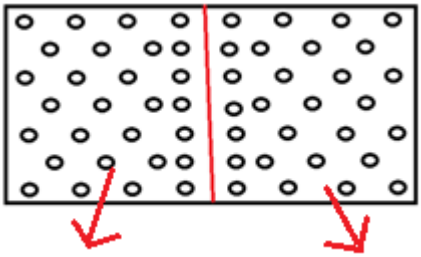


The effective application of this technique ideally requires a pre-elaborated design to provide the main conditions necessary for its execution, which are:

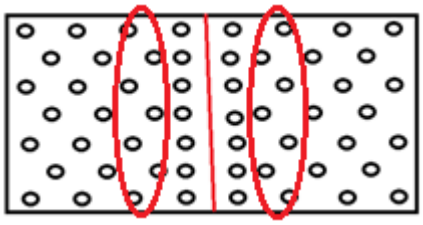
1. Realization of a square drill pattern parallel to the separation line, which will serve as an initial barrier and later create the separation valley.



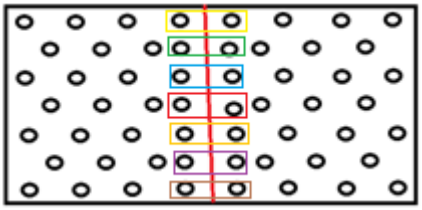
2. Materials are preferably directed to opposite sides.



3. In the regions in contact with the barrier, longer times are used to generate greater relief and thus generate more space for the formation of the separation valley.



4. The barrier hole pairs (contact region) must leave with equal times, in order to create a “valley” effect, since two charges when detonated in close times tend to throw the material in opposite directions, thus creating a valley in the contact region



- **<u>• Some relevant observations that should be considered:</u>**

1. Contact limit.

Ideally, this technique has better applicability when we have a linear contact, so in dispersed contacts it is important to draw a separation limit that will maximize the objectives of the operation.

As we will see in an example at the end of the article, it is possible to have diagonal or even different contacts along the plane, but it is important to evaluate the space conditions and direction of launching the material.

2. Drill Partern

The design of the perforation mesh must follow the free face, the direction of release of the material and the separation limits, allowing a favorable direction for the release of each part.

The square mesh in the contact region must be directed towards the free face or alignment direction of the “separation valley” in order to have a better distance from the materials.

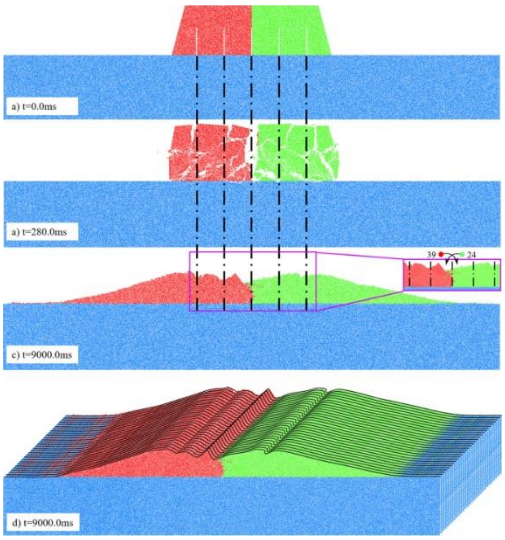
3. Swelling

Ter sempre em mente que o material aumenta de volume (empola) após ser detonado, sendo necessário que haja um espaço maior que o original para conter a mesma quantidade de material.

4. Free Face

Before talking specifically about the free face, it is important to understand that we have no control over the first row of holes and the tendency is for each hole to come out in the direction of its natural relief (usually forward), so ideally, we should have a free face for each launch direction we need.

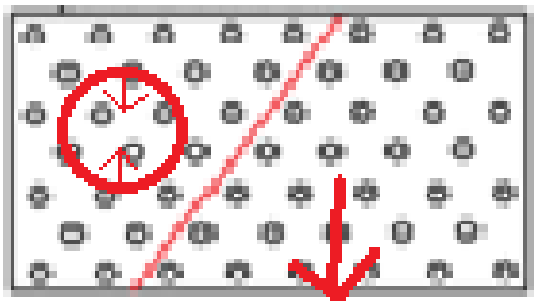
Then for the other lines, the sequencing of the holes is what creates the free face/launch direction, so we must “control” in order to create the path of each material towards the output direction we want.



The free face plays a key role in this technique, as it is the main reference to define the best direction for each material, where ideally we need large free faces that allow us to launch the materials in different directions.

Large detonations and with several free faces will allow a larger area for material separation.

When we have free face limitations or even separation limits that do not favor the separation of the material (illustration in the figure below), we need to evaluate the best direction to avoid dilution, but this may imply leaving with the detonation trapped, damaging the slope remainder, generate overbreaks and even reduce the effectiveness of the separation.



An important comment is that the greater the need to separate the material, whether due to a better distinction of materials or to facilitate their mining, a greater amount of space is needed to accommodate this material, and this is totally related to the dimensions the free face, as well as the area in front of us for accommodating the material after blistering.

5. Electronic detonators (sequencing)

An important observation is that although it is possible to use this technique with conventional detonators, the time limitation and the dispersion factor (error) can significantly affect its effectiveness. flexibility in the timing of each hole, as well as greater precision, essential for separation in the contact region.

6. Availability of information and time to analyze, carry out the designs and execute

Two fundamental needs for the successful implementation of any technique are the time available and the availability of fundamental information for carrying out the analyzes and applying the appropriate designs.

It is necessary to have the separation limit of the materials in advance, so that it can be analyzed together with the format and free face of each detonation so that an adequate design can be carried out for each scenario. This undoubtedly represents more than 50% of the effectiveness of this technique, which is based on creating, from the planning stages, the ideal conditions for carrying out the separation of materials.

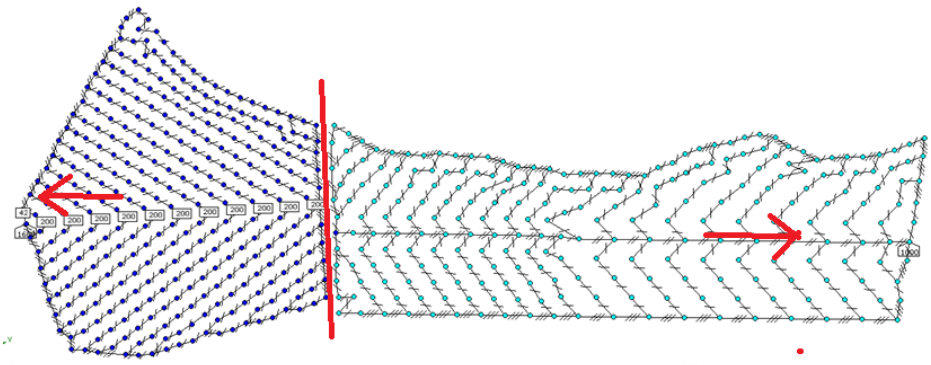
- **• Examples of dilution control drawings:**

To finish our article today, we have below 2 examples of detonations for dilution control that we carry out:

1. With detonating cord and surface delays

This first detonation was carried out more than 5 years ago, in an operation where we did not have electronic detonators available and therefore we needed to use detonating cord and surface delays.

In this detonation, we did not have a free face in any direction, so we opened the bank in opposite directions to facilitate the separation of the material..



As the areas had very different shapes and dimensions, including the mesh and number of holes, we started carrying out the design/timing at the contact limit, to ensure that the contact holes came out at the same time, then we determined the necessary relief for the nearby holes this region and from there we carry out the sequencing of the other holes following the standard mine design configurations.

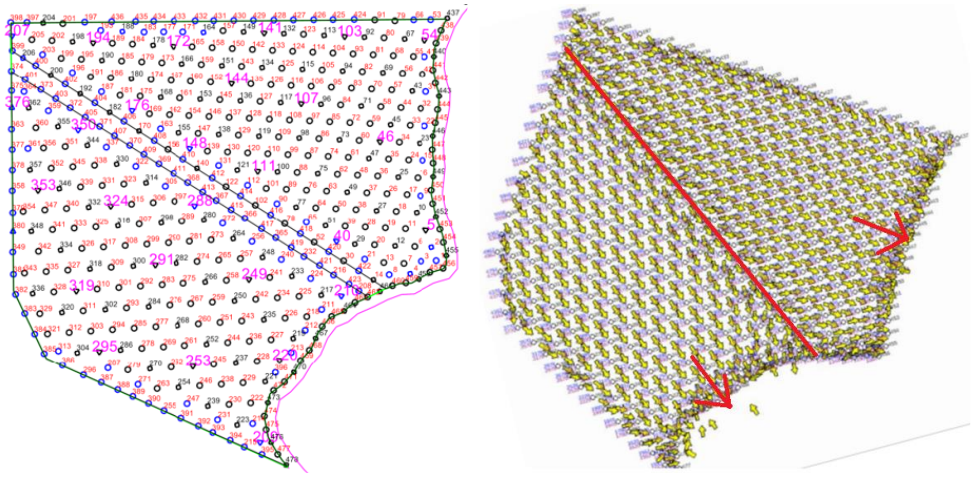
An important detail was the need for initiation at different times, to ensure that the detonation arrived at the same time in the contact holes, so we used delays in the initiator hole, so that each one started at the given time.

In this case, even with the dispersion of non-electrical delays, we achieved a very satisfactory material separation result, where it was possible to clearly identify the separation of the stacks, even with the limitation of space and the absence of a free face.

2. Electronic detonators

This was already a detonation that we carried out in the last few weeks, which unfortunately we do not have a photo after the detonation, but we have one during the mining of the material.

This detonation has already managed to use electronic detonators and carry out a more adequate design in the contact region, which facilitated the design of the timing, but due to the limitation of the free face, it was not possible to direct the material to opposite areas.



Two very important points that we could see in this detonation were first that the free face limitation had a direct impact on the size of the “separation valley”, because without enough space the material blistered upwards, limiting the separation, and the second was a ratio reduction of load used due to the low DF of the drills decreased the launching force, which limited the separation of the materials, but contributed to the preservation of the contact of the materials.

Despite the low % of separation, the preservation of the contact allowed an excellent result of dilution control.

That's it folks, I just wanted to share with you the main concepts of this technique that we've been using for a long time and have proven to be very effective when properly applied.

For today we are going to stop here, because despite the topic of dilution control being very interesting and broad, we prefer not to extend the topic so as not to get tired and at another time we intend to write other articles with other techniques, as well as some focused on applications in underground.

As always, we ask that you please comment and share, so that we have safer and quality detonations!!!

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