Rock fragmentation process (Part 01 of 03)

By Bruno Pimentel.

Hello my friends, I hope everyone is well, healthy and working safely. So, in order not to lose the habit, we leave here the links so that you can check our previous articles, as well as register, so that you are automatically notified of each new article that we publish. But before that, just reinforcing what we said at the beginning of our last article, we will be making our publications monthly, but as soon as we find some more volunteers we will be trying to provide as much knowledge and information as we can.

Português

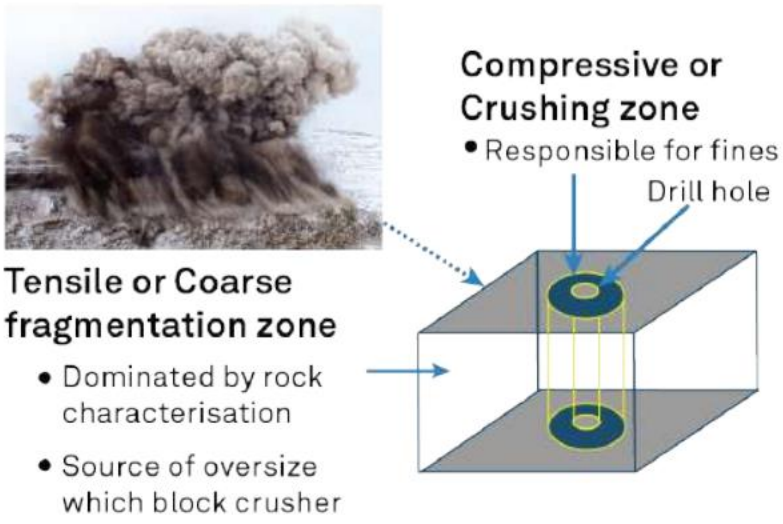
https://www.linkedin.com/newsletters/blast-de-rocha-c-explosivo-6941709482355748864/

English

https://www.linkedin.com/newsletters/rock-blasting-6959820770344595456/

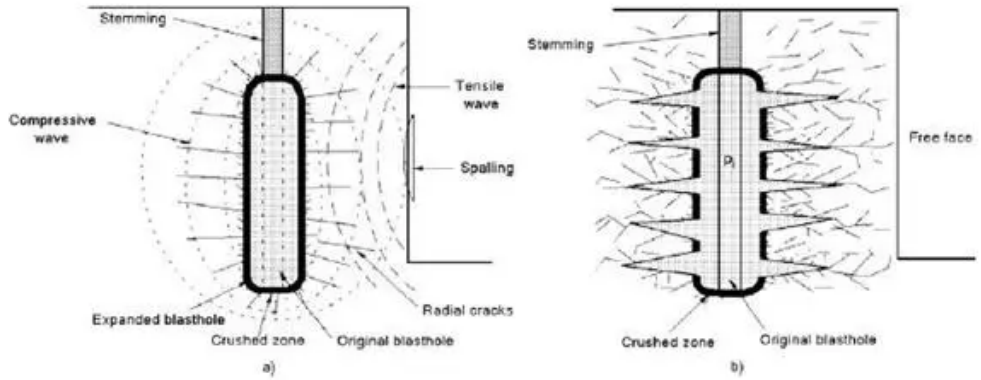
In our last articles we talked a little about the main points of the blast theory of an explosive when applied inside a hole to blast rocks, where we saw some basic concepts and then some factors that directly affect the blast performance of these explosives, ranging from the type and quality of the explosive to the characteristics of its application and the environment in which it is found.

Once we understand the blast process, in today's article we will start talking a little about the rock fragmentation process, which is one of the main results of the blast, and will be directly influenced by it, as well as by the other characteristics of the rock and from our blast.



So, based on what we mentioned in previous articles, when an explosive receives an initial stimulus that exceeds its activation energy, it starts its blast process, generating a shock wave that will continue this process, through the elevation of the pressure and temperature, which causes the components of the explosive to react, continuing the blast throughout the entire explosive charge, which in our case will be distributed along a hole, and throughout the decomposition/blast we have the generation of a large amount of rapidly released gases.

This whole process takes place very quickly, in just a few milliseconds, depending mainly on the quantity, quality and blast speed of the explosive, but all this momentum is what will cause a series of impacts on the rock, resulting in its final fragmentation.



a) Shock wave propagation, b) gas pressure expansion

First of all, it is important to bear in mind that there are several theories that try to explain this process and especially the reaction of the rock, which are usually called "fragmentation theories", where they try to explain the effects generated in the rock due to the action of the explosive. during its blast, but still no theory is completely accepted, and for that reason there is a series of assumptions around the theme and normally in practice what is done is to follow the most logical concepts and assume the results observed during the detonations as a reference key to making process optimizations.

Another important point to understand is that the speed at which it occurs, together with the large amount of energy that is released, makes it very difficult to observe and understand the whole process, making it difficult to analyze and define “concepts”. universal”, in addition to the large number of variables and the difficulty of carrying out laboratory tests or research that manage to represent all possible scenarios.

That's why, in a summarized way, and put it briefly, we'll try here just to understand a little of the logic of the process, putting together some basic concepts that are more accepted, among the different existing theories.

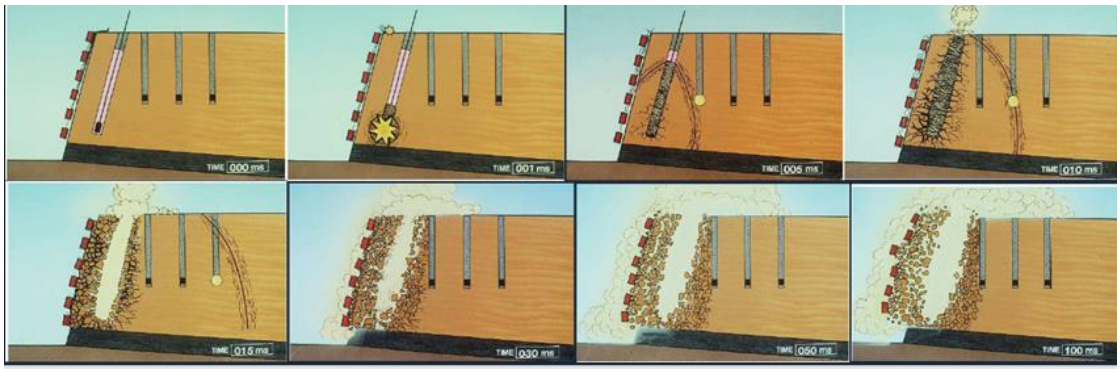
With that, first we need to bear in mind that the main mission of the rock blast is the fragmentation of the rock, either to facilitate its removal from the place or to be able to take advantage of the rock and its minerals, and in our case, this fragmentation occurs by the action of the blast from the explosive we use.

So we can say that the fragmentation will be a consequence of the interaction between the energy released by the explosive and the mass of rock that receives the effects of that energy, depending directly on the amount of energy released in the blast, the characteristics of the rock, and how this interaction will be.

This whole process involves several factors, such as the interaction time, the energy generated by the blast, the shock waves, the geomechanical characteristics of the rock, and several other points that we cannot fully control and understand, and that even, most of the time we don't

even have knowledge about all these variables, where some are estimated and others are simply disregarded.

Below we have an illustration, where we can observe that since the initiation of the explosive, the initial shock wave of its activation, already begins to generate impacts on the rock that is around it, and this interaction between the blast process, the effects in the rock, and put an end to its fragmentation, occurs during and after the complete blast of the explosive, ending only when all the energy is spent and the fragmented material stabilizes on the ground, where even the collision between the rock and the ground is still is responsible for a portion of the final fragmentation of the rock.



As we have already mentioned here, there are several theories that try to explain this complex mechanism of interaction between the blast energy and the rock fragmentation process, where some complement each other and others bring some assumptions, but as theories, they have not yet been proven, and so we use them only as a source of consultation/reference for a better understanding of what can happen in the process.

Here we have listed some of them:

• Theory of reflection

• Theory of gas expansion

• Torsion or shear theory

• Craterization theory

• Compression and tension wavefront energy theory

• Theory of sudden release of charges

• Nucleation theory of fractures in faults and discontinuities

• Others.

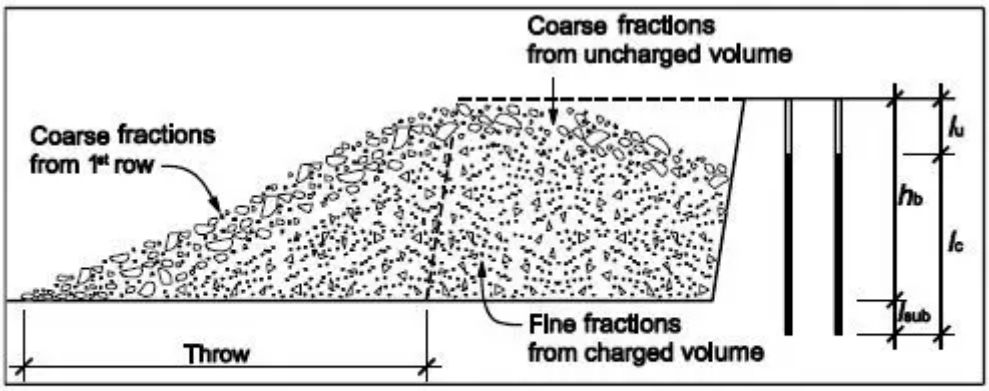
These theories try to conceptually present the possibilities of how the process of interaction between energy and rock occurs, and most of them are easily found in the literature, so those who want to go deeper into the subject, we recommend that they do a search to find more information available. about them.

These theories are based on several criteria, such as energy distribution, the action of compression and tension forces generated by shock waves, reflection of shock waves in different

media, shear and shear effects on the rock, gas pressure, rupture by bending, and several other effects that occur due to the interaction of the energy of the explosive and the rock, but most of them are based on laboratory tests, on mathematical and physical models, as well as some experimental tests, mainly due to the difficulty of large amounts of real tests are performed while performing the rock blasts.

Because we can all imagine, the difficulty of being able to do several tests, just for study purposes, and even more difficult, is to control the various variables that are present in the blast and fragmentation process, where for some of these variables we do not even have yet technologies available to measure or accurately indicate values that represent them.

Therefore, most of the time we have to be content with the opportunities to carry out tests during our detonations, changing some controllable variables, to reach the objectives we need, without being completely sure of what is happening in the process, and then, without know exactly how to reproduce those same results in other scenarios.

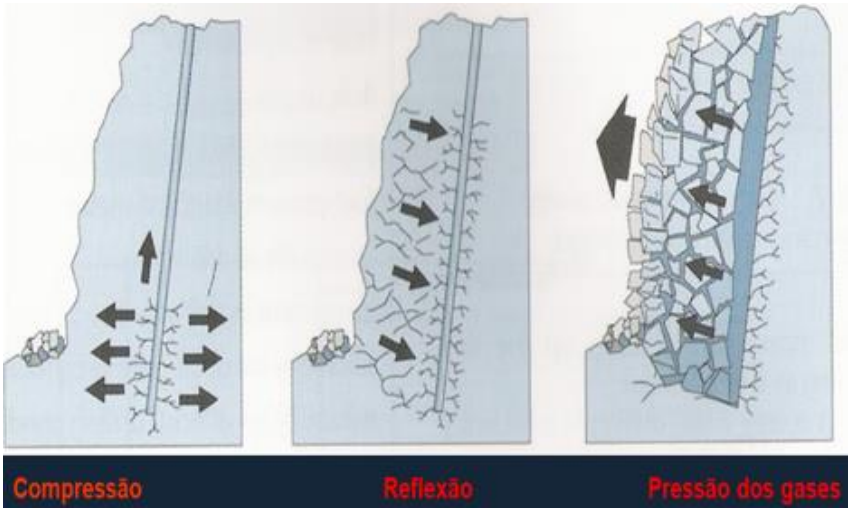


Typical profile through a rock pile from a surface blast, indicating the main fragmentation sections

So, to better understand the logic of the process, let's stick to a simple explanation, which is reasonably accepted by professionals and scholars in the area, where we summarize several concepts present in these theories.

In summary, it is estimated that the fragmentation process, resulting from the blast of the explosive, occurs in several phases, which develop almost simultaneously in a very short time interval, of just a few milliseconds.

Within these phases, we consider the blast action of an explosive charge, confined inside a hole, and its action on the rock, ranging from fragmentation to the total displacement of the material.



For this, it is important to keep in mind, as we mentioned in previous articles, that the blast configuration, as well as the conditions under which it is carried out, will directly interfere in each phase, causing infinite possibilities, and therefore, we need to simplify the understanding of each phase, limiting our focus on the performance of each phase separately, and in a staged way, although they act together and practically simultaneously.

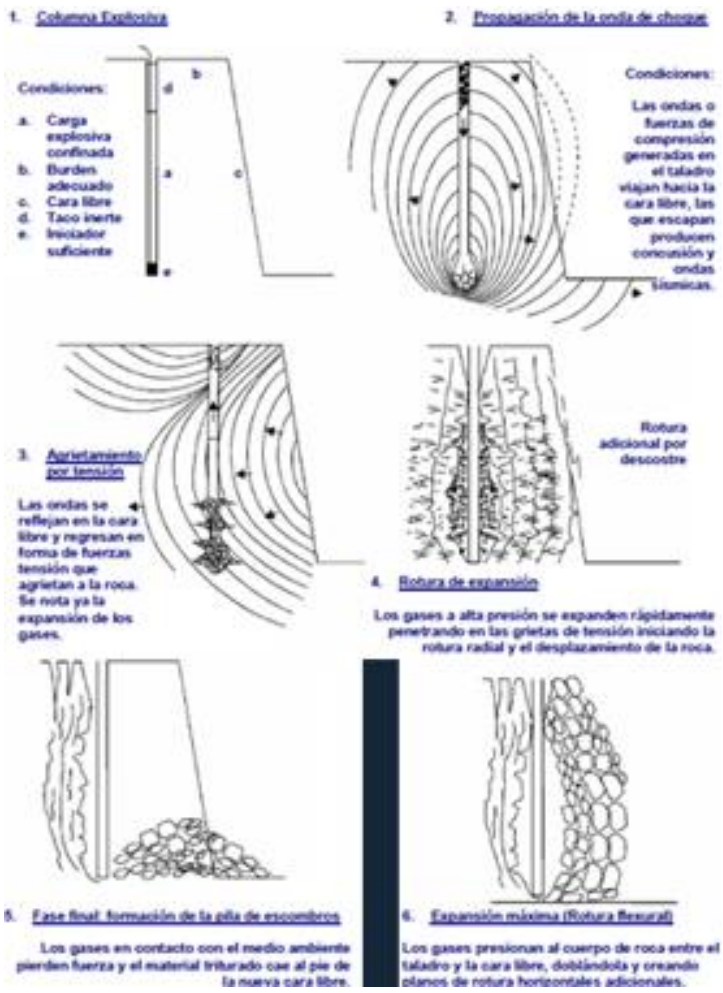
So, to begin with, let's consider that the rock fragmentation process by the action of the blast of the explosive confined in a hole, occurs in **four main phases**, which together will generate the results of our blast.

1. In the first phase, we have the blast of the explosive charge and the effects of this blast on the rock. Where, from the beginning of the explosive blast, we have the effect of generating a shock wave and the pressure generated by the expansion of gases, and this directly impacts the inner wall of the hole, transferring the rock in the form of waves and forces of compression, which act quickly causing an elastic deformation in the rock.

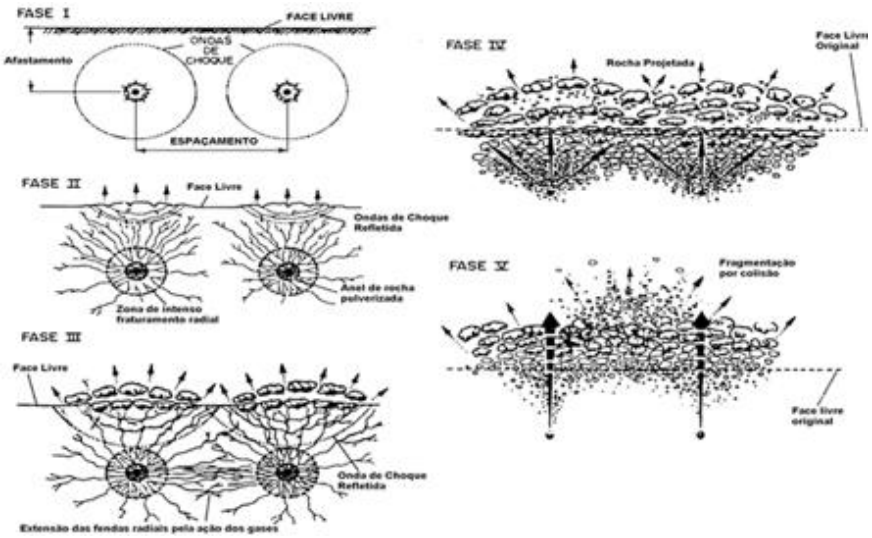
2. Then in phase two, we have the propagation of the shock wave through the rock, where the shock wave travels through the rock until it reaches the free face, and is reflected and returns pulling the rock, and when the rock's tensile strength is overcome, the waves break the rock, creating fissures and cracks along the rock mass.

3. In phase three, which occurs practically simultaneously with the propagation of the shock waves, the gases generated by the decomposition of the explosives, expand rapidly, at a very high pressure, penetrating the cracks formed in the rock, expanding these cracks and creating new ones, thus producing effective fragmentation of the rock mass.

4. Finally, we have phase four, which is the rock displacement phase, which occurs when we have an adequate burden, because in these conditions, the gases that continue expanding will be able to push the rock mass towards the free face . Where we will also have the finalization of the fragmentation process, due to the impact of the fragments with each other and with the ground.



As we said, these stages are not isolated events. They start in sequence, but overlap throughout the process, so they interact and complement each other in a very complex way, which is still not fully understood, and we still need to be clear that they and their effects will vary mainly according to with the characteristics of the explosive charge and the rock on which it is acting.



For today we will stop here, so that in the next article we can go into a little more detail about each of these 4 stages, which will indicate in a macro way what are the main effects that we have present during the rock fragmentation process.

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

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