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SPATIO-TEMPORAL PARAMETERS OF THE FRONT OF THE FORCE FIELD IN THE SYSTEM OF ELONGATED CHARGES

Purpose and task *is to study the nature of the formation of the force field in the heel region by the interaction of the upper end parts of adjacent charges.*

Research results. *Based on the fact that outside the zone of plastic deformations the force field is created by stresses close to elastic, analytical studies used a simplified computing apparatus based on known data on the shape and numerical values of force and time parameters of a single pulse from a single cylindrical charge of a given mass and length. .*

The main results. *The regularities of the formation of the force field in the boundary zones of action of the system of adjacent elongated charges are considered. The phenomenon of field degradation observed near the end part of the charges, which has a negative effect on the overall mechanical effect of the mass explosion, is analyzed.*

Conclusions and practical consequences. *The shape of the total field of maximum stresses on the middle axis between adjacent charges initiated simultaneously from the lower end should have manifestations of the cumulative effect in the area of the upper end areas of adjacent charges. Therefore, after the inclined counter power fronts, counter mass shifts should take place, generally directed towards the superbore layer of the rock mass at the level of the stamping. The technique of forming upward movements in the intercharging volume of the rock is a new technological element that takes over the experience of conducting mass blasting operations according to an effective traditional system of switching a network of wells in the form of a horizontal wedge or trapezoidal cut. Such a traditional scheme initiates successive pairwise counter mass shifts with short decelerations in the direction of the lateral slope of the ledge. In contrast to this scheme, the new technology of mass explosion is based on a combined technique of simultaneous lower charge initiation in groups of 2-3 rows and the use of traditional short decelerations between groups to prevent excessive seismic effect. Thus, in groups the combined scheme of KSP "vertical wedge" which promotes additional destruction of the top layer of the planted rock block and reduction of an exit of oversized fraction at the level of a stamping is realized.*

Keywords: *charges, cumulative effect, rock mass, intercharging volume, explosion, seismic effect, vertical wedge.*

THE INTRODUCTION

Actuality of theme. It is known that the axisymmetric nature of the development of the force field is disturbed at the ends of the cylindrical charge. It is believed that it directly at the level of the end part of the charge and along the axis outside the ends of the charge acquires a shape similar to a hemisphere. The problem is what part of the end is involved in the transformation of the force field, what measures are possible to compensate for energy losses, which can be 35-40% of the explosion energy of the end of the charge, and how the nature of field transformation changes in the interaction of adjacent linear charges.

Analysis of research and publications The phenomenon of the end effect is theoretically investigated [1] on the example of an explosion of a short cylindrical charge with its initiation at the lower point or - the origin (Fig. 1). The motion of gaseous products of the explosion is realized in a cylindrical coordinate system and is described by differential equations in partial derivatives, which are solved using numerical methods [1,2].

When the ratio of the height of the charge to its diameter is 4: 1 (Fig. 2.3, a) in the initial moments the force field looks close to the centrally symmetric (Fig. 2.3, a). However, in the following moments (Fig. 2.3, b) it is extended towards the upper end of the charge due to the predominance of the detonation velocity in the charge along the Z axis over the velocity of the shock wave in a neutral medium in the direction of the R axis. environment due to energy loss due to elastic and irreversible deformations. Then, with the development of the process and its release over the upper end of the charge (Fig. 2.3, c), the shape of the field becomes similar to a spherical one.

This fact is confirmed by theoretical studies of the camouflage effect of the explosion in the upper end of the well charge of limited length [2, 3]. The authors based their research on the assumption that the radius of the imaginary spherical charge at the end of the cylindrical is equal to the radius of the charge of the cylindrical. This assumption, in our opinion, is not true, it significantly underestimates the value of the end part, working in the direction of the charge axis. In practice, this part borders on the stamping and is responsible for the destruction of the upper layer of the array on the ledge. However, the authors rightly believe that the action of the stress field in the heel area should be superimposed on the quasi-static component due to the movement of the rock layers. This phase requires further research [6,8]. In addition, the end effect in the upper zone of the ledge is not enough to characterize the action of a single downhole charge.

The aim of the work is to study the nature of the force field formation in the heel area during the interaction of the upper end parts of adjacent charges to substantiate new elements of short-range blasting technology aimed at changing the direction of mass movements of destroyed rocks**.**

Materials and research results. An important condition for such interaction is the simultaneous action of pulses. The interaction of adjacent charges creates the most favorable conditions for the assembly of individual stress fields and, accordingly, the mass movements of the rock mass and to achieve the maximum mechanical effect.

Based on the position that outside the zone of plastic deformations the force field is created by stresses close to elastic, analytical studies used a simplified calculation apparatus based on known data on the shape and numerical values of force and time parameters of a single pulse from a single cylindrical charge of a given mass and length. The calculations were performed according to the scheme in Fig.2

To determine the total pressure in the array from adjacent charges, the scheme of interaction of two downhole charges of length is considered (Fig. 2).

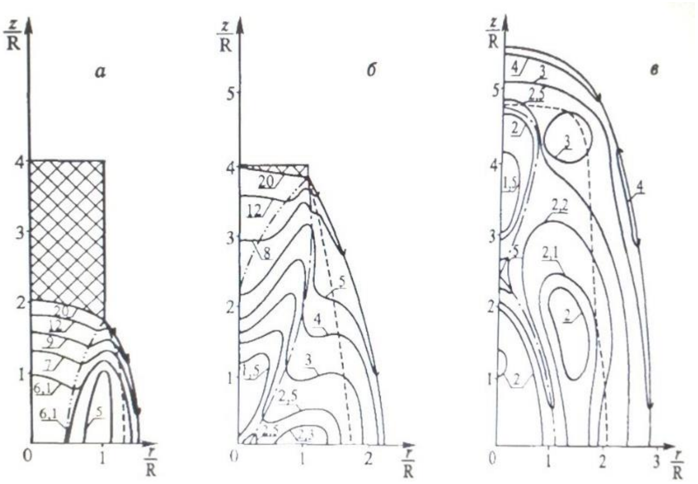


Figure 1 – Dynamics of the development of a force field from an explosion of a short cylindrical charge [1]

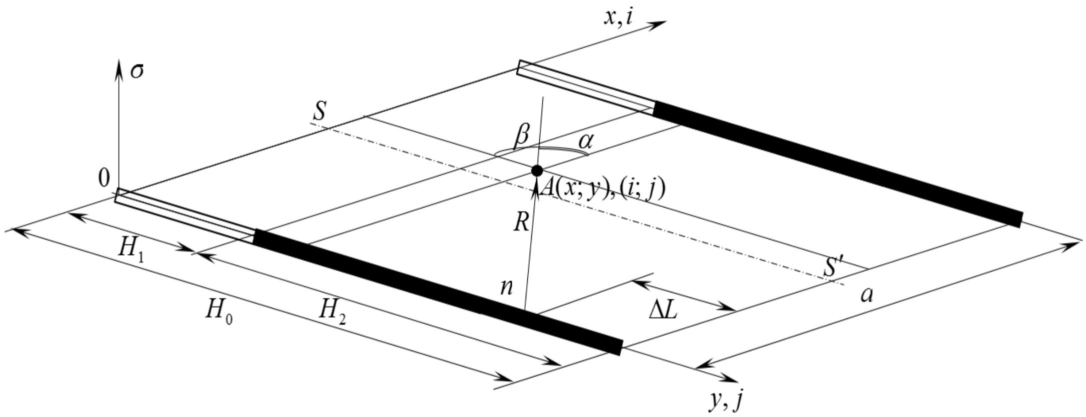


Figure 2 - Scheme for calculating the total pressure from the action of two adjacent charges on the axis of symmetry

Initiation of charges is performed from their lower end. The detonation process ends in the area above the upper end of the charges at the mark of 3m. Thus, the calculation covers the entire area of action of the downhole charge, including the intercharging area and especially the end zones.

Analysis of the above diagrams of the stress field distribution in time and space under the condition of interaction of adjacent downhole charges in the mode of lower simultaneous initiation shows that the stress intensity at the level between charges is almost an order of magnitude higher than stresses in the rock layer.

To study the peculiarities of the formation of the force field in the layer of the array at the level of the heel and compare their level with similar diagrams in the intercharging space, the corresponding pressure diagrams are constructed, one of the examples of which is shown in Fig. 3. separately for the rock layer at the level of the heel in the depth range 0… 3 m from the surface.

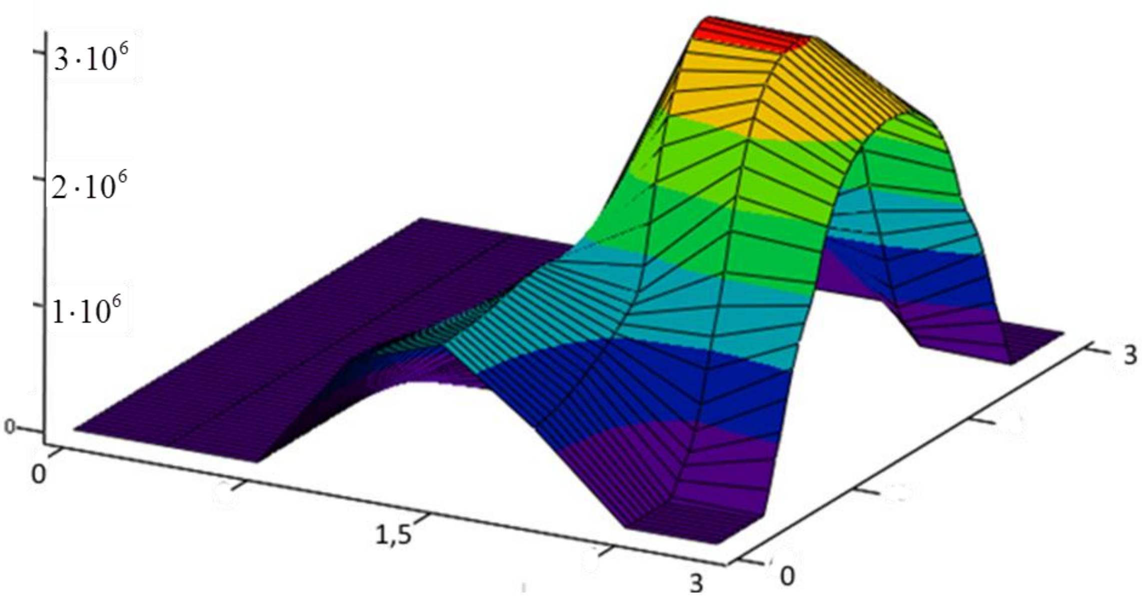


Figure 3 - Example of the distribution of the stress field in the array at the level of the stamping at a fixed point in time after the simultaneous initiation of two adjacent downhole charges (time after the initiation of 0.0025s)

After processing the family of obtained diagrams on the height of two adjacent charges, a graph of the distribution of the maximum total stresses from the action of adjacent charges on the axis equidistant from both charges is constructed (Fig. 4). From the analysis and comparison of the obtained diagrams on the height of the charges we can conclude that due to the degradation of both power fronts at the level of the charge in the center of the array between the wells is set an order of magnitude less than the total pressure at the height indicated as H1 in Fig. 1. According to the consolidated schedule of distribution of the maximum total stresses on the middle axis between adjacent charges (Fig. 4), the following effects are observed:

within the lower end of the charge (horizon 10… 8 m) there is a naturally reduced intensity of the total force field, which must be compensated by the end amplification of the charge;

at the horizon 3… 0 m, at the level of the heel the total force field maintains axial symmetry due to the lower initiation and immediately outside the plane of charges intensively sharply weakens and already at a depth of 2 m from the surface its intensity decreases twice.

A characteristic feature of the dependence in Fig. 4 is the pattern of formation of the force field at the ends of the elongated charge. In both the lower and upper ends of the charge, the mechanism of energy loss associated with the degeneration of the symmetry of the force front is triggered, but both breakpoints in the analyzed dependence are located asymmetrically with respect to the ends of the charge. The lower fracture point of the curve is shifted by 2 m up the charge (from 10 to 8 m), the upper fracture point is located exactly opposite the upper end of the charge. Let us explain this by the fact that the calculation was performed taking into account the real process of charge detonation from its lower part upwards. Thus, the lower initiation shifts the position of the force field in the opposite direction, in our case - towards the upper layer of the steppe, improving the conditions of destruction of the upper layer of the steppe. As follows from Fig.4, this weakens the energy field at the level of the sole of the ledge. Note that this problem is solved by using a powerful conical fighter [10,11] At the same time, the calculation does not take into account the presence of the fighter in its lower part, which enhances the energy flow at the level of the lower end of the charge. The inclusion of these factors in the calculation will complicate the comparison of the dynamics of the total force field along the length of the system of adjacent charges.

These observations indicate a significant positive effect of the lower simultaneous initiation of two adjacent charges on the development of the force field in the upper part of the destroyed block only due to the transfer of the zone of manifestation of the edge effect above the block height. However, since the force field degrades sharply from a depth of 3 m and above, the destructive factor associated with the stress field quickly loses its effectiveness due to the edge effect. It is logical to assume that the quality of grinding of the array in the area between the axes of charges at the level of the stamping also deteriorates and this area is one of the sources of oversized fractions [7]. Based on the above data, wave processes, as a destructive factor in the array at the level of the heel, should not be ignored, because they provide a preliminary weakening of structural connections throughout the destroyed block, ie perform preparatory work in the array. However, in our opinion, the main work on the destruction of the array within the upper end of the charge at the level of the stamping is primarily responsible for the mechanism associated with the formation of discharge funnels under the action of explosion of the upper ends of downhole charges, and subsequent mechanism of mutual contact In this regard, more attention should be paid to the peculiarities of the deformation processes in the rock layer above the ends of the charges.

It should be noted that the edge effects of the explosion and each individual charge, and the total edge effects in the intercharging space are amplified within the plane of charges by their lower initiation through the use of powerful conical fighters that simultaneously solve the problem of overdrive and generate counter (at a certain angle) fronts, followed by counter mass shifts

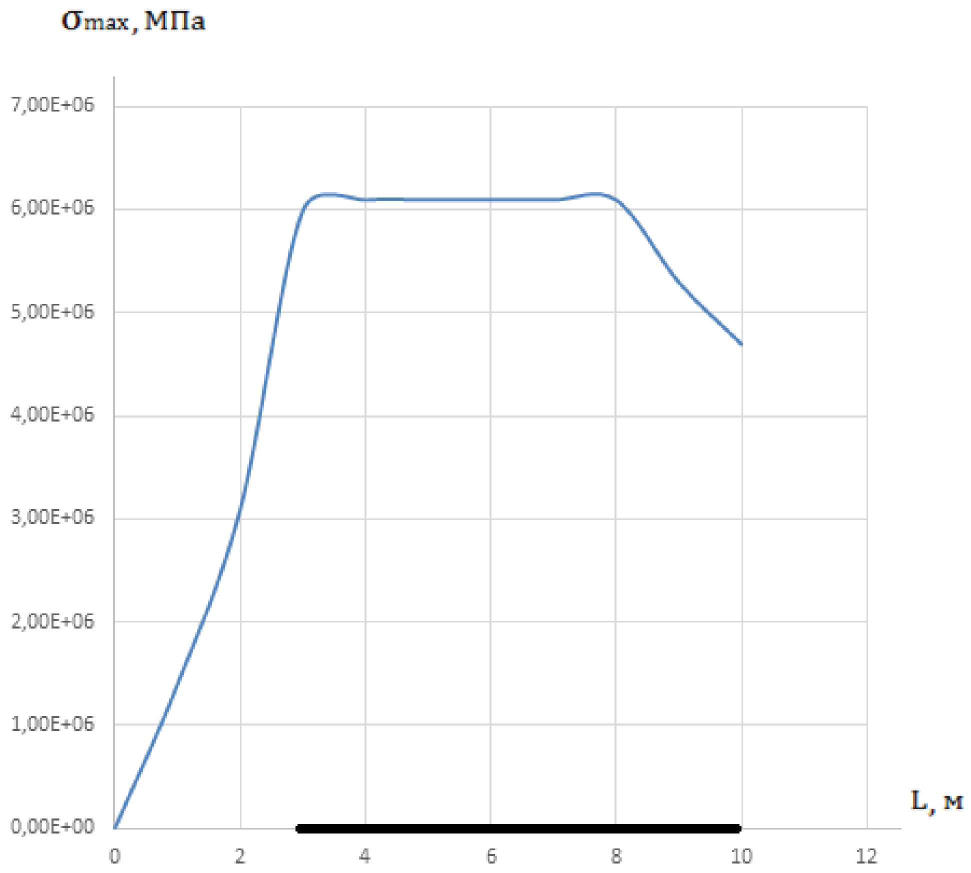


Figure 4 - Distribution of maximum total stresses on the middle axis of symmetry S-S` in a system of two adjacent charges

The presented picture of the interaction of force fields and mass displacements in the intercharging space is possible only under the condition of simultaneous initiation of adjacent charges, which contradicts the concept embedded in the technique of short-range detonation.

At the same time, counter-shifts at the stage of ascending mass displacements in the destroyed intercharging volume of the rock are seen as a new element of technology that takes over the experience of blasting by an effective system of horizontal wedge or trapezoidal cut, but the action of the cut is directed upwards. Thus, the basis for a new technology of mass explosion is laid by large groups consisting of several (2… 3) simultaneously planted rows of charges. The traditional millisecond deceleration periods required to prevent excessive seismic effects are established between these groups, ie a combined vertical wedge PCB scheme is implemented [4], in which the results of the above studies can be used.

Well charge network parameters. In the mechanism of formation of the crushing zone at the level of the upper ends of adjacent charges considered in the work, only the mechanism of interaction in the process of funnel formation in the area of the heel is taken into account. Accordingly, the parameters of the BPD are assigned, which would simultaneously meet the requirements for the quality of crushing of the downhole rock mass and provide a similar result at the level of the stamping. At the same time, technological solutions are possible, which, based on the emphasis on the choice of BPD parameters effective for the main rock mass between wells, will lead to unfavorable conditions for crushing the massif in the upper layer at the level of the stamping. In other words, when assigning technically and economically rational parameters of the network of wells, which take into account all 4 stages of interaction of charges, it is necessary to maintain the same approach for the layer at the level of the packing. In this regard, the manifestations of boundary effects in the area of the upper ends of well charges as a result of the action of physical processes and phenomena inherent in the initial stage of planning a mass explosion are considered.

For example, a fundamental change in the conditions for generating the initiating pulse in the downhole charge, the direction of the detonation process, the sequence of detonation of charges in the system should simultaneously enrich the capabilities of rock fracture technology in the wellbore and provide the necessary quality of mass explosion on the periphery.

The advantage of lower initiation of downhole charges with the use of conical bores, in addition to more complete use of industrial charge energy in the area of overburden and along the charge column, is the ability to control parameters, as well as reorientation of force and deformation fronts in the vertical direction. heels.

Possible positive and negative aspects of reorientation of fronts and sequence of their interaction are considered. In conventional methods of calculating the parameters of BVR in relation to mass explosions, it is conventionally assumed that downhole charges in the system interact in the direction normal to their axes. Similarly, in theoretical constructions this assumption is laid down, ie for simplification it is accepted that charges detonate simultaneously on length. This approach allows you to simplify the solution of the problem of stress field stresses in the downhole massif and in the first approximation to estimate the mechanical effect of the explosion.

Due to the specific "pear-shaped" shape of the radiated energy field, the explosion of the reverse conical action at the stage of initiation of the main (borehole) charge directing the initial section of the stress wave front faces the upper free surface, ie towards the surface layers located at the level of the charge. This area is not directly affected by the system of compressive radial and tangential stresses from the explosion of the charge in the well. Therefore, changing the direction of development of the force field towards the upper layers of the array should contribute to better grinding of this part of the array.

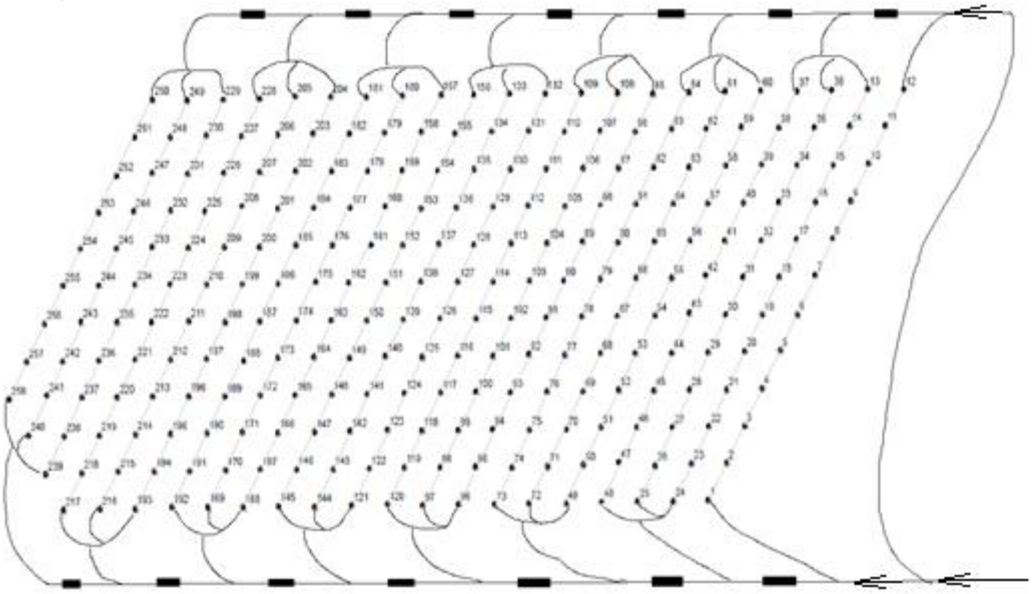
Thus, the greatest effect from such a reorientation of the force field can be achieved by lower initiation of adjacent downhole charges, provided they are almost simultaneously initiated.

Since the corresponding charges of adjacent series will be initiated simultaneously, the fronts of the stress fields will meet strictly in the intercharging space, and the total force field vector in the case of such interaction will be directed normally to the free surface of the block.

Given that technically such conditions are difficult to provide due to the high velocity of stress waves and its certain change under the influence of rock disturbances, especially in the weathered array of quartzites, it is more realistic to rely on the known mechanism of interaction of rock masses moving towards and according to the cutting scheme, ie on the mechanism of interaction at the level of a slower process - the collision of masses directed towards the upper free surface. Simultaneous lower initiation of elongated charges in adjacent rows generates opposing fronts inclined to the free surface of the ledge. In fact, in this case, a scheme of a vertical wedge cut is proposed, oriented instead of the free side surface towards the roof of the ledge, which due to its considerable extension is the source of most of the oversized fraction. It is clear that the new scheme of interaction of groups of charges contradicts the traditional methods of designing a scheme of short-range detonation, as it eliminates the mechanism of horizontal sequential movement of individual masses of the mountain massif and reorients the movement of these masses from horizontal to vertical, but increases the risk of seismic factor.

In order to combine these movements and taking into account the significant density of the network of wells of small diameter (102mm with a network of 3m x 3m), in work and practice tested and implemented a compromise switching scheme, which consists in simultaneous parallel landing of three adjacent rows of wells as one group (Fig. 5), followed by a short-range explosion of an adjacent three-row group with a deceleration period of 100ms and beyond.

a)



б)

Figure 5 - General view of the ledge (a) and the combined switching scheme of the explosive network (b) in the quarry for the development of the Chovdar ore quartzite deposit

The implementation of such a scheme allows to use its advantages due to the combination of mechanisms of mass movement in the vertical direction with the traditional collision of sections of the array in the horizontal direction. The advantages of using a mixed network switching scheme are proved by industrial tests of the method in conditions safe for seismic factor. According to the Chovdar Quarry, which develops ore-bearing quartzites with a naturally disturbed structure, with a maximum size of the oversized fraction of 0.8 m (determined by the width of the receiving hole of the crusher), the yield of oversize under blasting is 10%. After the implementation of the recommendations developed in the dissertation, the volume of oversized output decreased to 5%.

It should be noted that the proposed scheme of blasting the plug "vertical wedge cut" shows its effectiveness within the upper layer of the ledge at the level of the heel. With regard to the development of deposits on the slopes, the scheme requires improvement of the technique of contour blasting by combining in the contour row detachable protective crack with a zone of increased fracture facing the landing block.

CONCLUSIONS and practical consequences

The shape of the total field of maximum stresses on the middle axis between adjacent charges initiated simultaneously from the lower end should have manifestations of the cumulative effect in the area of the upper end areas of adjacent charges. Therefore, after the inclined counter power fronts, counter mass shifts should take place, generally directed towards the superbore layer of the rock mass at the level of the stamping. The technique of forming upward movements in the intercharging volume of the rock is a new technological element that takes over the experience of conducting mass blasting operations according to an effective traditional system of switching a network of wells in the form of a horizontal wedge or trapezoidal cut. Such a traditional scheme initiates successive pairwise counter mass shifts with short decelerations in the direction of the lateral slope of the ledge. In contrast to this scheme, the new technology of mass explosion is based on a combined technique of simultaneous lower charge initiation in groups of 2-3 rows and the use of traditional short decelerations between groups to prevent excessive seismic effect. Thus, in groups the combined scheme of KSP "vertical wedge" which promotes additional destruction of the top layer of the planted rock block and reduction of an exit of oversized fraction at the level of a stamping is realized.

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