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ASSESSMENT OF THE SIZE OF ROCKS IN BENCHS AND LUMPINESS OF THE BLASTED MOUNTAIN MASS ON PITS WITH USE OF GIS GEOMIX

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Abstract

On the basis of natural researches in career of SC 'Kovdorsky MCP' and computer processing of their results in GIS GEOMIX was developed the photometric method of assessment of blocks (sizes) of breeds in the slope of ledges of a pit, the existing version of this method intended for assessment of lumpiness of mountain mass is improved; the technique of assessment of the blocks and lumpiness of breeds is offered new, based on laser scanning of ledges and the surface of blasted mountain mass.

Key words: the field, pit, ledge, blocks of breeds, the surface of blasted mountain mass, lumpiness, computer technology, assessment technique, photometry, laser scanning, reliability.

Introduction

At open-cast mining of fields in massifs of rocks the most expensive technological operation – their destruction by blast [1]. The major natural factors influencing blast of breeds are their blocks (the size of breeds in massif) and fortress [2]. If for assessment of average values of durability of breeds it is enough to carry out laboratory researches of representative number of samples for each their petrologic type, then the size of breeds, as a rule, doesn't depend on their petrologic type, and defined by features of explosive tectonics that is very changeable, especially on fields with multi-stage manifestation of tectonic processes. The reliable assessment of blocks of breeds in the massif preparing for explosion is possible only by her direct studying in the slope of ledge. Quality of blasting preparation of mountain mass is characterized by value of the average size of a lump and shares of oversized blocks in her disorder.

High intensity of modern mining and the requirement to its safety determines relevance of development of remote methods of operational and reliable assessment of blocks of breeds in the massif and their lumpiness in the disorder created by blast. By authors of article based on created by JSC 'VIOGEM' GIS GEOMIX the photometric method of

assessment of blocks of breeds in the slope of ledge of a pit is developed, the existing version of this method intended for assessment of lumpiness of blasted mountain mass is enhanced and the technique of assessment of blocks and lumpiness of breeds is offered new, based on laser scanning of slopes of ledges and disorders of mountain mass [3] Natural researches are conducted in career of SC 'Kovdorsky MCP' developing the apatite-magnetite field in Murmansk region.

Methodology

The photometric method requires availability of the following technical means: a support, the professional SLR camera (a matrix from 20 million pixels), a telephoto lens with focal length of 600-1300 mm (the stabilizer, manual and automatic focusing). The sequence of transactions in implementation process of this method for assessment of blocks of breeds in ledges of a pit is shown in the figure 1.

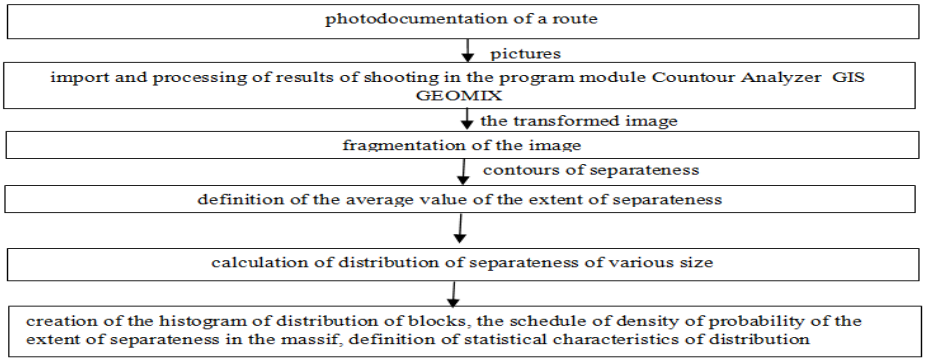

Figure 1: The block - the scheme of an algorithm of assessment of blocks of breeds in pit ledges.

The slope of a ledge is photographed from an opposite board of a pit provided that the axis of a lens of the camera is perpendicular to a slope. It guarantees uniform distribution of perspective distortions in a picture and the identical accuracy of assessment of blocks of breeds on all height of a ledge [4]. The researched site of a ledge of a pit on the lower and upper its edge of the ledge breaks into intervals 20 m long which borders are fixed by pegs. Ledge slope pictures within each interval, with the indication of "rulers" (the pieces connecting points of the beginning and the end of an interval on each brow) between which distance is equal to ledge height (figure 2, a) are loaded into the program module Contour Analyzer in GIS GEOMIX.

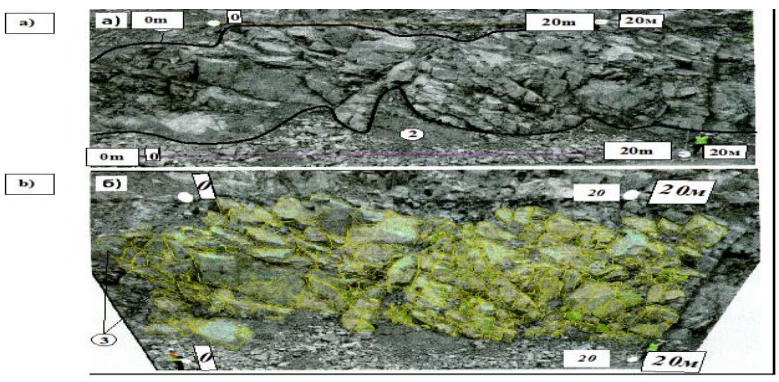

Figure 2: Pictures of the researched interval of a slope of a ledge of a pit to (a) and later (b) perspective transformations and fragmentations of separateness of rocks 1-lower bound of a zone of red rills of explosive wells; 2 – the upper bound of a talus in the ledge slope basis; 3 – the contours of separateness of rocks received as a result of fragmentation

Perspective distortions of pictures are eliminated with use of the return perspective transformation (figure 2, b) which parameters calculate on coordinates of rulers on a photo and their actual (model) coordinates [5]. Taking into account that rulers are the parties of a rectangle of the known sizes (A, B), the system of coordinates of model is located so that corners of a rectangle had coordinates ({ 0; 0 }, { A; 0 }, { A; B }, { B; 0 }) in space of model [6].

Recalculation of coordinates of points from raster (p, q) in coordinates of model (x, y) is carried out by multiplication of uniform coordinates (p, q, 1) on a matrix, the return to a matrix of perspective transformation M:

$$M^{-1} = \begin{pmatrix} p \\ q \\ l \end{pmatrix} = \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} \qquad (1)$$

$$x = x'/z'$$

$$y = y'/z',$$

where x, y, z – uniform coordinates of a point in model space.

The matrix 1 is from a ratio:

$$\begin{pmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a & b & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix} = \begin{pmatrix} p' \\ q' \\ r' \end{pmatrix}$$

$$p = p'/r'$$

$$q = q'/r'$$

The following formulas of calculation of coordinates from him (p, q):

$$p = \frac{a_1 x + b_1 y + c_1}{ax + by + 1}$$

$$q = \frac{a_2 x + b_2 y + c_2}{ax + by + 1}. \qquad (2)$$

For drawing up system of the linear equations for the purpose of definition 8 unknown (a_1,b_1,c_1,a_2,b_2,c_2,a,b) are necessary 4 points with known in model coordinates (x_1,y_1,x_2,y_2,x_3,y_3,x_4,y_4) and raster coordinates (p_1,q_1,p_2,q_2,p_3,q_3,p_4,q_4) values which are substituted in formulas (2):

$$\begin{cases} a_1x_1+b_1y_1+c_1=p_1(ax_1+by_1+1) \\ a_1x_2+b_1y_2+c_1=p_2(ax_2+by_2+1) \\ a_1x_3+b_1y_3+c_1=p_3(ax_3+by_3+1) \\ a_1x_4+b_1y_4+c_1=p_4(ax_4+by_4+1) \\ a_1x_1+b_2y_1+c_2=q_1(ax_1+by_1+1) \\ a_1x_2+b_2y_2+c_2=q_2(ax_2+by_2+1) \\ a_1x_3+b_2y_3+c_2=q_3(ax_3+by_3+1) \\ a_1x_4+b_2y_4+c_2=q_4(ax_4+by_4+1) \end{cases} \begin{cases} a_1x_1+b_1y_1+c_1-ap_1x_1-bp_1y_1=p_1 \\ a_1x_2+b_1y_2+c_1-ap_2x_2-bp_2y_2=p_2 \\ a_1x_3+b_1y_3+c_1-ap_3x_3-bp_3y_3=p_3 \\ a_1x_4+b_1y_4+c_1-ap_4x_4-bp_4y_4=p_4 \\ a_1x_1+b_2y_1+c_2-aq_1x_1-bq_1y_1=q_1 \\ a_1x_2+b_2y_2+c_2-aq_2x_2-bq_2y_2=q_2 \\ a_1x_3+b_2y_3+c_2-aq_3x_3-bq_3y_3=q_3 \\ a_1x_4+b_2y_4+c_2-aq_4x_4-bq_4y_4=q_4 \end{cases}.$$

The received system of the equations decides rather unknown elements (a_1,b_1,c_1,a_2,b_2,c_2,a,b) matrixes of perspective transformation M.

On the transformed picture set the area of fragmentation and determination of the extent of separateness of breeds from which are excluded a zone of red rills in the top part of a slope of a ledge and a zone of taluses in his basis (see figure 2, b). Fragmentation of separateness is carried out in the automatic mode by means of function of the "fragmentation of the image" based on the algorithm of "a marker watershed" offered by F. Maier [7] which will transform the color image to the image containing one color (gray) with various shades. Sites of light gray color are allocated as separateness of breeds between which borders (crack) are fixed by fragments of dark gray color. The inaccuracies of allocation which are visually found in a picture are eliminated with use of function of manual correction of their borders. The extent of natural separateness of breeds on a picture is estimated taking into account the following factor. At blast of the massif any part of its separateness doesn't collapse that predetermines existence in the blasted mountain mass of the large fractions similar established in a slope of a ledge [8]. Among them there can be oversized separateness which size (on the greatest of three dimensions) exceeds the most admissible for the loading, transport and crushing equipment used when developing this field. The characteristic of the extent of separateness is the maximum distance (L_{max}) between two points of a contour of separateness (1,2) which are the most removed from each other on a picture which is determined by a formula:

$$L_{\max}=\sqrt{(X_1-X_2)^2+(Y_1-Y_2)^2}, \qquad (3)$$

where $X_1\ Y_1$ and $X_2\ Y_2$ - coordinates of points 1,2 respectively.

Average value of the extent of separateness of breeds in this interval of a slope of a ledge ($d_{cp.}$) is calculated by a formula:

$$d_{cp}=\frac{\sum_{i=1}^{N}L_iW_i}{\sum_{i=1}^{N}W_i}, \qquad (4)$$

where N – the number of measurements of separateness, L_i – the extent of separateness, Wi – its weight, or a share in the general set of measurements, equal to the extent of separateness ($W_i=L_i$).

Results and Discussions

The photometric method of quality evaluation of blasted mountain mass is known long ago [9] and is used at many mining entities of Russia (Lebedinsky, Stoylensky, Kovdor, Olimpiadinsky and other mining and processing works). Object of a research is the disorder of pieces of rocks formed by blast which is fulfilled by the excavator that creates quite difficult and changeable geometry of a surface of disorder. To receive a picture of such surface with uniform distribution of perspective distortions very difficult. Besides, usually photographing of disorder is carried out from the horizon of a sole of the blasted block and owing to a disorder surface inclination at an angle 50-80^0 distortions in the top part of a picture significantly more, than in lower part.

At photography they settle down on the center of a shot on the greatest possible removal from each other. The conditional surface passing through two laths has to coincide as much as possible with a disorder surface between them. It is impossible to settle down laths so that between them there were wavy bends of a surface of the explosion mountain mass it will lead to increase in distortions of pictures on this site. For elimination of the perspective misstatements caused by various remoteness of laths from a shooting point the procedure of perspective transformation of a picture similar to that which was used when handling pictures of slopes of ledges of a pit is performed. Usually in modern programs ("WipFrag", "K-Granules" and others.) intended for assessment of particle size distribution of the blasted mountain mass by means of standard graphic filters (the median filter of degradation and level of contrast) the areas of color scale for which dimension recognition isn't made are designated (figure 3, the specified areas are painted in green color). This circumstance leads to inexact fragmentation of pieces.

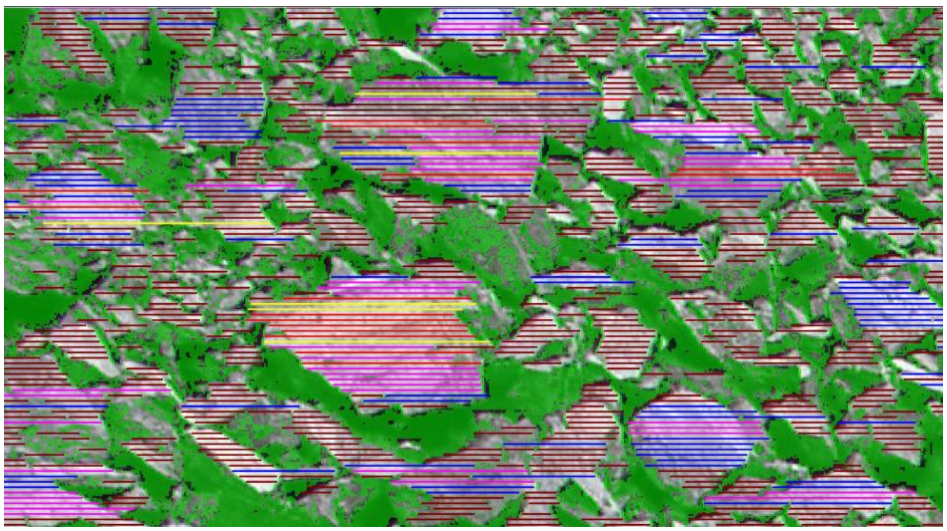

Figure 3: Picture of a surface of the blown-up block fragmented with use of the median filter of degradation.

Further on all height of the image horizontal parallel lines with the set step are drawn (in image pixels) and for each line the large-scale coefficient (mm/pixel) is defined, and also recognition of the pieces concluded between the allocated areas is carried out. The recognizable pieces are grouped in fractions and a total assessment distribution of pieces of various size on the explored site is given. The average size of a piece meets population mean of distribution. At such methodical approach value of the average size of a piece (d_{cp}) will always depend on the step of fraction in distribution accepted without justifications that results in some uncertainty of the obtained data [10].

The shortcomings of the existing technique of assessment of the size of pieces of breed of the disorder created by blast noted above testify to need of her improvement. Articles of a research executed by authors showed efficiency of application of the algorithm of a marker watershed mentioned above for allocation of contours of pieces on a disorder picture with use of the special program Contour Analyzer module (figure 4).

a) b)

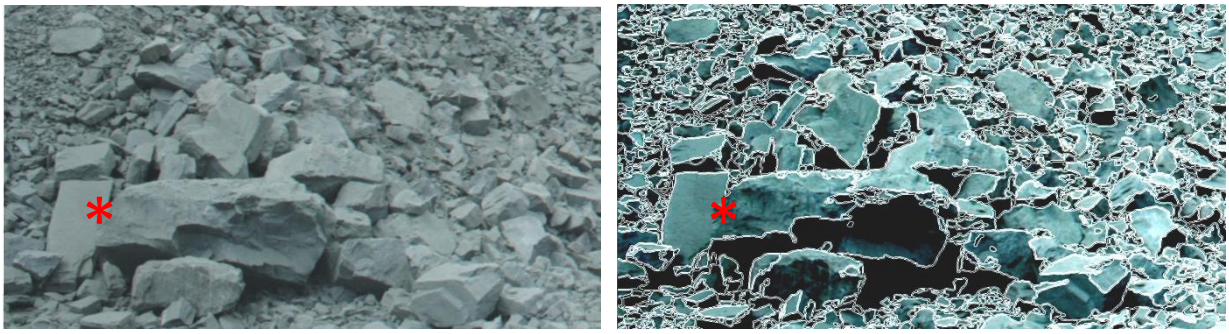

Figure 4: A picture of disorder of the blown-up mountain weight before fragmentation (a) and after fragmentation (b).

It is necessary to tell that additional manual processing of a picture in some cases is required. In particular, if an object is painted in different colors or at photography it has appeared in a shadow (in figure 4 it is noted by an asterisk), at fragmentation he will be artificially divided into several parts, or on the contrary different pieces at indistinct border between them unite in one.

The size of each piece and average value of the size of a piece on this site of disorder are determined by the formulas (3, 4) stated above which were used at assessment of blocks of breeds in slopes of ledges.

The comparative analysis of assessment of the average size of a piece (dcp) in the blast mountain mass by results of manual measurements (are taken for a reference), with use of a classical photometric method and by means of fragmentation of the image on an algorithm of a marker watershed has shown the following. Measurements were carried out on four sites of a pit, various on a geological structure. In total 1644 measurements were made. In the first case the deviation from a reference has averaged 9 cm at fluctuation in an interval the 4-15 cm, and in the second

respectively 5 cm and 2-9 cm. From this it follows that application of an algorithm of a marker watershed at assessment of particle size distribution and the average size of a piece in the blasted mountain mass allows to obtain more reliable data in comparison with a classical photometric method.

The high-quality break in a technique of assessment of blocks of breeds in a ledge of a pit and lumpiness of the blasted mountain mass managed to be reached with emergence at the mining entities of systems of laser scanning. The benefit of the method of such assessment based on laser scanning consists in lack of need of stay of the person near slopes of ledges of a pit for breakdown and photography of a geological route, or in the danger area of operation of the excavator for installation of measuring laths on a face surface; reducing time for natural transactions in career and higher reliability in comparison with photo method as in difference from a flat picture with a set of perspective misstatements the laser picture is provided by a set of points with the known coordinates (X, Y, Z). Besides, the laser picture is painted in real colors that gives the chance more precisely to establish and take out on geological graphics of border of petrographic differences of the breeds differing from each other on color and also to visually estimate in a picture correctness of allocation of pieces in the blasted mountain mass.

Scaning was carried out with use of the scan system Riegl VZ-4000. Techniques of scanning of slopes of ledges of a pit and faces of the blast blocks for assessment of distribution of separateness or pieces of various size differ from each other a little. If the researched site of a pit is characterized considerable (more than 500 m) by the extent of ledges and variability of pro-deleting of their slopes, then for receipt of the scan which is most in detail reflecting a ledge slope surface it is necessary to execute its scanning from three different points, two of which are located at the edges of the site, and the third – on its middle. On the site of a ledge less than 500 m long sustained on pro-deleting of a slope there is enough scanning from two extreme points. Unlike a ledge the extent (width) of a face in disorder of the blasted mountain mass doesn't exceed 30 m, and height of disorder fluctuates in the range of 7-12 m. Therefore for lumpiness assessment in a disorder face scanning is carried out from one point located on the lower or top part of the fulfilled ledge. Data processing of laser scanning was carried out in GIS the GEOMIX with use of the computer program developed by specialists of JSC VIOGEM [11].

The essence and the sequence of procedures, components the technique of assessment of blocks of breeds developed by authors in a ledge of a pit or lumpiness of the blasted mountain mass with use of laser scanning, is reflected in figure 5, and the processed laser picture of the site of disorder with the allocated contours of pieces is provided in figure 6. This technique provides manual and semi-automatic fragmentation in an urgent condition in a scan picture

of limits of separateness or pieces, and the computer technology of their automatic fragmentation is in a development stage.

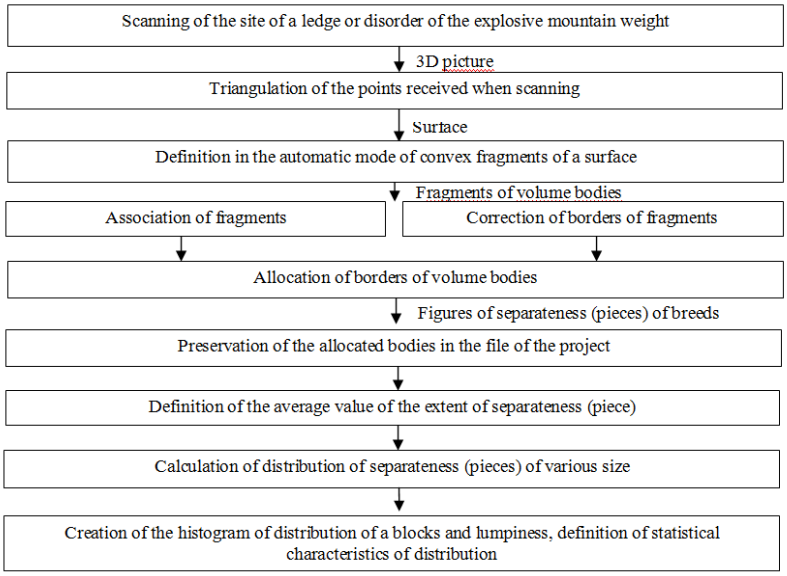

Figure 5: The block - scheme of an algorithm of assessment of a blocks of breeds in ledges of a pit and lumpiness of the explosive mountain weight with use of system of laser scanning.

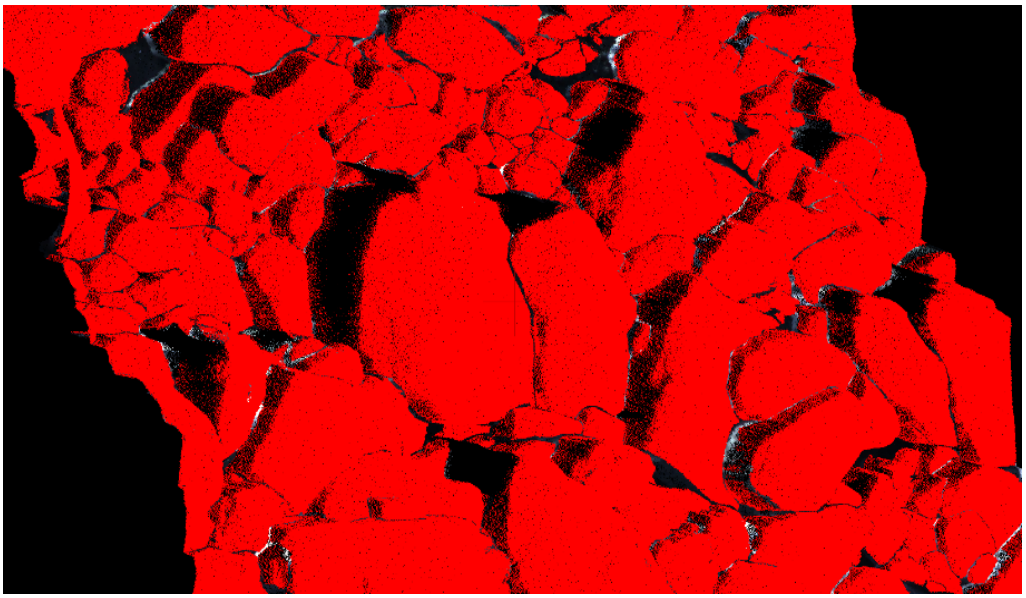

Figure 6: Contours of pieces of the explosive mountain weight according to laser scanning.

Comparison of results of determination of particle size distribution of the blasted mountain mass manual measurement, by a photometric method with application of an algorithm of a marker watershed and with use of laser scanning on five skilled sites has shown that in comparison with manual measurement the relative error of determination of the average size of a piece by a photometric method is equal to 12.21%, and according to laser scanning of 6.93%. At the same time in absolute values the deviation for a photo method has averaged 5 cm at fluctuation in the range of 2-9 cm, and for laser scanning respectively 3 cm and 1-4 cm.

Conclusion

The main results of the researches on a subject of this article executed by authors:

1. The technique of natural studying and computer handling of the obtained data is developed for assessment of blocks of rocks in slopes of ledges of a pit with use of photometry.

2. The photometric method of assessment of lumpiness of disorder of the explosive mountain weight is improved due to application for allocation of contours of pieces on a picture of an algorithm of a marker watershed.

3. The innovative technique of assessment of blocks of breeds based on laser scanning in a slope of a ledge and lumpiness of disorder of the blasted mountain mass which increases reliability of assessment of the specified parameters is developed, excludes direct contact of the person with the subject, reduces time for natural transactions in career. The existing option of this technique provides a manual and semi-automatic fragmentation in a scan picture of separateness or pieces of breeds; the computer technology of their automatic fragmentation is in a development stage.

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